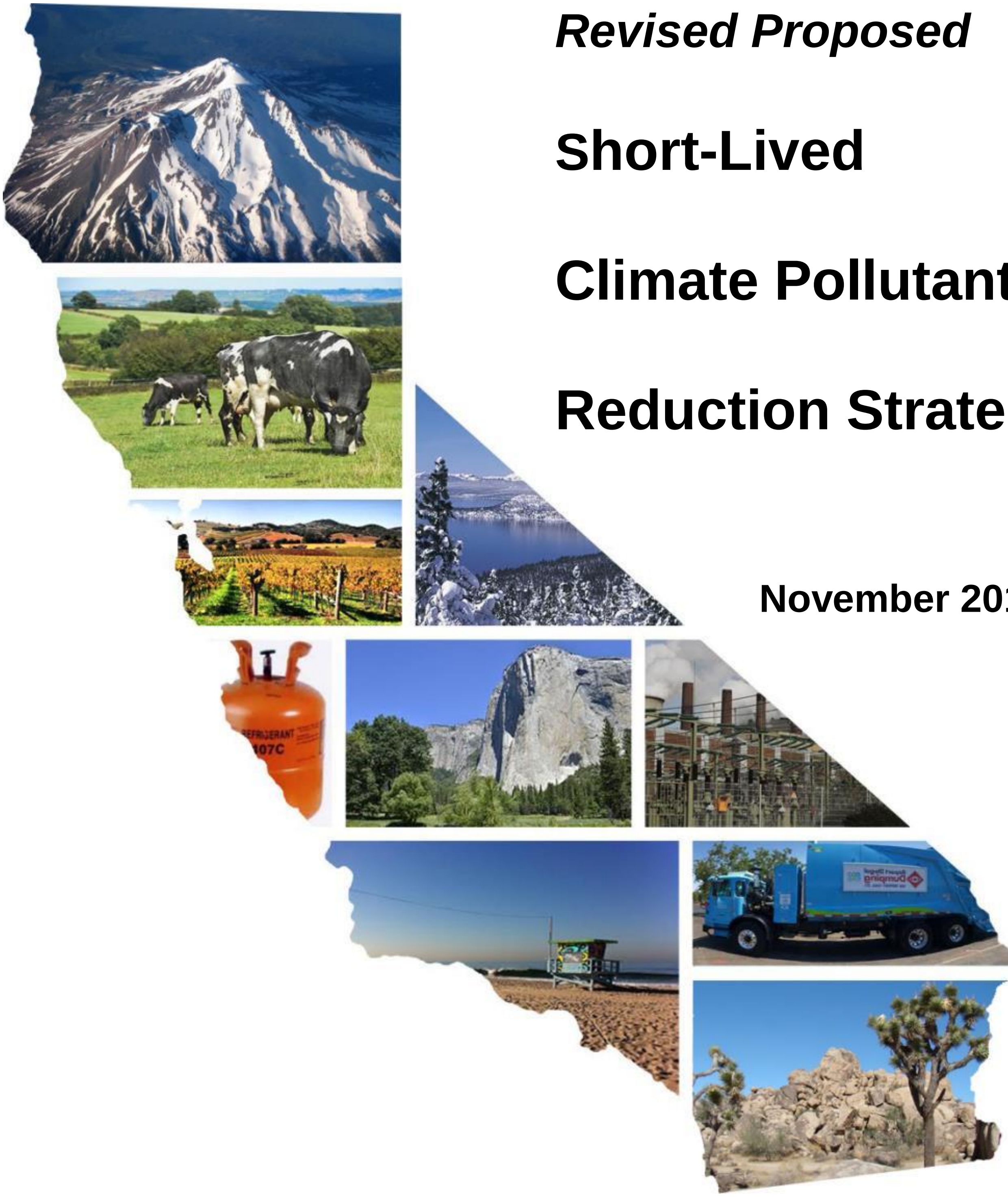

Revised Proposed

Short-Lived Climate Pollutant Reduction Strategy

November 2016

California Environmental Protection Agency

Air Resources Board

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EXECUTIVE SUMMARY

California's dramatic landscapes—including deserts, mountains, valleys, and coastlines—and abundant natural resources, have drawn early explorers and settlers and today's residents. However, climate change is threatening Californian's way of life. The State suffers through historic temperatures, persistent droughts, and more intense and frequent wildfires. Each year seems to bring a new global temperature record, and new evidence suggests sea levels are rising much faster than predicted. What was once, and remains, a generational problem of greenhouse gas (GHG) balance in the atmosphere has now become an immediate threat to our California lifestyle.

> ***The Need for an SLCP Strategy***
>
> - SLCP's are the most potent short-term GHGs
> - Significant reductions are needed to minimize the impact of these powerful climate forcers
> - Viable opportunities exist to reduce emissions locally and globally
> - Reduction measures would provide co-benefits (valuable energy and soil amendment products, reduced reliance on fossil fuel, public health benefits, co-pollutant benefits, etc.)

The only practical way to rapidly reduce the impacts of climate change is to employ strategies built on the tremendous body of science. The science unequivocally underscores the need to immediately reduce emissions of short-lived climate pollutants (SLCPs), which include black carbon (soot), methane (CH_4), and fluorinated gases (F-gases, including hydrofluorocarbons, or HFCs). They are powerful climate forcers and harmful air pollutants that have an outsized impact on climate change in the near term, compared to longer-lived GHGs, such as carbon dioxide (CO_2). SLCPs are estimated to be responsible for about 40 percent of current net climate forcing. Action to reduce these powerful "super pollutants" today will provide immediate benefits as the effects of our policies to reduce long-lived GHGs further unfold.

California's Global Warming Solutions Act, AB 32 (Nuñez, Chapter 488, Statutes of 2006), charges the California Air Resources Board (ARB or Board) with reducing statewide GHG emissions to 1990 emission levels by 2020 and maintaining a statewide GHG emission limit, while seeking continuing GHG emission reductions. In September 2016, Governor Brown signed SB 32 (Pavley, Chapter 249, Statutes of 2016), codifying a reductions target for statewide GHG emissions of 40 percent below 1990 emission levels by 2030. SLCP emission reductions will support achieving these targets. Indeed, specific to SLCP emission reductions, Senate Bill 605 (Lara, Chapter 523, Statutes of 2014) requires the ARB to develop a plan to reduce emissions of SLCPs, and Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016) requires the Board to approve and begin implementing the plan by January 1, 2018. SB 1383 also sets targets for statewide reductions in SLCP emissions of 40 percent below 2013 levels by 2030 for methane and HFCs and 50 percent below 2013 levels by 2030 for anthropogenic black carbon, as well as provides specific direction for reductions from dairy and livestock operations and from landfills by diverting organic materials.

This revised proposed SLCP Reduction Strategy (SLCP Strategy) was developed pursuant to SB 605 and SB 1383 and lays out a range of options to accelerate SLCP emission reductions in California, including regulations, incentives, and other market-supporting activities. The SLCP Strategy will inform and be integrated into the upcoming 2030 Target Scoping Plan Update, which will incorporate input from a wide range of stakeholders to develop a comprehensive plan for achieving the SB 32 statewide 2030 GHG limit of 40 percent below 1990 levels. The process for updating the Scoping Plan began in fall 2015 and is scheduled for completion in 2017.

Achievable Goals through Implementing the SLCP Strategy:

- Achieve the following reductions by 2030 (from 2013 levels): ...
  - 50% for anthropogenic Black Carbon
  - 40% for Methane, and
  - 40% for HFCs
- Convert manure and organic wastes into valuable energy and soil amendment products
- Reduce disposal of edible foods by diverting them to food banks and other outlets
- Reduce harmful emissions from residential wood stoves
- Accelerate the reductions of the fastest-growing source of GHG emissions by building on global HFC phasedown agreements.

Scientific research indicates that an increase in the global average temperature of 2°C (3.6°F) above pre-industrial levels, which is only 1.1°C (2.0°F) above present levels, poses severe risks to natural systems and human health and well-being. Deploying existing technologies and resource management strategies globally to reduce SLCP emissions can cut the expected rate of global warming in half and keep average warming below the dangerous 2^{o}C threshold at least through 2050. We can slow sea level rise significantly, reduce disruption of historic rainfall patterns, and boost agricultural productivity by reducing crop losses to air pollution. Cutting global SLCP emissions immediately will slow climate feedback mechanisms in the Arctic and elsewhere that would otherwise further accelerate global warming and make climate change far more difficult to solve and far more costly to live with—as more resources would be required for disaster relief, conflict management, and adaptation. Most importantly, we can dramatically reduce global air pollution, saving millions of lives each year. Many of these benefits will primarily accrue in regions and populations disproportionately impacted by climate change, including the developing world.

Using cost-effective and available technologies and strategies, worldwide anthropogenic sources of SLCP emissions can be largely controlled by 2030 and the global benefits of a collective commitment to substantially reduce SLCP emissions would be profound. Leading efforts by California, the United States, Mexico, Norway, Europe, the Arctic

Council, and several countries and non-governmental entities acting through the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants (CCAC) are already targeting SLCPs. Many other countries included SLCP emissions in their commitments made at the Paris climate conference, or are targeting them through separate policies to improve air quality and promote sustainable agriculture and transportation, among other efforts.

Glacial decline in the Glacier Peak Wilderness (Washington state) from 1973 to 2006.

Assembly Bill 1613 (Committee on Budget, Chapter 370, Statutes of 2016) and Senate Bill 859 (Committee on Budget and Fiscal Review, Chapter 368, Statutes of 2016) lays out a spending plan for Cap-and-Trade revenues which specifically target SLCP emission reductions. These include $5 million for black carbon wood smoke reductions, $40 million for waste reduction and management, $7.5 million for Healthy Soils, and $50 million for methane emission reductions from dairy and livestock operations.

An Opportunity for California

In this SLCP Strategy, we outline SLCP emission reduction actions that provide a wide array of climate, health, and economic benefits throughout the State. The State's organic waste should be put to beneficial use, such as for soil amendments/compost, electrical generation, transportation fuel, and pipeline-injected renewable natural gas. Organic wastes converted to biogas could supply enough renewable natural gas for about 2 million residential units.[1] Practical solutions must be developed and implemented to overcome barriers to waste gas utilization for pipeline injection and grid interconnection. Additional data on SLCP sources must be collected in order to improve California's SLCP emission inventory and better understand potential mitigation measures. Finally, the State should provide incentives to accelerate market transitions to cleaner technologies that foster significant system-wide solutions to cut emissions of SLCPs. Many of the sources and sectors responsible for SLCP emissions are concentrated in communities with high levels of pollution or unemployment, which could especially benefit from targeted investments to


Dairy gas cleanup system (gas scrubber)

[1] For illustrative purposes only. This SLCP Strategy calls for a variety of waste management approaches, some of which do not yield energy products.

improve public health and boost economic growth.

In the coming years, many billions of dollars in public and private investments are anticipated to support efforts to reduce SLCP and CO_2 emissions and support our agricultural and waste sectors, build sustainable freight systems, and encourage low-Global Warming Potential (GWP) refrigerants. These investments will strengthen the State as a whole and the communities where they occur. Many of the benefits will accrue in the Central Valley, rural parts of the State, or other areas disproportionately impacted by pollution, such as those along freight corridors.

Stubborn barriers remain, including connecting distributed electricity and biogas projects, which have slowed previous efforts to reduce emissions of SLCPs and capture a wide array of benefits. These barriers are not insurmountable, and now is the time to solve them. State agencies, utilities, and other stakeholders need to work immediately to identify and resolve remaining obstacles to connecting distributed electricity with the grid and injecting renewable natural gas into the pipeline, as called for in SB 1383. Supporting the use of the cleanest technologies with funding and strategies that maximize air quality, climate, and water quality benefits can accelerate their introduction. Building market certainty and value for the energy, soil amendment, and other products such as a uniform fertilizer that come from compost or anaerobic digestion facilities will help to secure financing to accelerate and scale project development.

Building on California Leadership

This SLCP Strategy builds on California's ongoing leadership to address climate change and improve air quality. It has been developed with input from State and local agencies, academic experts, a working group of agricultural experts and farmers convened by the California Department of Food and Agriculture (CDFA), businesses, and other interested stakeholders in an open and public process. ARB and State agencies collaborated to identify reduction measures for specific sectors, including the dairy, wastewater, and waste sectors. In addition, ARB collaborated with the local air districts to identify SLCP emission reduction measures that could be implemented through district action. Throughout this process, ARB has sought advice from academic, industry, and environmental justice

SLCP Guiding Principles

Measures to reduce SLCP emissions should be:

- Commercially and technologically feasible
- Informed by sound science and best available information
- Designed to maximize air pollution reductions and other co-benefits, especially considering disadvantaged communities
- Leveraged with other market programs, incentives, and investments to maximize the measures' efficacy
- Developed in consultation with disadvantaged communities, affected industries, relevant local and State agencies, and other stakeholders

representatives. Additionally, ARB staff is working closely with manufacturers to determine the feasibility and cost of replacement products for high-GWP refrigerants, and with the dairy industry and academics to evaluate options and costs for reducing emissions of methane at dairies.

While reducing GHG emissions is a key objective for the State, California remains committed to further reducing emissions of criteria (smog-forming) pollutants and toxic air pollutants, as well. Many of the concepts described in this SLCP Strategy have already been discussed in the context of the California Sustainable Freight Action Plan, 2016 Mobile Source Strategy and other efforts related to developing State Implementation Plans for air quality, and plans for bioenergy, waste management, water management, healthy soils, and sustainable management of the state's natural resources.

State agencies and the air districts are committed to continuing to work together to ensure that the concepts outlined in this SLCP Strategy are implemented in a coordinated and synergistic way. The sections below describe goals, regulations, incentives, and other efforts that would:

- Encourage national and international deployment of California's well-established and proven measures to reduce black carbon emissions;
- Further reduce black carbon emissions from off-road and non-mobile sources;
- Significantly cut methane emissions from dairy and livestock operations while providing farmers with new, potentially lucrative revenue streams;
- Significantly reduce disposal of organics in landfills and create and expand industries to capture value from organic waste resources in California;
- Significantly reduce fugitive methane emissions from oil and gas systems and other sources; and
- Accelerate the transition to low-GWP refrigerants and more energy efficient refrigeration systems.

Achieving Significant Emission Reductions

SB 1383 sets statewide emission reduction targets of 40 percent below 2013 levels by 2030 for methane and HFCs, and 50 percent below 2013 levels by 2030 for anthropogenic black carbon emissions, codifying the proposed targets included in earlier versions of this SLCP Strategy. These targets will assist the State in meeting its SB 32 goals and federal air quality standards for 2031 and beyond.

The emission reductions associated with these targets are summarized in Table 1. The goals and proposed measures included in this SLCP Strategy will reduce SLCP emissions to levels in line with these targets. Recognizing how damaging SLCPs can be over the short-term, 20-year GWPs are used in this report to quantify emissions of SLCPs, as opposed to 100-year GWPs, which are used in the State's official GHG inventory and for accounting for emissions in programs adopted under AB 32.

Table 1: California SLCP Emissions and Emission Reduction Target Levels (MMTCO2e)*

Pollutant	2013	2030 BAU**	2030 Emission Reduction Target (percent reduction from 2013)
Black carbon (anthropogenic)	38	26	19 (50%)
Methane	118	117	71 (40%)
Hydrofluorocarbons (HFCs)	40	65	24 (40%)

*Using 20-year GWPs from the 4th Assessment report of the IPCC for methane and HFCs, and 5th Assessment report for black carbon (the first report to define a GWP for black carbon)
**Business As Usual (BAU) forecasted inventory includes reductions from implementation of current regulations

Black Carbon

Black carbon is not one of the climate pollutants originally included in international climate frameworks, and it is not included in California's AB 32 inventory. However, recent studies have shown that black carbon plays a far greater role in global warming than previously believed. California has made tremendous progress in reducing black carbon emissions as part of its efforts to reduce carcinogenic diesel particulate matter emissions and improve air quality. California has already cut anthropogenic black carbon emissions by over 90 percent since the 1960s, and existing measures are projected to cut mobile source emissions by 75 percent and total anthropogenic emissions by nearly 60 percent between 2000 and 2020. Putting measures in place to achieve similar levels of reductions worldwide is the quickest way to reduce the impacts of climate change, and would save millions of lives per year.

These reductions have come from strong efforts to reduce on-road vehicle emissions, especially diesel particulate matter. Car and truck engines used to be the largest sources of anthropogenic black carbon emissions in California, but the State's existing air quality policies will virtually eliminate black carbon emissions from on-road diesel engines within 10 years. These policies are based on existing technologies, which could be deployed throughout the U.S. and the world.

With the large reduction in emissions of black carbon from vehicles, other sources of black carbon emissions will become more significant contributors to the State's black carbon inventory over time. In particular, without additional actions, off-road mobile, fuel combustion in the industrial and power sectors, and woodstoves and fireplaces will account for more than three-quarters of anthropogenic black carbon emissions in

California in 2030. However, black carbon emissions from these sources have declined significantly as well, by almost 30 percent since 2000. Continued progress on these sectors—transitioning to cleaner and more efficient uses of energy, reducing emissions from woodstoves and fireplaces, taking steps to meet federal health-based air quality standards by 2031, and developing and implementing a sustainable freight system—will continue to reduce black carbon emissions and should allow us to meet the targets established in this SLCP Strategy. The State's 2016 Mobile Source Strategy, 2030 Target Scoping Plan Update, and Sustainable Freight Action Plan, a multi-agency effort to deploy a sustainable and efficient system for goods movement, will build on these measures to reduce black carbon. Additionally, ARB will work with local air districts to further reduce particulate matter and black carbon emissions from woodstoves and fireplaces. Governor Brown recently signed legislation allocating $5 million to reduce black carbon from wood smoke.

Wildfire is the largest source of black carbon in California. Prescribed fires also emit black carbon, but are an important tool for forest managers. However, since the legislative direction and intent of SB 1383 is to include only non-forest sources of black carbon in the target, a target for forest-derived black carbon emission reductions is not included in this SLCP Strategy. In general, forests are burning at increasing rates and at increasing levels of severity. This trend raises concern over the long-term health of these forests and ability to sequester carbon and provide resource amenities. Fuel treatments are key elements of forest restoration strategies, and are embedded in management strategies at local, state and national levels. The Forest Carbon Plan, as well as the 2030 Target Scoping Plan Update, will continue to explore the interrelation of climate change and natural lands.

Methane

Methane is responsible for about 20 percent of current net climate forcing globally. In California, about half of methane emissions come from dairy and livestock manure or organic waste streams that are landfilled. These resources could be put to valuable use as sources of renewable energy or fuel, soil amendments, and other products. The other half mostly comes from enteric fermentation (burps) from dairy cows and livestock and fugitive emissions (leaks) from oil production, processing, and storage, gas pipeline system, or industrial operations. California can cut methane emissions by 40 percent below current levels in 2030 by capturing or altogether avoiding methane from manure at dairies, pursuing opportunities to reduce methane emissions from enteric fermentation, significantly reducing disposal of organics in landfills, and reducing fugitive methane emissions by 40-45 percent from all sources.

Strong market support and broad collaboration among State agencies, industry, and other stakeholders will be necessary to reduce landfill and manure methane emissions by putting organic waste streams to beneficial use. The State will support early action to build infrastructure capacity and reduce emissions through existing incentives and accelerated efforts to overcome barriers and foster markets. Government agencies and stakeholders will work to foster market conditions to support private sector investment in expanded or new infrastructure, including building markets for compost, soil amendments, and low carbon transportation fuels; overcoming barriers to pipeline injection of biomethane, grid connection for electricity or another best-use alternative; and identifying effective financing mechanisms and levels to reach the goals in this SLCP Strategy.

Ultimately, a combination of incentives, State and private sector collaboration and investment, and regulations will be necessary to capture the value in organic waste streams and ensure lasting emission reductions in order to achieve an economy-wide 40 percent reduction in methane.

Manure is responsible for 25 percent of California's methane emissions and improved manure management offers significant, near-term potential to achieve deep reductions in the State's methane emissions. Before ARB regulates dairy and livestock manure emissions, as required by SB 1383, California agencies will encourage and support near-term actions by dairies to reduce manure emissions through financial incentives, collaboration to overcome barriers, development of policies to encourage renewable natural gas production, and other market support.

Enteric fermentation from all livestock is responsible for roughly 30 percent of the State's methane emissions and is a critical source to control, but development of effective control measures face a unique set of challenges. The State will support and monitor research and explore voluntary, incentive-based approaches to reduce enteric fermentation emissions from dairy and non-dairy livestock sectors until cost-effective and scientifically-proven methods to reducing these emissions are available and regulatory actions can be evaluated.

Any regulations will be developed according to the time frames and requirements set forth in SB 1383 and AB 32, and in coordination with CDFA, CPUC, and local air quality and water quality agencies. The development of measures to reduce methane will be done in close coordination with dairy industry and will consider public input; available financial incentives; technical, market, and regulatory barriers to the development of dairy methane emission reduction projects; research on dairy methane emission reduction projects; and the potential for emissions leakage. A key effort will include working with CPUC and the dairy industry to implement a series of pilot projects that will help to better inform the opportunities for economically viable methane reduction strategies as well as the barriers that must be addressed. SB 1383 stipulates that manure methane emission control regulations are to be implemented on or after January 1, 2024. However, the statute allows ARB to require monitoring and reporting of emissions from dairy and livestock operations before that date. Consistent with SB 1383, ARB, in consultation with CDFA, will analyze the progress dairies are making in achieving the goals in this SLCP Strategy by July 1, 2020, and may adjust those goals as necessary.

For organic waste currently landfilled, the California Department of Resources Recycling and Recovery (CalRecycle) will consult with ARB to develop regulations by 2018 to reduce the level of the statewide disposal of organic waste by 50 percent of 2014 levels by 2020 and 75 percent of 2014 levels by 2025. These regulations will take effect on or after January 1, 2022. CalRecycle plans to consider the regulations for adoption by the end of 2018, which will: 1) allow jurisdictions that want to adopt early the ability to do so, thus contributing to the 2020 goal; and 2) provide clear direction to all jurisdictions, their service providers, and regulated businesses so that they can plan and budget for the required program changes that will need to take effect in 2022.

To support this, CalRecycle, with assistance from ARB, will build on its partnerships with local governments, industry, nonprofits, local air districts and water boards to support regional planning efforts and identify ways to safely and effectively develop necessary organics recycling capacity. Key issues include quantifying the co-benefits and the GHG emission reduction benefits of applying compost, addressing the cross-media regulatory tradeoffs between product use benefits relative to compost facility impacts, making beneficial use of biomethane generated from anaerobic digestion projects, and overcoming difficult issues associated with siting, social acceptance, CEQA mitigation, and other issues associated with new organics processing facilities.

Under SB 1383, 20 percent of the edible food destined for the organic waste stream is to be recovered to feed people in need by 2025. CalRecycle will explore new ways to foster food waste prevention and food rescue. Recovering and utilizing food that would otherwise be landfilled can help to reduce methane emissions and increase access to healthy foods for millions Californians lacking access to an adequate food supply. Additionally, CalRecycle and ARB will work with the State and regional Water Boards to assess the feasibility and benefits of actions to require capturing and effectively utilizing methane generated from wastewater treatment, and opportunities for co-digestion of food waste at existing or new anaerobic digesters at wastewater treatment plants.

This SLCP Strategy also establishes a goal of reducing fugitive methane emissions from oil and gas by 40 percent below current levels in 2025 and a minimum 45 percent in 2030, and from all other sources by 40 percent in 2030. This aligns with the federal government's goal of reducing methane emissions from oil and gas operations by 40–45 percent below 2012 levels by 2025.

California has a comprehensive and stringent emerging framework to reduce methane emissions from oil and gas systems. ARB is developing a regulation to reduce fugitive methane emissions from the oil and gas production, processing and storage sector, which will be among the most stringent such regulations in the country. Additionally, pursuant to Senate Bill 1371 (Leno, Chapter 525, Statutes of 2014), the California Public Utilities Commission

(CPUC) has launched a rulemaking to minimize methane leaks from natural gas transmission and distribution pipelines. Increases in energy efficiency and renewable energy, as well as more dense development patterns, will reduce oil and gas demand and fugitive emissions.

ARB and the California Energy Commission (CEC) have also conducted several research projects to improve methane emission monitoring and accounting, as well as identify emission "hotspots," which are responsible for large fractions of total fugitive emissions. In addition, AB 1496 (Thurmond, Chapter 604, Statutes of 2015) requires ARB, in consultation with the local air districts, to monitor and measure high-emission methane hot spots in the State. These efforts will continue, and are critical to accelerating leak detection and fugitive methane emission reductions from all sectors, not just oil and gas. Ultimately, to eliminate fugitive methane emissions, the State needs to transition away from its use of oil and natural gas.

HFCs

Fluorinated gases, and in particular HFCs, are the fastest-growing source of GHG emissions in California and globally. More than three-quarters of HFC emissions in California come from the use of refrigerants in the commercial, industrial, residential, and transportation sectors. In many cases, alternatives with much lower GWPs are already available and the United States Environmental Protection Agency (U.S. EPA) is beginning to impose bans on the use of F-gases with the highest GWPs in certain applications and sectors.

The annual Montreal Protocol Meeting of Parties in October 2016 in Kigali, Rwanda, resulted in an historic international agreement, known as the "Kigali Amendment", to phase down the production of HFCs globally. The agreement requires a reduction in the production and supply of HFCs for developed countries, including the U.S., as follows: 10 percent reduction in 2019; 40 percent in 2024, 70 percent in 2029, 80 percent in 2034, and 85 percent in 2036. Developing countries will not have to begin the phasedown until 2029, and will be allowed until 2045 to reach the 85 percent reductions in HFC consumption. Although the HFC phasedown will result in significant reductions, a long lag time of 10-20 years exists between a production phase-out and an equivalent emission reduction, due to an average 15-year lifetime for refrigeration equipment. During the equipment lifetime, it continues to use and emit the high-GWP refrigerants it was designed to use.

ARB will sponsor a third-party assessment of the impact of the Kigali Amendment on HFC emissions and reductions in California, especially as they pertain to meeting the 40 percent emission reduction goal. The assessment will be completed in early 2017, and pending results of the assessment, specific HFC reduction measures described in this SLCP Strategy may be revised accordingly. ARB will focus on measures that can move low-GWP alternatives and technologies forward both nationally and internationally. For example, as effective alternatives become available, ARB will consider developing limitations on the use of high-GWP refrigerants in new refrigeration and air-conditioning equipment where lower-GWP alternatives are feasible and readily available. California has a wide range of climate zones from alpine conditions to hot desert environments. As such, California could be instrumental as a proving ground for low-GWP refrigeration and air-conditioning technologies that can be used in extreme environments across the world.

A summary of all proposed SLCP emission reduction measures and estimated reductions is presented in Table 2. These estimates may change as more information on emission sources becomes available and as programs or regulations are developed.

Table 2: Summary of Proposed New SLCP Measures and Estimated Emission Reductions (MMTCO2e)[1]

Measure Name	2030 Annual Emission Reductions	2030 Annual Emissions
BLACK CARBON (ANTHROPOGENIC)		
2030 BAU[2]		**26**
Residential Fireplace and Woodstove Conversion	3	
State Implementation Plan Measures and Clean Energy Goals[3]	4	
2030 BAU with new measures		**19**
METHANE		
2030 BAU[2]		**117**
Dairy and Other Livestock (Manure and Enteric Fermentation)	26	
Landfill	4	
Wastewater, industrial and Other Miscellaneous Sources	7	
Oil and Gas Sector	8	
2030 BAU with new measures		**71**[4]
HYDROFLUOROCARBONS		
2030 BAU[2]		**65**
Financial Incentive for Low-GWP Refrigeration Early Adoption	2	
HFC Supply Phasedown (to be achieved through the global HFC phasedown)[5]	19	
Prohibition on sales of very-high GWP refrigerants	5	
Prohibition on new equipment with high-GWP Refrigerants	15	
2030 BAU with new measures		**24**

[1]Using 20-year GWPs from the 4th Assessment report of the IPCC for methane and HFCs, and 5th Assessment report for black carbon (the first report to define a GWP for black carbon)
[2]Business As Usual (BAU) forecasted inventory includes reductions from implementation of current regulations
[3]Future emission reduction measures that will be developed to help the State meet its air quality and climate change goals are also expected to help the State meet the black carbon target by 2030
[4] The specific annual reduction values shown above do not sum exactly to the total shown due to rounding error.
[5] A global HFC production and consumption phasedown was agreed to on October 15, 2016, in Kigali, Rwanda. ARB is currently evaluating the impact upon HFC emission reductions in California and plans to utilize the results from the assessment to inform future updates to BAU projections for HFC emissions.

Cost-Effective Measures with Significant Health Benefits

Significantly reducing SLCP emissions in line with the targets presented in this SLCP Strategy will continue California's long and successful legacy of implementing innovative and effective environmental and health policies while fostering the growth of a vibrant and sustainable economy. The proposed actions in this SLCP Strategy can contribute to health, environmental, and economic benefits that will positively impact Californian businesses and individuals. As California industry and households shift to cleaner technologies, many benefits will be concentrated in disadvantaged communities or other parts of the State most in need of economic development opportunities. The San Joaquin Valley, rural areas where wood smoke is a primary health concern, and communities along freight corridors are anticipated to see improvements in health as well as green job growth and environmental benefit.

Collectively, implementing these measures would bring thousands of jobs from several billion dollars of investment in clean technologies and strategies that would lead to significant reductions in SLCP emissions. Potential revenues and efficiency savings could also be significant—and potentially outweigh the costs of some measures. In particular, for projects that utilize organic waste to create transportation fuel, the value of Low Carbon Fuel Standard (LCFS) credits and RIN credits from the federal Renewable Fuel Standard can make these projects profitable. However, there remain market barriers that must be addressed, and continued incentives and State support can help to demonstrate and scale these strategies. In other cases, there may be net costs, but associated SLCP emission reductions may come at relatively low cost or provide other environmental and health benefits. For example, strategies at dairies that may not include energy production and associated revenues can still reduce emissions at low cost, and may deliver other environmental benefits, as well. And the collection of HFC measures identified in this SLCP Strategy could significantly reduce GHG emissions through 2030 at a very low cost per tonne.

Achieving the targets identified in this SLCP Strategy would help reduce ambient levels of ozone and particulate matter, and the cardiovascular and respiratory health effects associated with air pollution. These and other health benefits can be maximized as part of an integrated approach to ensure that strategies used to reduce SLCP emissions also help to improve air quality and water quality on a regional basis. Many of these benefits would accrue in disadvantaged communities, which are often located near sources of SLCP emissions.

The proposed actions are supported through an integrated set of air quality and climate policies in the State, including the LCFS, Bioenergy Feed-In-Tariff, utility investments to defray the costs of connecting renewable natural gas supplies to the pipeline, and direct investments from State funds. Together, and with additional targeted State support, we can meet the goals identified in this SLCP Strategy and capture additional economic, environmental and health benefits.

Putting the Strategy into Action

SB 1383 requires ARB to begin implementing the SLCP Strategy by January 1, 2018, as well as stipulates timeframes for other requirements (Table 3). All regulatory measures developed pursuant to the SLCP Strategy would undergo a complete, public rulemaking process including workshops, and economic and environmental evaluations. While this SLCP Strategy is intended to be comprehensive, it is not exhaustive. We will continue to pursue new cost-effective programs and measures as technology and research on SLCP emission sources and potential mitigation measures advances. Staff will track the progress of implementation of the SLCP measures and provide periodic updates to the Board. This information, as well as updates to the SLCP emission inventory, will be posted to ARB's SLCP website.

Table 3: Timeline for SB 1383 Mandates

Action	**Deadline**
ARB approves SLCP Strategy and begins Implementation Expected approval date Statutory deadline	 First Quarter 2017 By January 1, 2018
ARB, CDFA, State Water Resources Control Board and Regional Water Quality Control Boards in coordination with the energy agencies, will work with the dairy industry to establish a dairy workgroup to identify and address barriers to the collection and utilization of biomethane.	First Quarter 2017
ARB, in consultation with CPUC and CEC, develops policies to encourage development of infrastructure and biomethane projects at dairy and livestock operations	By January 1, 2018
ARB develops a pilot financial mechanism to reduce LCFS credit value uncertainty from dairy-related projects and makes recommendations to the Legislature to expand the mechanism to other biogas sources	By January 1, 2018
ARB provides guidance on the impact of regulations on LCFS credits and compliance offsets	By January 1, 2018
CPUC, in consultation with ARB and CDFA, directs utilities to develop at least 5 dairy biomethane pipeline injection projects	By January 1, 2018
CEC develops recommendations for the development and use of renewable gas as part of its 2017 Integrated Energy Policy Report	By early 2018
PUC renewable gas policies based on CEC IEPR	Ongoing
ARB, in consultation with CDFA, evaluates the feasibility of enteric fermentation methane reduction incentives and regulations and develops regulations as appropriate	Ongoing

Action	Deadline
ARB, in consultation with CDFA, analyzes and reports on the methane reduction progress of the dairy and livestock sector	By July 1, 2020
CalRecycle, in consultation with ARB, evaluates progress towards meeting the 2020 and 2025 organics waste reduction goals, the status of organics markets and barriers, and recommendations for additional incentives	By July 1, 2020
CalRecycle adopts an organics disposal reduction regulation	2018
CalRecycle implements an organics disposal reduction regulation	On or after January 1, 2022
ARB begins developing and considers for adoption a manure management methane reduction regulation	Before January 1, 2024
ARB implements a manure management methane reduction regulation	On or after January 1, 2024

Effectively implementing this SLCP Strategy will require working with local, regional, federal and international partners, and strategically investing time and money to overcome market barriers that hinder progress. The extent to which we do so will drive results, which can include a wide range of significant economic and environmental benefits for California broadly, and many of the State's most disadvantaged communities, specifically.

Implementing the SLCP Strategy will also require overcoming barriers to connecting distributed electricity, generated from renewable natural gas (RNG), to the grid and injecting renewable natural gas into the pipeline. To address these obstacles, SB 1383 calls for ARB to establish energy infrastructure development and procurement policies needed to encourage dairy biomethane projects and calls on the CPUC to direct gas companies to implement no fewer than five dairy biomethane pilot projects to demonstrate interconnection to the common carrier pipeline system. The same issues also apply to organic waste biomethane projects. On a broader scale, SB 1383 requires CEC to develop recommendations for the development and use of renewable gas as a part of its 2017 Integrated Energy Policy Report. Based on CEC's recommendations, State agencies will strive to meet the State's climate change, renewable energy, low carbon fuel, and SLCP goals by considering and adopting policies and incentives to significantly increase the sustainable production and use of renewable gas. CPUC will consider additional policies to support the development and use in-State of renewable gas that reduces SLCPs. These policies shall prioritize fuels with the greatest GHG emission benefits, taking into account RNG carbon intensity and reductions in SLCP emissions.

Finally, the State will only realize the full benefits of strong action to reduce SLCP and CO_2 emissions if others take committed action, as well. Strong, near-term action to cut emissions of SLCPs, in conjunction with immediate and continuous reductions in emissions of CO_2, is the only way to stabilize global warming below $2^{o}C$. Accordingly, California has signed a number of agreements to work together with other countries, including China and Mexico, to support actions to fight climate change and cut air pollution. Additionally, California is bringing together subnational jurisdictions under the Subnational Global Climate Leadership Memorandum of Understanding (the “Under 2 MOU”), which commits signatories to take steps to reduce SLCP and CO_2 emissions and meet the goal of keeping global average warming below the $2^{o}C$ threshold by reducing their GHG emissions to under 2 metric tons per capita, or 80–95 percent below 1990 levels, by 2050. To date, a total of 165 jurisdictions have signed or endorsed the Under 2 MOU, collectively representing more than one billion people and nearly $26 trillion in GDP, equivalent to 35 percent of the global economy.[2] As it implements the actions identified in this SLCP Strategy and other related climate change planning efforts, California will continue to share its successes and approach with others, to expand action to address climate change and deliver local and global benefits for the State.

[2] http://under2mou.org/

I. Introduction: Showing the Way to 2°C

California must achieve deep reductions in short-lived climate pollutant (SLCP) emissions by 2030 to help avoid the worst impacts of climate change and meet air quality goals. Additionally, intensified, global action to reduce these emissions is the only practical way to immediately slow global warming and is necessary to keep warming below 2°C through at least 2050, which is a critical threshold to manage the damaging effects of climate change. A broad scientific consensus has emerged, based on extensive research, that a 2°C (3.6°F) increase in global average temperature above pre-industrial levels poses severe risks to natural systems and human health and well-being. This is an increase of only 1.1°C (2.0°F) above the present level. Even a slight increase in global warming would lead to significant sea level rise, and the overall impact from climate change would be substantially greater if global warming exceeds 2°C. Strong, near-term action to cut emissions of SLCPs, in conjunction with immediate and continuous reductions in emissions of carbon dioxide (CO_2), is the only way to stabilize global warming below 2°C.

In December 2015, at the 21st Conference of Parties (COP21), 25,000 delegates from 196 countries gathered recognizing that "climate change represents an urgent and potentially irreversible threat to human societies and the planet and thus requires the widest possible cooperation by all countries, and their participation in an effective and appropriate international response, with a view to accelerating the reduction of global greenhouse gas emissions." An agreement was reached to substantially reduce GHG emissions with the aim of limiting a global temperature increase to below 2°C, mobilize investments to support low-carbon development, and create a pathway for long-term de-carbonization. Additionally, the agreement aims to strengthen the ability to deal with the impacts of climate change.

Short-lived climate pollutants, including methane (CH_4), black carbon (soot), and fluorinated gases (F-gases, including hydrofluorocarbons, or HFCs), are among the most harmful to both human health and global climate. They are powerful climate forcers that remain in the atmosphere for a much shorter period of time than longer-lived climate pollutants, including CO_2, which is the primary driver of climate change. Their relative climate forcing, when measured in terms of how they heat the atmosphere, can be tens, hundreds, or even thousands of times greater than that of CO_2. Short-lived climate pollutants contribute about 40 percent to current anthropogenic global radiative forcing, which is the primary forcing agent for observed climate change. [3,4,5,6,7]

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[3] Calculation based on IPCC AR5 WGI Chapter 8. https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf

[4] Ramanathan V, Xu Y. The Copenhagen Accord for limiting global warming: criteria, constraints, and available avenues. Proceedings of the National Academy of Sciences of the United States of America. 2010;107 (18):8055–8062. [PMC free article]

[5] IGSD (2013) Primer on Short-Lived Climate Pollutants, Institute for Governance and Sustainable Development, February 2013. http://igsd.org/documents/PrimeronShort-LivedClimatePollutantsFeb192013.pdf

California has taken significant steps to reduce SLCP emissions, especially black carbon from transportation, methane from oil and gas operations and landfill emissions, and HFC emissions from refrigerants, insulating foams, and aerosol propellants. Still, more can and must be done to reduce emissions from these and other sources in the State, including methane from waste management and dairies, black carbon from off-road and non-mobile sources, and HFC emissions from refrigeration and air conditioning systems.

The State is committed to further reducing SLCP emissions. SLCP emission reductions are important, first of all, to continuing and maintaining the GHG emission reductions called for by AB 32 and SB 32, and to ensuring emissions meet the statewide GHG emission limits as codified. This SLCP Strategy is identified in the First Update to the Climate Change Scoping Plan as one of the recommended actions to achieve additional GHG emission reductions. Growing SLCP emissions (such as from fluorinated gases) threaten to erode the State's progress towards this limit; in other sectors (such as from oil and gas and agriculture) continued emissions will put increased pressure on the remainder of ARB's regulatory structure to maintain overall emissions below the GHG limit and to continue reductions. Conversely, addressing SLCP emissions will help to ensure that the statewide GHG limits are maintained, and will fulfill AB 32's mandate to continue to seek the maximum technologically feasible and cost-effective reductions of GHG emissions. Reducing these powerful climate-forcers early also produces a compound-interest effect through which the effectiveness of future reductions are magnified: those future reductions start from a baseline substantially lower than where they would have started in the absence of aggressive early reduction efforts. The Legislature directly recognized the critical role that SLCPs must play in the State's climate efforts with the passage of two bills: Senate Bill 605 (Lara, Chapter 523, Statutes of 2014), which requires the Air Resources Board (ARB or Board) to develop a strategy to reduce SLCP emissions; and Senate Bill 1383 (Lara, Chapter 395, Statutes of 2016), which requires the Board to approve and begin implementation of the SLCP Strategy by January 1, 2018, and sets 2030 reduction targets for SLCPs emissions.

Significant reductions in SLCP emissions can be achieved globally using cost-effective technologies and strategies, some of which have already been demonstrated effectively in California. Over the past several decades, the State's efforts in controlling these harmful emissions have prevented thousands of premature deaths in California, saved the State many tens of billions of dollars in energy and health costs, and have occurred

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[6] Akbar, Sameer; Ebinger, Jane; Kleiman, Gary; Oguah, Samuel. 2013. *Integration of short-lived climate pollutants in World Bank activities: a report prepared at the request of the G8*. Washington DC ; World Bank. http://documents.worldbank.org/curated/en/2013/06/18119798/integration-short-lived-climate-pollutants-world-bank-activities-report-prepared-request-g8
web.stanford.edu/group/efmh/jacobson/Articles/VIII/BCClimRespJGR0710.pdf

[7] Molina M, Zaelke D, Sarma KM, Andersen SO, Ramanathan V, Kaniaru D. Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO2 emissions. *Proceedings of the National Academy of Sciences of the United States of America*. 2009;106(49):20616-20621. doi:10.1073/pnas.0902568106.
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2791591/

alongside strong economic growth throughout our diverse economy. Applying California's experiences to reduce SLCP emissions globally would help prevent millions of premature deaths each year; boost agricultural productivity; limit disruption of historic rainfall patterns; slow the melting of glaciers, snowpack, and sea ice; reduce sea level rise; and provide trillions of dollars in economic benefits each year.

A. Significant Benefits from Accelerated Action to Cut SLCP Emissions

While reducing CO_2 emissions limits climate change over the long term, reducing emissions of SLCPs will effectively slow the rate of climate change in the near-term. Therefore, the best path forward is to emphasize parallel strategies for reducing SLCP and CO_2 emissions.[8,9] Studies indicate that available technologies, if universally adopted, can effectively reduce global methane emissions an estimated 40 percent and black carbon an estimated 80 percent relative to a "reference" scenario by 2030.[10,11] Additionally, a new proposed global phase down of HFCs under the Montreal Protocol that was adopted in October 2016, is expected to cut the production of HFCs by up to 70 percent by 2030, and up to 85 percent by 2036 in developed countries including the U.S.[12,13]

Achieving this scale of global reductions would deliver significant climate benefits. It would cut the expected rate of global warming in half by 2050, slowing global temperature rise by about $0.6^{o}C$,[14,15] which would reduce the risk of dangerous climate

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[8] Shoemaker, J K; Schrag, D P; Molina, M J; Ramanathan, V (2013) What Role for Short-Lived Climate Pollutants in Mitigation Policy? Science 342 (6164) 1323-1324

[9] Rogelj, J, Schaeffer M, Meinshausen M, Shindell D, Hare W, Klimont Z, Velders G, Amann M, Schellnhuber HJ. 2014. Disentangling the effects of CO2 and short-lived climate forcer mitigation. Proceedings of the National Academy of Sciences (PNAS). http://www.pnas.org/cgi/doi/10.1073/pnas.1415631111

[10] UNEP (2014) Time to Act (To Reduce Short-Lived Climate Pollutants), The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, United Nations Environment Programme, Second Edition, May. http://www.unep.org/ccac/Publications/Publications/TimeToAct/tabid/133392/Default.aspx

[11] UNEP and WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone, United Nations Environment Programme and World Meteorological Association. http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_report.pdf

[12] UNEP (2016). United Nations Environment Programme (UNEP). Further Amendment of the Montreal Protocol submitted by the Contact Group on HFCs. 14 October 2016. http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=27086&ArticleID=36283&l=en

[13] IGSD (2016) Institute for Governance and Sustainable Development (IGSD) "Nations Agree to Kigali Amendment: Largest Near-Term Temperature Reduction from Single Agreement", 15 October 2016. http://www.igsd.org/nations-agree-to-kigali-amendment-largest-near-term-temperature-reduction-from-single-agreement/.

[14] Ramanathan V, Xu Y. The Copenhagen Accord for limiting global warming: criteria, constraints, and available avenues. Proceedings of the National Academy of Sciences of the United States of America. 2010;107 (18):8055–8062. [PMC free article]

[15] UNEP (2014) Time to Act (To Reduce Short-Lived Climate Pollutants), The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, United Nations Environment Programme, Second Edition, May. http://www.unep.org/ccac/Publications/Publications/TimeToAct/tabid/133392/Default.aspx

feedbacks such as accelerated Arctic melting and sea level rise.[16] It would also increase the probability of staying below the 2^{o}C threshold to more than 90 percent through 2050.[17,18]

The benefits could be even greater in the Arctic, which is especially vulnerable to black carbon emissions and is warming twice as fast as the rest of the world.[19] Slowing climate change impacts in the Arctic could be critically important for stabilizing climate change and its impacts, as the Arctic is an important driver of sea level rise and weather patterns throughout the Northern Hemisphere.[20,21] Reducing emissions of SLCPs can slow down the rate of sea level rise by 24–50 percent this century, if efforts to reduce emissions begin now. Mitigating emissions of both CO_2 and SLCPs can reduce the projected sea level rise rate by 50–67 percent by 2100.[22]

Deploying existing, cost-effective technologies to reduce SLCP emissions can also cut global emissions of fine particulate matter (PM2.5) by an estimated 50 percent, oxides of nitrogen (NO_x) emissions by 35 percent, and carbon monoxide (CO) emissions by 60 percent.[23] If these measures were fully in place by 2030, an estimated 3.5 million premature deaths and 53 million metric tons of crop losses could be avoided globally, each year. The economic value of these climate, crop, and health benefits is estimated to be about $5.9 trillion annually.[24] Most of these benefits would accrue in the developing world and places where disproportionate climate impacts are already being felt.

Many of the benefits of cutting SLCP emissions in California will accrue in the most disadvantaged parts of the State, where pollution levels and their health impacts are

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[16] UNEP and WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone, United Nations Environment Programme and World Meteorological Association. http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_report.pdf

[17] Ramanathan, V. and Yangyang Xu (2010) The Copenhagen Accord for Limiting Global Warming: Criteria, Constraints, and Available Avenues, *Proceedings of the National Academies of Sciences* **107** (18), pp.8055-8062. http://www.pnas.org/content/107/18/8055

[18] Xu, Y., D. Zaelke, G. J. M. Velders, and V. Ramanathan (2013), The role of HFCs in mitigating 21st century climate change, *Atmos. Chem. Phys.,* 13(12), 6083–6089

[19] Quinn et al (2008) Short-lived pollutants in the Arctic: Their impact and possible mitigation strategies, *Atmospheric Chemistry and Physics* **8**, 1723-1735. http://www.atmos-chem-phys.net/8/1723/2008/acp-8-1723-2008.html

[20] Francis, J. A. and S. J. Vavrus. 2012. Evidence linking Arctic amplification to extreme weather in mid-latitudes. Geophysical Research Letters 39.

[21] Screen, J. A. and I. Simmonds. 2013. Exploring links between Arctic amplification and mid-latitude weather. Geophysical Research Letters 40(5):959-964.

[22] Hu, A., Y. Xu, C. Tebaldi, W. M. Washington, and V. Ramanathan (2013), Mitigation of short-lived climate pollutants slows sea-level rise *Nature Climate Change* 3(5), 1–5, doi:10.1038/nclimate1869

[23] UNEP and WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone, United Nations Environment Programme and World Meteorological Association. http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_report.pdf

[24] Shindell et al. (2012) Simultaneously Mitigating Near-Term Climate Change and Improving Human Health and Food Security, *Science* **335**, 183 (2012). http://www.sciencemag.org/content/335/6065/183

often highest, and where further economic development may be most needed. For example:

- Further cutting black carbon emissions from the transportation sector and building a sustainable freight system would have health and economic benefits for communities in the East Bay, Southern California, and the Inland Empire along freight corridors and near ports and rail yards where diesel particulate matter concentrations are highest.
- Investments to cut methane and black carbon emissions as part of an integrated strategy to reduce emissions from agriculture and waste can provide important benefits for the Central Valley and other agricultural communities. They can help build an increasingly resilient and competitive agricultural sector by supporting jobs and economic growth, healthy soils, and improved air quality, water quality, and public health in those communities.
- Switching to low-GWP refrigerants can also improve the energy efficiency of refrigeration and air conditioning equipment, which can help to cut electricity bills throughout the State.

B. Building on California's Air Quality and Climate Leadership

California's ongoing efforts to improve air quality and address climate change have already led to important reductions in SLCP emissions, and they provide a strong foundation to support further efforts to reduce emissions of these dangerous pollutants.

- *Black carbon*: California has cut anthropogenic sources of black carbon emissions by more than 90 percent since the 1960s. From 2000 to 2020, California will have cut black carbon from mobile sources by 75 percent. These efforts prevent an estimated 5,000 premature deaths in the State each year, and deliver important climate benefits. If the world replicated this success, it would slow global warming by an estimated 15 percent,[25] essentially offsetting one to two decades' worth of CO_2 emissions.[26]
- *Methane*: California has the nation's strongest standards for limiting methane emissions from landfills, has offset protocols under our Cap-and-Trade Program to encourage the reduction of methane emissions, and has rules under development and being implemented to create a comprehensive approach to limit methane leaks from the oil and gas production, processing, and storage sector, and the natural gas pipeline system. These efforts are serving to keep methane emissions fairly steady in the State.

[25] Ramanathan et al (2013) Black Carbon and the Regional Climate of California, Report to the California Air Resources Board, Contract 08-323, April 15. http://www.arb.ca.gov/research/single-project.php?row_id=64841

[26] Wallack, J. and Veerabhadran Ramanathan (2009) The Other Climate Changers: Why Black Carbon and Ozone Also Matter, *Foreign Affairs*, September/October 2009, pp. 105-113. https://www.foreignaffairs.com/articles/2009-09-01/other-climate-changers

- *HFCs*: The State has regulations in place to reduce emissions from refrigerants, motor vehicle air-conditioning, and consumer products that together are expected to cut emissions of HFCs by 25 percent below otherwise projected levels in 2020.

Still, more remains to be done. California is home to some of the highest levels of air pollution in the country, and although the State has substantially reduced particulate matter and black carbon emissions from on-road transportation, vehicles still pollute the air in our communities and harm the lungs of some of our most vulnerable populations. Global methane emissions are responsible for about 20 percent of current global warming, [27] and its emissions continue to increase. F-gases, specifically HFCs, are the fastest growing source of GHG emissions in California and globally.

C. Purpose of SLCP Reduction Strategy

The State is committed to further reducing SLCP emissions. The 2014 Update to the Climate Change Scoping Plan (2014 Scoping Plan Update) identified SLCPs as an important aspect of a comprehensive approach to addressing climate change. In September 2016, the Legislature passed and Governor Brown signed SB 32 (Pavley, Chapter 249, Statutes of 2016), which codifies an earlier Executive Order, and reinforces direction already in AB 32 by requiring statewide GHG emissions to be reduced to 40 percent below 1990 emission levels by 2030. Specific to SLCP emission reductions, Senate Bill 605 requires ARB to develop a plan to reduce emissions of SLCPs, and Senate Bill 1383 requires the Board to approve and begin implementation of the SLCP Strategy by January 1, 2018, and sets SLCP emission reduction targets for 2030 that are in-line with the 40 percent reductions called for in SB 32.

Senate Bill 605 (Appendix A), requires ARB to develop a comprehensive strategy, in consultation with other State agencies and the air districts, to reduce emissions of SLCPs in the State, including completing an inventory of SLCPs in the State, identifying research gaps, identifying existing and potential new control measures to reduce emissions, and prioritizing the development of new measures for SLCPs that offer co-benefits.

Senate Bill 1383 (Appendix B) requires ARB to approve and begin implementing the SLCP Strategy by 2018, codifies the statewide SLCP emission reduction targets that were in earlier versions of the SLCP Strategy, provides specific direction for reductions from dairy and livestock operations and from landfills by diverting organic materials, requires actions to support in-State production and use of renewable natural gas, and stipulates guidelines and analyses that will shape the implementation of this SLCP Strategy.

ARB developed this revised proposed SLCP Reduction Strategy (SLCP Strategy) pursuant to SB 605 and SB 1383, in coordination with other State agencies and local air

[27] Kirschke, S. *et al.* (2013) Three decades of global methane sources and sinks. *Nature Geosci.* **6**, 813–823. http://www.nature.com/ngeo/journal/v6/n10/full/ngeo1955.html?WT.ec_id=NGEO-201310

quality management and air pollution control districts. The SLCP Strategy has been developed with input from interested stakeholders in an open and public process and describes a strategy for California to reduce emissions of SLCPs through 2030. It describes ongoing and potential new measures to reduce SLCP emissions from all major sources in the State, and describes current and future research needs for improving the SLCP emission inventory and better understanding potential mitigation measures. California's SLCP emission inventory[28] and current and future research needs are included in Appendix C, and research efforts to evaluate potential mitigation measures for each SLCP is included in Appendix D.

Measures included in this SLCP Strategy will be developed under future public regulatory processes with the appropriate public process, economic analyses, environmental analyses, and consideration of environmental justice. ARB's rulemaking process includes extensive stakeholder input. California law and policy require a careful, deliberative process when regulations are being developed, that includes extensive review and analysis of economic and environmental impacts as required by the Administrative Procedure Act (APA) and California Environmental Quality Act (CEQA). SB 1383, and SB 605 also make clear that ARB is to carefully consider such matters, including potential effects on compliance with state programs to reduce criteria pollutants, potential interactions with other environmental challenges, the risk of leakage (a reduction in GHG emissions within the State that is offset by an increase in out of State GHG emissions), and impacts on disadvantaged communities.

D. Achieving Science-Based Targets

SB 1383 sets statewide SLCP emission reduction targets of 40 percent below 2013 levels by 2030 for methane and HFCs, and 50 percent below 2013 levels by 2030 for anthropogenic black carbon emissions, codifying the proposed targets included in earlier versions of this Strategy. For purposes of this SLCP Strategy, anthropogenic black carbon emissions do not include forest-related sources (wildfires and prescribed burning). The emission reductions associated with these targets are translated into millions of metric tonnes of CO_2-equivalent ($MMTCO_2e$) in Table 4.

[28] Inventory methodology and detailed inventory tables available at: http://www.arb.ca.gov/cc/inventory/slcp/slcp.htm

Table 4: California SLCP Emissions and Emission Reduction Target Levels (MMTCO2e)*

Pollutant	2013	2030 BAU**	2030 Emission Reduction Target (percent reduction from 2013)
Black carbon (anthropogenic)	38	26	19 (50%)
Methane	118	117	71 (40%)
Hydrofluorocarbons (HFCs)	40	65	24 (40%)

*Using 20-year GWPs from the 4th Assessment report of the IPCC for methane and HFCs, and 5th Assessment report for black carbon (the first report to define a GWP for black carbon)
**Business As Usual (BAU) forecasted inventory includes reductions from implementation of current regulations

The measures identified in this SLCP Strategy and their expected emission reductions will feed into the update to the Climate Change Scoping Plan that is currently being developed. The 2030 Target Scoping Plan Update will establish a broad framework for meeting all of California's climate-related targets and will include an evaluation of all proposed GHG reducing activities, for both short-lived and longer-lived pollutants.

Throughout this SLCP Strategy, there is an emphasis on early actions, often supported by public investments and strong policy incentives. This approach is intended to achieve earlier reductions (in the 2020 timeframe), bring projects online quickly, and help scale sector-wide solutions while potential regulatory or other measures to reduce SLCP emissions are developed. By supporting early action through investments and commitments to overcome barriers, we can maximize benefits throughout California, while minimizing the impact of future regulations on businesses in these sectors.

Together with California's previous efforts to successfully reduce black carbon and other SLCP emissions, implementing the measures identified in this SLCP Strategy to meet these targets would put California on the path to meet the State's 2030 climate goals, while delivering significant agricultural, air quality, economic, health, water, and other climate co-benefits.

E. Coordinating Research Efforts Related to SLCPs

Many California State agencies sponsor climate-related research. State-sponsored climate research, including research related to SLCPs, has been guided by the needs identified in state laws, Executive Orders, and other policy documents, as well as the best and latest science.

Since 2008, the Climate Action Team Research Working Group (CATRWG) has provided a forum for State agencies to discuss and coordinate their proposed research activities. The CATRWG also facilitates coordination with external groups including academia, federal agencies, the international community, and private entities.

Integration and coordination with non-state sponsored research programs is important to leverage State resources and to provide coherent and practical research results for California.

To support these efforts, the CATRWG has created a catalog of relevant research projects supported by the State since the early 2000s.[29] The catalog keeps State agencies and interested stakeholders informed about the range of activities and the status of individual projects. The catalog includes a number of projects related to the impacts of SLCPs on regional climate in California, research underway to enhance SLCP inventories, and evaluations of SLCP mitigation strategies.

In 2015, the CATRWG released a Climate Change Research Plan for California.[30] The Plan synthesizes the knowledge gaps, and presents research priorities for the next three to five years for policy-relevant, California-specific research. It includes research needs related to the mitigation of SLCPs and specific needs to improve SLCP inventories. The Plan outlines these research needs in order to inform the State's ongoing activities without duplicating federal research activities. This is an unprecedented effort resulting in the first comprehensive climate change research plan developed by any state. The CATRWG will update the Plan every other year, with major revisions every four years. Research related to SLCPs will continue to be a priority in these updates.

Future State-sponsored research will be guided by recommendations in the CATRWG Research Plan, as well as other documents such as this SLCP Strategy. State agencies will continue to leverage funding and avoid duplication of effort through coordination in CATRWG meetings. State agencies that sponsor research will also continue their individual efforts to align future research needs with input from stakeholders, academic experts and other public and private research entities.

F. Process for Developing the SLCP Reduction Strategy

This SLCP Strategy was developed with input from State and local agencies, academic experts, a working group of agricultural experts and farmers convened by CDFA, and other interested stakeholders in an open and public process. ARB and State agencies collaborated to identify reduction measures for specific sectors, including the dairy, wastewater, and waste sectors. In addition, ARB collaborated with the

Gas monitoring probe at an unnamed state landfill.

[29] California's State-sponsored Research Catalog: http://cal-adapt.org/research/
[30] Climate Change Research Plan for California (2015) http://www.climatechange.ca.gov/climate_action_team/reports/CAT_research_plan_2015.pdf

local air districts to identify SLCP emission reduction measures that could be implemented through district action, such as residential wood burning incentive programs

ARB released for public review, a Concept Paper for the SLCP Strategy in May 2015, a Draft SLCP Reduction Strategy in September 2015, and a Proposed Strategy and an accompanying draft Environmental Analysis (EA) in April 2016. Staff reported to the Board on the Proposed Strategy in May 2016.

With the enactment of SB 1383, ARB took a fresh look at the SLCP Strategy and is re-issuing it in a revised form. Accordingly, this revised Proposed SLCP Reduction Strategy, which incorporates requirements of SB 1383, was released in November 2016. Additionally, ARB revised the Draft Environmental Analysis (EA) that was initially released for review on April 11, 2016, to address changes that were made to the SLCP Strategy (Appendix E). Since the entire Draft EA has been substantially revised and is being recirculated for a new 45-day public comment period, new comments must be submitted on the Revised Draft EA, and ARB will respond only to those comments received on the recirculated Revised Draft EA. Staff will hold public workshops to solicit public input on the revised SLCP Strategy and Revised Draft EA by the end of 2016. The Final SLCP Strategy, the final EA, and written responses to comments received on the Revised Draft EA will be presented to the Board for consideration at a public hearing in early 2017.

II. California's Approach to Reducing SLCP Emissions

The 2014 Scoping Plan Update described California's approach to climate change as one reliant on science and foundational research. The Update focused on: preserving natural resources that provide for our economy and define our lifestyle in California, fostering resilient economic growth throughout the State, improving public health, and supporting economic, social and environmental justice. The State's commitment to addressing climate change and public health is born of necessity, but provides tremendous opportunity to build competitiveness and resilience into our communities, resources, and economy. We understand that steps we take to reduce emissions and strengthen our State against the impacts of climate change provide economic opportunities today, and untether our future potential from limits imposed by resource constraints and pollution.

This approach continues to guide us as we focus on reducing emissions of SLCPs to meet the targets in this SLCP Strategy, as well as other requirements in SB 1383 and SB 605. Additionally, California's approach to reducing SLCP emissions is framed by the principles described below.

A. Prioritize Actions with Diverse Benefits

The direct benefits of cutting SLCP emissions will be immediately tangible, and can be substantial. As part of an integrated strategy to not only reduce emissions of SLCPs, but also to develop renewable sources of energy and strengthen the competitiveness and resiliency of our agricultural, waste, and other sectors, they can deliver even greater benefits, including:

- Reduced asthma risk, hospitalization, premature death, and associated medical costs from air pollution, especially in disadvantaged communities;
- Reduced global and localized climate change impacts, including sea level rise and disrupted precipitation patterns, and associated costs;
- Reduced crop losses from air pollution;
- Healthy soils that are more sustainable and resilient to climate change, sequester GHGs, require less synthetic amendments, and improve water retention;
- The creation of a new industry, mostly in rural parts of the State and the Central Valley, around utilizing organic waste streams to generate renewable energy, fuels, and compost—bringing billions in investment; and
- Stronger agricultural and freight sectors that are well positioned to continue competing globally and growing as a source of jobs and economic development in California.

Clearly, there are a number of drivers and benefits to reducing SLCP emissions that extend beyond mitigating the impacts of climate change. The measures identified in this SLCP Strategy are intended to provide a wide array of climate, health, and economic benefits throughout the State. As they are further developed and implemented, a key focus will be to provide and maximize multiple benefits.

B. Put Organic Waste to Beneficial Use

California's organic waste streams are responsible for half of the State's methane emissions and represent a valuable energy and soil-enhancing resource. Effectively implementing the measures described in this SLCP Strategy will not only reduce methane emissions but provide many other benefits as well, including cutting emissions of CO_2 and boosting economic growth in agricultural and rural communities.

Building infrastructure to better manage organic waste streams could lead to billions of dollars of investment and thousands of jobs in the State.[31,32] This infrastructure could provide valuable new sources of renewable electricity or biogas, clean transportation fuels, compost as well as other beneficial soil amendments, and other products. Adopting state policies to promote biogas from organic waste would provide a strong durable market signal to industry, agencies, and investors. In addition, this biogas can help the State meet its 33 percent renewable mandate for hydrogen transportation fuel. The State's new 50 percent renewable portfolio standard may drive renewable hydrogen production even higher. SB 1383 requires CEC, CPUC, and ARB to develop policies to support the development and use of in-state renewable natural gas to support dairy and other biomethane project developments. It also requires CalRecycle, in consultation with ARB, to adopt regulations to achieve the landfill organics disposal reduction goals, assess progress towards meeting those goals, to conduct a product markets analysis and identify project barriers to best use biomethane (pipeline and grid connections, products, etc.), and to make recommendations for additional policies if warranted.

Covered dairy digester lagoon

Collectively, products from organic waste streams in California, and potential environmental credits from them, could represent a market worth billions of dollars in California.

Utilizing clean technologies to put organic waste streams to a beneficial use can also serve to improve regional air and water quality and support economic growth in agricultural and other communities throughout the State. For example, most dairies in California currently store manure in

[31] Kaffka et al (2011) Economic, Social, and Environmental Effects of Current and Near-term Biomass Use in California, California Biomass Collaborative, University of California, Davis. http://biomass.ucdavis.edu/publications/

[32] Due to its large dairy industry, California likely represents more than its share of the estimated 11,000 potential new biogas systems that could be built in the U.S. and the associated $33 billion in capital deployment, 275,000 short-term construction jobs, and 18,000 permanent jobs.
USDA, USEPA, USDOE (2014) Biogas Opportunities Roadmap: Voluntary Actions to Reduce Methane Emissions and Increase Energy Independence.
http://www.usda.gov/oce/reports/energy/Biogas_Opportunities_Roadmap_8-1-14.pdf

uncovered lagoons and use lagoon water to fertilize on-site forage crops. This approach to managing manure has helped to improve the efficiency of dairy farms and milk production over the years. However, these lagoons also create one of the largest sources of methane emissions in the State, and—when combined with imprecise or improper land application of nutrients, water, and salts via flood irrigation of lagoon effluent—can create adverse groundwater and nutrient management issues on farms. Alternatively, manure can be managed in a way to reduce or avoid methane emissions and open up opportunities for improving farm nutrient management activities. For composting, utilizing clean technologies such as aerated static piles results in reduced emissions of volatile organic compounds at the compost facilities, as well as GHG emission reductions in the form of avoided landfill emissions and realization of co-benefits such as increased soil health when the compost product is applied to soils.

In order to capture the entire potential value from California's waste resources, significant amounts of infrastructure remain to be built and markets must be fully enabled. Barriers remain to achieving these wide-ranging economic and environmental benefits, and must be addressed.

C. Identify Practical Solutions to Overcome Barriers

Maximizing the diverse benefits of putting organic waste streams to beneficial uses will require overcoming barriers that have hindered such efforts in the past. Barriers affect many parts of the supply and marketing chain, including feedstock, technology, market/economics, permitting, technical feasibility, infrastructure, logistics, and user behavior.

For example, inexpensive and abundant landfill capacity may make diverting organic material relatively costly in some cases. Developing projects to generate renewable energy and soil amendments from this waste stream will require additional investments in clean technology and management practices, aligning economic incentives that currently favor landfilling with the State's objectives to put organic resources to better use, streamlining various governmental and utility permitting processes, and quantifying the co-benefits of using compost and incorporating that information into cross-media regulatory decisions.

Technology or market barriers also remain in some sectors. Interconnecting distributed sources of renewable energy onto the electricity grid, or biogas into pipelines, remains an unnecessarily long and costly process in many cases. Utilizing biogas in a conventional combustion engine to create electricity can exacerbate air quality problems in many parts of the State, including the Central Valley and Southern California. Clean engine and fuel options, or low-GWP refrigerants, are not available for all applications. Markets for compost and soil amendments need to be built out and strengthened, which would provide an important value stream for financing anaerobic digestion and compost facilities. Additional support and time may be needed to strengthen existing and emerging markets for renewable natural gas and fuels, soil amendments, and their associated environmental attributes.

These barriers are not insurmountable, however. As California develops a SLCP Strategy to reduce SLCP emissions and plans to meet its climate and air quality goals for 2030, now is the time to solve them. This SLCP Strategy identifies strategies and funding mechanisms to encourage the use of the cleanest technologies to advance the State's air quality, water quality, climate change, and other environmental objectives. Solutions that address several environmental concerns—air quality, climate, and water quality—and can be easily financed, are clear winners. SB 1383 requires ARB, CalRecycle, and CDFA to work with stakeholders to identify and address technical, market, regulatory and other challenges to putting California's waste resources, including diverted landfill organics and dairy manure, to beneficial use.

Several existing programs already provide incentives to convert waste streams to various forms of energy, which can be leveraged along with new efforts to increase the share of renewable biogas used in California buildings, industry, and transportation. For example, the LCFS and federal Renewable Fuel Standard provide strong economic incentives to utilize organic waste resources for production of transportation fuels. At current LCFS and RIN credit prices, anaerobic digestion projects that generate transportation fuels at dairies, wastewater treatment plants, or elsewhere can be self-sustaining (see Chapter VIII). In order to enable this market, however, barriers to pipeline injection of biogas, among others, must be addressed. The CPUC has authorized an incentive program, capped at $40 million in total, to offset half of renewable natural gas interconnection costs of individual projects. AB 2313 (Williams, Chapter 531, Statues of 2016) raised the incentives cap on dairy cluster projects to $5 million and on other individual projects from $1.5 million to $3 million. State agencies are already collaborating to overcome barriers to pipeline injection of biogas, pursuant to the Governor's call to make heating fuels cleaner,[33] and they will redouble their efforts. This includes monitoring market progress pursuant to Assembly Bill 1900 (Gatto, Chapter 602, Statutes of 2012) and considering appropriate adjustments, as needed. Additional research regarding constituents of concern in biomethane produced from different feedstocks may lead to refinements in testing requirements for pipeline injection and associated cost savings. Also, supplemental policy options to accelerate biogas projects and access to the pipeline will be considered, including steps that utilities can take, options to accommodate varying heat rates of pipeline gas in certain instances, and potential new policies like a feed-in-tariff for renewable natural gas.

Dairy manure separator

SB 1383 places biomethane development requirements on ARB, CPUC, and CEC. By January 1, 2018, ARB is to establish energy

[33] https://www.gov.ca.gov/news.php?id=18828

infrastructure development and procurement policies needed to encourage dairy biomethane projects. CPUC is required to direct gas companies to implement no fewer than five dairy biomethane pilot projects to demonstrate interconnection to the common carrier pipeline system. On a broader scale, SB 1383 requires CEC to develop recommendations for the development and use of renewable gas as a part of its 2017 Integrated Energy Policy Report, including identifying cost-effective strategies that are consistent with existing State policies, including the Renewable Portfolio Standard, LCFS, Cap-and-Trade, the State's waste diversion goals, and the SLCP Strategy. Based on CEC's recommendations, State agencies will strive to meet the State's climate change, renewable energy, low carbon fuel, and SLCP goals by considering and adopting policies and incentives to significantly increase the sustainable production and use of renewable gas. CPUC will consider additional policies to support the development and use in-State of renewable gas that reduces SLCPs. These policies shall prioritize fuels with the greatest GHG emission benefits, taking into account RNG carbon intensity and reductions in SLCP emissions.

Building market certainty and value for compost and other soil amendment products will also help to secure financing for projects to use organic waste and cut emissions of SLCPs. Soil amendments from organic waste streams in California represent a potential $200-400 million market in California, exceeding the likely value of energy products from the resource.[34] Efforts to increase composting and anaerobic digestion—and capture the diverse benefits from doing so—can be supported by efforts to promote and account for the benefits of using compost, manure, and other soil amendments that come from these processes. ARB, in cooperation with CalRecycle, has developed a quantification methodology to estimate GHG emission reductions from composting and anaerobic digestion projects funded through the Greenhouse Gas Reduction Fund (GGRF). ARB is also coordinating with CDFA, CalRecycle, and other agencies working on the Healthy Soils Initiative to identify additional research needs to inform the science and accounting methods necessary to quantify the benefits of using compost and other soil amendments and address any potential problems such as buildup of salts or heavy metals in soil. Collaboration among state agencies, water districts, and local governments will help quantify the benefits of using compost for urban storm water management, soil remediation, water conservation, and other beneficial uses.

D. Invest in SLCP Emission Reductions and Communities

Achieving significant reductions in SLCPs will require substantial investments to provide incentives and direct funding for priority sectors, sources, and technologies. Public investments should be smart and strategic, to leverage private investment and accelerate market transitions to cleaner technologies that foster significant system-wide solutions to cut emissions of SLCPs, maximize resource recovery from organic waste streams, and provide economic and health benefits in agricultural, disadvantaged, and rural parts of the State. Examples may include targeted support to reduce emissions of

[34] Informa Economics (2013) National Market Value of Anaerobic Digester Products, Prepared for the Innovation Center for U.S. Dairy, February.

SLCPs and CO_2 through integrated strategies at dairies and in organic waste management; throughout the freight system; in commercial refrigeration applications; and from the management of woody waste materials in agricultural and other sectors.

Many of the sources and sectors responsible for SLCP emissions are concentrated in communities with high levels of pollution or unemployment, which could especially benefit from targeted investments to improve public health and boost economic growth. These include SLCP emissions from sources of organic waste and dairies in the Central Valley; ports and freight corridors in the East Bay, Los Angeles area and Inland Empire; and oil production, landfills and other sources of SLCP emissions throughout the State. Many communities in these areas, along with rural communities in the northern part of the State and the Sierra, have some of the worst pollution burdens in the State, and high rates of poverty and unemployment. They are also where many billions of dollars in public and private investment will accrue in the coming years to reduce SLCP and CO_2 emissions and strengthen our agricultural sector and build sustainable freight systems.

Initial estimates regarding State support for infrastructure to meet the goals identified in this SLCP Strategy is similar for both the waste sector and dairy sector. CalRecycle and CDFA both estimate that direct State investments or incentives on the order of $100 million per year for five years could significantly scale project development to cut SLCP emissions associated with dairy manure and waste management. There could also be some opportunity to optimize investments and co-locate infrastructure or utilize existing infrastructure, including excess digestion capacity that exists at many wastewater treatment plants, which could potentially reduce the level of incentive funding needed to reach the targets outlined in this SLCP Strategy. Additional research and working group efforts will focus on opportunities to optimize infrastructure rollout and maximize benefit from any State investment.

The State will need to continue coordinating and utilizing funding sources, such as the Greenhouse Gas Reduction Fund (Cap-and-Trade auction proceeds),[35] the Alternative and Renewable Fuel and Vehicle Technology Program (AB 118), Electric Program Investment Charge (EPIC) Program, Carl Moyer program, Air Quality Improvement Program, and Proposition 39 to expand clean energy investments in California and further reduce emissions of SLCPs and other GHGs. Additionally, programs including the Bioenergy Feed-In Tariff, created by Senate Bill 1122 (Rubio, Chapter 612, Statutes of 2012), Low Carbon Fuel Standard, Cap-and-Trade, Self-Generation Incentive Program, Federal Renewable Fuel Standard, utility incentives pursuant to Assembly Bill 1900 (Gatto, Chapter 602, Statutes of 2012), and others provide important market signals and potential revenue streams to support projects to reduce SLCP emissions. These programs are described in more detail in Chapter VII.

[35] AB 1532 (Pérez, Chapter 807), SB 535 (De León, Chapter 830), and SB 1018 (Senate Budget Committee, Chapter 39) established the GHG Reduction Fund to receive Cap-and-Trade auction proceeds.

Potential new funding mechanisms and incentive structures must also be considered. These could include adjusting the waste disposal tipping fee and establishing a waste generator fee to account for the full cost of managing organic materials and landfills, state procurement contracts for renewable natural gas and other fuels in buildings or vehicles as well as for compost and mulch products in landscaping and erosion control, or labeling programs to recognize leading companies in the market place, including freight haulers using clean technologies.

E. Advance the Science of SLCP Sources and Emissions

Data related to SLCPs and their sources is often less available or of lower quality than it is for CO_2. One reason is that energy-related emissions of CO_2 are often easier to quantify than emissions of other GHGs, which may form through complex biological or other processes where existing reporting guidelines and procedures may not apply. There has also been less of a focus on collecting additional data that could help to quantify GHG emissions from some non-CO_2 sources.


Rooftop HVAC system

This SLCP Strategy, including Appendices C and D, describes several coordinated research efforts under way and potential new ones to provide a better understanding of methane emissions from the natural gas system and natural gas and oil supplied to California, dairy operations, landfills, as well as various sources of HFCs and black carbon emissions. Others not identified here also may be considered in the future.

For example, methane emissions are emitted from a wide range of biological processes and fugitive and area sources that make estimating emissions difficult. California's methane emission estimates are derived from a variety of surveys, government data sources, growth assumptions and modeling methodologies. ARB staff is continuously assessing ways to improve the methane inventory by incorporating the latest scientific understanding of methane sources, through coordinated research with other agencies, and by using the best available activity data. Additional research and improved data sources will be needed to continue to refine the methane inventory and provide California-specific activity data.

While improving data access and quality is not a prerequisite for many actions to reduce emissions of SLCPs, it is nonetheless important for informing ongoing efforts to reduce SLCP emissions and meet broader climate targets. Improved data and reliable GHG measurements from landfills, dairies, and other more difficult-to-measure sources would also be necessary before these sources could be potentially included in California's Cap-and-Trade Program. State agencies will continue to monitor technology development and support continued research to improve the accuracy and reliability of emissions accounting from these sources.

F. Need for Focused SLCP Programs

This SLCP Strategy outlines specific emission reduction measures that could reduce California's emissions of SLCPs. This reliance on direct regulations, in concert with the existing greenhouse gas Cap-and-Trade Program, is consistent with California's approach on addressing climate change. California has already adopted several direct measures that ensure GHG emission reductions are achieved in specific sectors, including for SLCPs (for example, the Refrigerant Management Program that regulates F-gas emissions). These types of requirements motivate focused change— such as increased deployment of renewable energy (Renewable Portfolio Standard) or transformation of transportation fuels (Low Carbon Fuel Standard)—which may be more readily realized through direct measures than sole reliance on the Cap-and-Trade Program.

The Cap-and-Trade Program covers combustion and process operations. These emissions can be measured according to the accuracy requirements of the Mandatory Greenhouse Gas Emissions Reporting Regulation, which includes accurate quantification methodologies that allow for consistent carbon costs,[36] and the sources align with those covered by federal reporting programs.[37] In contrast, most fugitive emissions[38] (a category into which SLCP emissions generally fall) do not meet these criteria.[39] They are frequently difficult to measure, measurements have high uncertainties,[40] measurement methods are often difficult and less precise,[41] and carbon costs are hard to assign with the same reliability as for combustion sources of CO_2.[42]

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[36] *California Air Resources Board (2011) California's Cap-and-Trade Program Final Statement of Reasons*, Response to Comment E-31, at pg. 425. available at http://www.arb.ca.gov/regact/2010/capandtrade10/fsor.pdf.

[37] *Id.*, Response to Comment E-69, at pg. 448. available at http://www.arb.ca.gov/regact/2010/capandtrade10/fsor.pdf.

[38] Fugitives from certain oil and gas sources are an exception because, unlike other fugitive emissions, they are possible to quantify with rigor.

[39] ARB's responses to comments in the 2011 Final Statement of Reasons for the Regulation and Western Climate Initiative design documentation provide detailed rationale for the treatment of fugitive emissions in specific sectors. For example, the quantification methods that are often used to quantify fugitive emissions, including calibrated bagging, high volume sampling, and a default emissions factor, only provide a snapshot of emissions rather than actual measurements of emissions from the source. *See also* Western Climate Initiative, Inc. (2010) WCI Comments on the Proposed Mandatory Reporting of GHG Emissions from Proposed Reporting for Oil and Gas Operations (Subpart W), at pg. 44. available at http://www.westernclimateinitiative.org/document-archives/func-download/258/chk,ab6041717dc1be9cd3430f4f7585cb8e/no_html,1/.

[40] Western Climate Initiative, Inc. (2010) WCI Comments on the Proposed Mandatory Reporting of GHG Emissions from Proposed Reporting for Oil and Gas Operations (Subpart W) at pg. 39. available at http://www.westernclimateinitiative.org/document-archives/func-download/258/chk,ab6041717dc1be9cd3430f4f7585cb8e/no_html,1/.

[41] California Air Resources Board (2011) California's Cap-and-Trade Program Final Statement of Reasons, Response to Comment E-69, pg. 430 and 448. available at http://www.arb.ca.gov/regact/2010/capandtrade10/fsor.pdf.

[42] *Id.*, Response to Comment E-31, at pg. 425. available at http://www.arb.ca.gov/regact/2010/capandtrade10/fsor.pdf.

Because of these difficulties, and the importance of seeking SLCP-specific emission reductions, which the Cap-and-Trade Program is not designed to produce; this SLCP Strategy does not recommend expanding Cap-and-Trade Program coverage.[43] Instead, the SLCP Strategy focuses on specific measures for SLCP-emitting sectors, consistent with the approach ARB adopted while developing the AB 32 Scoping Plan and Cap-and-Trade Program.

ARB notes that stakeholders have expressed divergent views on this basic approach as it relates to animal agriculture. On one hand, the Animal Legal Defense Fund has petitioned ARB to include emissions from that sector in the Cap-and-Trade Program. On the other hand, representatives of many environmental justice and environmental groups have argued that direct, sector-specific measures are preferable, as have representatives of the dairy industry. This SLCP Strategy focuses on direct measures, consistent with the necessity of reducing SLCP emissions from the dairy sector specifically, and in-line with the design principles that underlie the State's climate strategy and the Cap-and-Trade Regulation.[44]

[43] ARB considered this option in detail, however. Further discussion is available in the California Environmental Quality Act (CEQA) appendix to this Strategy (Appendix E).

[44] The Livestock Project Compliance Offset Protocol is one such more focused measure now in operation. It contrasts with the wholesale coverage of the sector by the Cap-and-Trade Program that some stakeholders suggest. This protocol, focused on encouraging sector-specific reductions, would not operate if facilities in the sector had compliance obligations in the Program. The protocol balances the need for clear quantification methodologies and regulatory program requirements and ensures any credited voluntary GHG emission reductions meet the AB 32 criteria. The quantification methods included in this protocol use conservative factors to ensure that only real emission reductions are eligible for issuance of compliance offset credit.

III. Latest Understanding of Science on SLCPs

Climate change is already beginning to transform life on Earth**.** Around the globe, seasons are shifting, temperatures are climbing and sea levels are rising. Continued emissions of GHGs will cause further warming and changes in all components of the climate system. Limiting climate change will require substantial and sustained reductions of GHG emissions.

There is growing recognition within the scientific and policy communities that efforts to address climate change should focus not only on reducing CO_2 emissions, but also on reducing emissions of SLCPs. While reducing CO_2 emissions will limit total warming over the long-term, reducing emissions of SLCPs will effectively slow the near-term rate of climate change. Therefore, the best path forward is to emphasize a coordinated strategy for simultaneous emission reductions for both SLCPs and CO_2,[45,46] which is needed to keep average warming below 2^{o}C this century.

Mount Shasta

Short-lived climate pollutants have atmospheric lifetimes on the order of a few days to a few decades, and their relative climate forcing impacts, when measured in terms of how they heat the atmosphere, can be tens, hundreds, or even thousands of times greater than that of CO_2. Short-lived climate pollutants contribute about 40 percent to the current anthropogenic global radiative forcing, which is the primary forcing agent for observed climate change.[47,48,49,50,51]

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[45] Shoemaker, J K; Schrag, D P; Molina, M J; Ramanathan, V (2013) What Role for Short-Lived Climate Pollutants in Mitigation Policy? Science 342 (6164) 1323-1324

[46] Rogelj, J, Schaeffer M, Meinshausen M, Shindell D, Hare W, Klimont Z, Velders G, Amann M, Schellnhuber HJ. 2014. Disentangling the effects of CO2 and short-lived climate forcer mitigation. Proceedings of the National Academy of Sciences (PNAS). http://www.pnas.org/cgi/doi/10.1073/pnas.1415631111

[47] Calculation based on IPCC AR5 WGI Chapter 8. https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf

[48] Molina M, Zaelke D, Sarma KM, Andersen SO, Ramanathan V, Kaniaru D. (2009) Reducing abrupt climate change risk using the Montreal Protocol and other regulatory actions to complement cuts in CO_2 emissions. *Proceedings of the National Academy of Sciences of the United States of America*. 2009;106(49):20616-20621. doi:10.1073/pnas.0902568106. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2791591/

[49] Ramanathan V, Xu Y. (2010) The Copenhagen Accord for limiting global warming: criteria, constraints, and available avenues. Proceedings of the National Academy of Sciences of the United States of America. 2010;107 (18):8055–8062. [PMC free article]

[50] IGSD (2013) Primer on Short-Lived Climate Pollutants, Institute for Governance and Sustainable Development, February 2013. http://igsd.org/documents/PrimeronShort-LivedClimatePollutantsFeb192013.pdf.

[51] Akbar, Sameer; Ebinger, Jane; Kleiman, Gary; Oguah, Samuel. (2013) *Integration of short-lived climate*

Co-Benefits of Reducing SLCPs


Flood damage from Hurricane Sandy at Assateague Island National Seashore Park (Virginia)

In addition to limiting climate change impacts already underway, SLCP emission reductions would reduce local air pollution and produce other co-benefits. The benefits could be even greater in the Arctic, which is especially vulnerable to black carbon emissions and is warming twice as fast as the rest of the world.[52] This would be critically important for stabilizing climate change and its impacts, as the Arctic is an important driver of sea level rise and weather patterns throughout the Northern Hemisphere. Climate change in the Arctic potentially impacts drought in California and extreme snow and cold in the upper Midwest and New England, although such links have not been definitively proven.[53,54] Accelerated warming in the Arctic could also lead to irreversible climate "tipping points," such as the release of vast quantities of CO_2 and methane from melting permafrost.[55]

In California, State and international action to reduce emissions of SLCPs can improve air quality and reduce related health risks. Other benefits to California include reducing damage to crops, reducing background ozone and particulate levels to help meet federal air quality standards, and reducing disruption of historic rainfall patterns. California is working with a set of national and subnational partners throughout the world to fight air pollution and climate change, which will help deliver these benefits to our State while providing significant benefits where emission reductions occur.

Climate Impact

Global mean sea level will continue to rise during the twenty-first century, and the rate of sea level rise will exceed that observed during 1971 to 2010 due to increased ocean

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pollutants in World Bank activities: a report prepared at the request of the G8. Washington DC; World Bank. http://www-wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2013/08/19/000333037_20130819113818/Rendered/PDF/804810WP0G80Re00Box0379805B00OUO090.pdf

[52] Quinn et al (2008) Short-lived pollutants in the Arctic: Their impact and possible mitigation strategies, *Atmospheric Chemistry and Physics* **8**, 1723-1735. http://www.atmos-chem-phys.net/8/1723/2008/acp-8-1723-2008.html

[53] Francis, J. A. and S. J. Vavrus. 2012. Evidence linking Arctic amplification to extreme weather in mid-latitudes. Geophysical Research Letters 39.

[54] Screen, J. A. and I. Simmonds (2013) Exploring links between Arctic amplification and mid-latitude weather. Geophysical Research Letters 40(5):959-964.

[55] Ramanathan V, Xu Y. The Copenhagen Accord for limiting global warming: criteria, constraints, and available avenues. Proceedings of the National Academy of Sciences of the United States of America. 2010;107 (18):8055–8062. [PMC free article].

warming and increased loss of mass from glaciers and ice sheets.[56] A recent study raises the possibility of a more rapid rate of sea level rise in this century than forecast by the U.N.'s Intergovernmental Panel on Climate Change (IPCC).[57] The authors conclude that 2^o C global warming above the preindustrial level would spur ice shelf melt sufficient to cause a sea level rise of several meters. Sea level rise is an important impact of climate change on California due to the long coastline and large population that lives near coastal waters. Mitigating SLCP emissions can have significant benefits for slowing sea level rise, reducing the rate by 24-50 percent by 2100, if it begins now. Mitigating emissions of both CO_2 and SLCPs can reduce the projected rate of sea level rise by 50–67 percent by 2100.[58]

Climate warming has intensified the recent drought in the southwestern U.S. as part of a trend toward enhanced drought that is projected to intensify through this century.[59] California droughts may be increasingly intensified due to declining availability of groundwater reserves. In the Central Valley, the current drought has cost California agriculture about $2.7 billion and more than 20,000 jobs in 2015, and agriculture is expected to face more frequent drought.[60] The current California drought highlights the critical need for developing drought resilience, even if wet conditions mitigate the current drought.[61,62]

Achieving Climate Stabilization

Scientific research indicates that an increase in the global average temperature of 2°C (3.6°F) above pre-industrial levels, which is only 1.1°C (2.0°F) above present levels, poses severe risks to natural systems and human health and well-being. Increased climate extremes, already apparent at present day climate warming (~0.9°C), will be

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[56] IPCC, 2013: Summary for Policymakers. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf.

[57] Hansen, J., Sato, M., Hearty, P., Ruedy, R., Kelley, M., Masson-Delmotte, V., Russell, G., Tselioudis, G., Cao, J., Rignot, E., Velicogna, I., Kandiano, E., von Schuckmann, K., Kharecha, P., Legrande, A. N., Bauer, M., and Lo, K.-W.(2015) Ice melt, sea level rise and superstorms: evidence from paleoclimate data, climate modeling, and modern observations that 2 °C global warming is highly dangerous, Atmos. Chem. Phys. Discuss., 15, 20059-20179, doi:10.5194/acpd-15-20059-2015, 2015. http://www.atmos-chem-phys-discuss.net/15/20059/2015/acpd-15-20059-2015.html

[58] Hu, A., Y. Xu, C. Tebaldi, W. M. Washington, and V. Ramanathan (2013), Mitigation of short-lived climate pollutants slows sea-level rise *Nature Climate Change* 3(5), 1–5, doi:10.1038/nclimate1869

[59] Cook, B. I., T. R. Ault, and J. E. Smerdon (2015), Unprecedented 21st century drought risk in the American Southwest and Central Plains, *Science Advances*, *1*(1), e1400082, doi:10.1126/sciadv.1400082.

[60] Economic Analysis of the 2015 Drought for California Agriculture. https://watershed.ucdavis.edu/droughtimpacts

[61] Noah S. Diffenbaugh, N.S., D.L. Swain, and D. Touma (2015) Anthropogenic warming has increased drought risk in California *PNAS 2015 112 (13) 3931-3936; published ahead of print March 2, 2015, doi:10.1073/pnas.1422385112. http://www.pnas.org/content/112/13/3931.abstract*

[62] A.P. Williams et al. (2015) Contribution of anthropogenic warming to California drought during 2012–2014**.** *Geophysical Research Letters*, 2015 DOI: 10.1002/2015GL064924

more severe. Studies indicate that available technologies, if universally adopted, can effectively reduce global methane emissions an estimated 40 percent and black carbon an estimated 80 percent relative to a "reference" scenario by 2030".[63,64] Additionally, a new proposed global phase down of HFCs under the Montreal Protocol that was adopted in October 2016, is expected to cut the production of HFCs by up to 70 percent by 2030, and up to 85 percent by 2036 in developed countries including the U.S.[65,66] Achieving this scale of global reductions would deliver significant climate benefits. It would cut the expected rate of global warming in half by 2050, slowing global temperature rise by about 0.6^{o}C,[67,68] which would reduce the risk of dangerous climate feedbacks such as accelerated Arctic melting and sea level rise.[69] It would also increase the probability of staying below the 2^{o}C threshold to more than 90 percent through 2050.[70,71]

Global Warming Potential

The IPCC developed the concept of global warming potential (GWP) as an index to evaluate the climate impacts of different GHGs, including SLCPs. This metric provides a comparison of the ability of each GHG to trap heat in the atmosphere relative to CO_2 over a specified time horizon. Global warming potentials account for the lifetime of different GHGs in the atmosphere, and the amount of energy they absorb on a per-kilogram basis, relative to CO_2, to represent the relative climate forcing of a kilogram of emissions when averaged over a time period of interest (for example, 20 years or 10 years). Current practice in most of the world for developing GHG emission inventories, including California's inventory, is to use GWP values from the

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[63] UNEP (2014) Time to Act (To Reduce Short-Lived Climate Pollutants), The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, United Nations Environment Programme, Second Edition, May. http://www.unep.org/ccac/Publications/Publications/TimeToAct/tabid/133392/Default.aspx

[64] UNEP and WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone, United Nations Environment Programme and World Meteorological

[65] UNEP (2016). United Nations Environment Programme (UNEP). Further Amendment of the Montreal Protocol submitted by the Contact Group on HFCs. 14 October 2016. http://www.unep.org/Documents.Multilingual/Default.asp?DocumentID=27086&ArticleID=36283&l=en

[66] IGSD (2016) Institute for Governance and Sustainable Development (IGSD) "Nations Agree to Kigali Amendment: Largest Near-Term Temperature Reduction from Single Agreement", 15 October 2016. http://www.igsd.org/nations-agree-to-kigali-amendment-largest-near-term-temperature-reduction-from-single-agreement/.

[67] Ramanathan V, Xu Y. The Copenhagen Accord for limiting global warming: criteria, constraints, and available avenues. Proceedings of the National Academy of Sciences of the United States of America. 2010;107 (18):8055–8062. [PMC free article]

[68] UNEP (2014) Time to Act (To Reduce Short-Lived Climate Pollutants), The Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants, United Nations Environment Programme, Second Edition, May. http://www.unep.org/ccac/Publications/Publications/TimeToAct/tabid/133392/Default.aspx

[69] UNEP and WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone, United Nations Environment Programme and World Meteorological Association. http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_report.pdf

[70] Ramanathan, V. and Yangyang Xu (2010) The Copenhagen Accord for Limiting Global Warming: Criteria, Constraints, and Available Avenues, *Proceedings of the National Academies of Sciences* **107** (18), pp.8055-8062. http://www.pnas.org/content/107/18/8055

[71] Xu, Y., D. Zaelke, G. J. M. Velders, and V. Ramanathan (2013), The role of HFCs in mitigating 21st century climate change, *Atmos. Chem. Phys.*, 13(12), 6083–6089

4th Assessment Report of the IPCC (AR4), which was released in 2007. For the first time, GWP estimates for black carbon are reported in the 5th Assessment Report of the IPCC (AR5), which includes the independent scientific assessment of black carbon radiative forcing published by Bond et al.[72] This SLCP Strategy uses AR4 values for methane and HFCs, but AR5 for black carbon.

Considering ways of comparing the contributions of different climate pollutants to climate change has been raised in the IPCC AR5. The report focuses the discussion on the more well-known GWP and Global Temperature change Potential (GTP), though other concepts are also briefly discussed. The GTP is defined as the change in global mean surface temperature at a chosen point in time in response to an emission pulse, relative to that of CO_2. The Norwegian Environment Agency has recently performed an integrated assessment of climate, health and environmental effects of Norwegian emissions of SLCPs, and proposed measures for reducing such effects by 2030.[73] Specifically, they used the “GTP10, Norway”, a global temperature change potential calculated ten years after the emission occurred in Norway, which they identify as the most practically appropriate metric for analyzing measures for Norwegian emissions of SLCPs in the short term. Overall, there is not one, single metric that describes the comparative climate effects of various short-lived and long-lived climate pollutants perfectly. The use of GWPs with a time horizon of 20 years better captures the importance of the SLCPs and gives a better perspective on the speed at which SLCP emission controls will impact the atmosphere relative to CO_2 emission controls. Thus, the emission estimates presented later in this report are calculated using 20-year GWP. Table 5 illustrates the lifetime and 20-year GWP for each SLCP.

Table 5: Global Warming Potential for SLCPs[1]

Pollutant	Lifetime (years)	20-year GWP
Carbon dioxide	~100[2]	1
Methane	12	72
F-Gases (Hydrofluorocarbons)	1.4 – 52	437 – 6350
Black carbon	Days to weeks	3,200

[1]All AR4 except black carbon which uses AR5 (the first report to define a GWP for black carbon)
[2]CO_2 has a variable atmospheric lifetime and cannot be readily approximated as a single number

[72] Bond, T. C., S. J. Doherty, D. W. Fahey, et al. (2013) “Bounding the role of black carbon in the climate system: A scientific assessment.” Journal of Geophysical Research: Atmospheres doi:10.1002/jgrd.50171. http://onlinelibrary.wiley.com/doi/10.1002/jgrd.50171/pdf

[73] Norwegian Environment Agency, *Summary of proposed action plan for Norwegian emissions of short lived climate forcers*, report M135/2014; http://www.miljodirektoratet.no/Documents/publikasjoner/M135/M135.pdf

The following sections describe the major SLCPs. An inventory of sources and emissions, and a discussion of current and proposed new control measures are included in other portions of this report.

A. Black Carbon

Airborne particulate matter (PM) varies in its composition and plays a significant role in human health and the climate system. Particulate matter is emitted from a variety of natural processes and human activities, and tends to remain in the air for only a few days to about a week, resulting in extreme spatial and temporal variability. Among different types of particles, carbonaceous particles (those that contain organic and black carbon) are particularly important because of their abundance in the atmosphere. With respect to climate impact, black carbon is the principal absorber of visible solar radiation in the atmosphere while organic carbon is often described as a light-reflecting compound.

Black carbon is emitted from burning fuels such as coal, diesel, and biomass, as well as from various forms of non-fuel biomass combustion (destruction of excess woody wastes, wildfires, etc.). Black carbon contributes to climate change both directly by absorbing sunlight and indirectly by depositing on snow and by interacting with clouds and affecting cloud formation. In addition to its climate and health impacts, black carbon disrupts cloud formation, precipitation patterns, water storage in snowpack and glaciers, and agricultural productivity.

Scientists have known for some time that sources that emit black carbon also emit other short-lived particles that may either cool or warm the atmosphere. Lighter colored particles, for example, tend to reflect rather than absorb solar radiation and so have a cooling rather than warming impact. Until recently, it had been thought that the impact of lighter colored and reflecting organic carbon from combustion sources largely offset the warming impact of black carbon from this source. However, new studies have suggested that certain fractions of organic carbon known as “brown carbon” could be a stronger absorber of solar radiation than previously understood.[74,75] The warming effect of brown carbon may offset the cooling impact of other organic carbon particles; hence, quantification of that absorption is necessary so that climate models can evaluate the net climate effect of organic carbon.

To help characterize and differentiate sources of brown carbon from black carbon and understand their climate impact in California, a current ARB-funded research project is applying advanced measurement methodology along with regional and global climate modeling simulations to characterize the extent to which brown carbon contributes to

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[74] Jacobson, M. Z. (2014), Effects of biomass burning on climate, accounting for heat and moisture fluxes, black and brown carbon, and cloud absorption effects, J. Geophys. Res. Atmos., 119, 8980–9002, doi:10.1002/2014JD021861 http://onlinelibrary.wiley.com/doi/10.1002/2014JD021861/pdf

[75] Kodros, J. K., Scott, C. E., Farina, S. C., Lee, Y. H., L'Orange, C., Volckens, J., and Pierce, J. R.: Uncertainties in global aerosols and climate effects due to biofuel emissions, Atmos. Chem. Phys., 15, 8577-8596, doi:10.5194/acp-15-8577-2015, 2015. http://www.atmos-chem-phys.net/15/8577/2015/acp-15-8577-2015.pdf

climate forcing in California. This project will improve our understanding of the fundamental processes that dominate brown carbon formation, and help to determine the potential climate benefit of mitigating sources of brown carbon emissions in California.

B. Methane

Methane is the principal component of natural gas and is also produced biologically under anaerobic conditions in ruminants (animals with a four-part stomach, including cattle and sheep), landfills, and waste handling. Atmospheric methane concentrations have been increasing as a result of human activities related to agriculture, fossil fuel extraction and distribution, and waste generation and processing. The atmospheric lifetime of methane is about 12 years. It is well-mixed within the atmosphere, and like other GHGs, warms the atmosphere by blocking infrared radiation (heat) that is re-emitted from the earth's surface from reaching space. Almost all of methane's impact occurs within the first two decades after it is emitted.

Methane is responsible for about 20 percent of current global warming,[76] and methane emissions continue to increase globally. There is particular concern among scientists that continued climate warming may cause massive releases of methane from thawing arctic permafrost, and dissolve frozen methane clathrate deposits trapped within shallow ocean sea floors.

A recent study, which examines the interaction of methane with other atmospheric gases, indicates methane emissions may have even greater climate change impacts than previously understood.[77] In the AR5 report, when all the feedbacks are included, the GWP for methane was increased, from 25 to 28 over a 100-year timespan and from 72 to 84 over a 20-year timespan. However, for consistency with reporting requirements under the United Nations Framework Convention on Climate Change, ARB is using GWP values from the AR4.

Methane also contributes to global background levels of ozone in the lower atmosphere (troposphere). Photo-oxidation of both methane and carbon monoxide lead to net production of global background levels of ozone. Ozone itself is a powerful SLCP as well as a regional ground level air pollutant. Tropospheric ozone is not emitted directly into the atmosphere, but rather formed by photochemical reactions. Its average atmospheric lifetime of a few weeks produces a global distribution highly variable by season, altitude, and location. The radiative forcing of tropospheric ozone is primarily attributed to emissions of methane, but also to carbon monoxide, volatile organics, and nitrogen oxides that eventually form ozone.

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[76] Kirschke, S. *et al.* (2013) Three decades of global methane sources and sinks. *Nature Geosci.* **6**, 813–823. http://www.nature.com/ngeo/journal/v6/n10/full/ngeo1955.html?WT.ec_id=NGEO-201310

[77] Holmes, C. D., M. J. Prather, O. A. Sovde, and G. Myhre. 2013. "Future methane, hydroxyl, and their uncertainties: Key climate and emission parameters for future predictions." Atmospheric Chemistry and Physics 13: 285–302. http://www.atmos-chem-phys.net/13/285/2013/acp-13-285-2013.pd

Ozone negatively impacts human health, and can lead to asthma attacks, hospitalizations, and even premature death. It impairs the ability of plants to absorb CO_2, thereby suppressing crop yields and harming ecosystems. Ozone also affects evaporation rates, cloud formation, and precipitation levels. In addition to the direct climate benefits of cutting methane emissions, it can also reduce global background levels of ozone pollution and provide additional climate, health, and other benefits.[78,79,80]

Regional ozone concentrations reflect contributions from both ozone formed from criteria pollutant emissions (NO_X and volatile organic compounds [VOCs]) on a regional scale, and ozone transported on hemispheric scales (global background levels of ozone). Due to its low reactivity, methane emissions do not affect regional scale ozone production that occurs over hours to days. However, regional methane emissions which are fairly well-mixed in the atmosphere contribute to the global abundance of methane, which in turn contributes to global background levels of ozone. About two-thirds of the rise in global levels of tropospheric background ozone can be attributed to methane emissions. Studies have also shown that the global background ozone concentrations can approach 40 parts per billion and have been increasing in recent years. Increases in background ozone make it harder to attain the health-based ambient air quality standards set by U.S. EPA and California.

C. Fluorinated Gases (Hydrofluorocarbons)

Hydrofluorocarbons (HFCs) are synthetic gases used in refrigeration, air conditioning, insulating foams, solvents, aerosol products, and fire protection. They are primarily produced for use as substitutes for ozone-depleting substances, including chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which are being phased out under the Montreal Protocol. Currently, HFCs are a small fraction of the total climate forcing, but they are the fastest growing source of GHG emissions in California and globally, primarily driven by the increased demand for refrigeration and air conditioning.

HFCs vary significantly in their ability to influence climate. Their differing ability is mostly due to differences in their atmospheric lifetimes, which determine how much they accumulate in the atmosphere. The mix of HFCs in current use, weighted by usage

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[78] Fiore, A. M., J. J. West, L. W. Horowitz, V. Naik, and M. D. Schwarzkopf (2008) Characterizing the tropospheric ozone response to methane emission controls and the benefits to climate and air quality, J. Geophys. Res., 113, D08307, doi:10.1029/2007JD009162.

[79] West, J. J., A. M. Fiore, L. W. Horowitz, and D. L. Mauzerall (2006), Global health benefits of mitigating ozone pollution with methane emission controls, Proc. Natl. Acad. Sci. U.S.A., 103, 3988–3993.

[80] Fiore, A. M., F. J. Dentener, O. Wild, C. Cuvelier, M. G. Schultz, P. Hess, C. Textor, M. Schulz, R. M. Doherty, L. W. Horowitz, I. A. MacKenzie, M. G. Sanderson, D. Shindell, D. S. Stevenson, S. Szopa, R. Van Dingenen, G. Zeng, C. Atherton, D. J. Bergmann, I. Bey, G. Carmichael, W. J. Collins, B. Duncan, G. Faluvegi, G. Folberth, M. Gauss, S. Gong, D. Hauglustaine, T. Holloway, I. S. A. Isaksen, D. Jacob, J. E. Jonson, J. W. Kaminski, T. J. Keating, A. Lupu, E. Marmer, V. Montanaro, R. J. Park, G. Pitari, K. J. Pringle, J. A. Pyle, S. Schroeder, M. G. Vivanco, P. Wind, G. Wojcik, S. Wu, and A. Zuber (2009), Multimodel estimates of intercontinental source-receptor relationships for ozone pollution, J. Geophys. Res., 114, D04301, doi:10.1029/2008JD010816.

(tonnage), has an average atmospheric lifetime of 15 years. HFCs are also potent GHGs, with a warming effect hundreds to thousands of times more powerful than CO_2. The average 100-year GWP of the current mix of HFCs being used is about 1700, and the average 20-year GWP is about 3800. The major concern with respect to HFCs is that their contribution to climate forcing is expected to increase rapidly in the future as they continue to replace ozone depleting substances (ODS), such that they will become very significant contributors. Studies indicate that a lack of action to prevent the growth of HFCs would greatly undermine efforts to address climate change. A recent study concluded that replacing high-GWP HFCs with low-GWP alternatives could avoid 0.1°C of warming by 2050 and warming of up to 0.5°C by 2100,[81] offering one of the most cost-effective climate mitigation strategies available.

The successful phase-out of CFCs and the ongoing phase-out of HCFCs have made the Montreal Protocol an effective climate treaty.[82,83] Between 1990 and 2010 the Montreal Protocol reduced CO_2e emissions nearly twenty times more than the initial commitment period of the Kyoto Protocol.[84] Although HFCs have contributed a miniscule amount of historical climate forcing, they are projected to increase significantly in the absence of control policies. Hence, a global phase down of HFCs is necessary to slow their effect on climate change. International, national, and state efforts to reduce emissions of HFCs are discussed in more detail in Chapter VI.

[81] Xu Y., Zaelke D., Velders G. J. M., & Ramanathan V. (2013) The role of HFCs in mitigating 21st century climate change , ATMOS. CHEM. PHYS. 13:6083-608.
[82] Velders G. J. M. *et al.* (2007) *The importance of the Montreal Protocol in protecting climate*, Proc. Nat'l. Acad. Sci. USA 104:4814.
[83] Wu, Y., L.M. Polvani and R. Seager, (2013): The Importance of the Montreal Protocol in Protecting the Earth's Hydroclimate. *J. Climate*, 26, DOI: 10.1175/JCLI-D-12-00675.1, http://www.ldeo.columbia.edu/res/div/ocp/glodech/PDFS/Wu_etal_O3_2013.pdf
[84] UNEP (2012) The Montreal Protocol and the Green Economy: Assessing the contributions and co-benefits of a Multilateral Environmental Agreement.

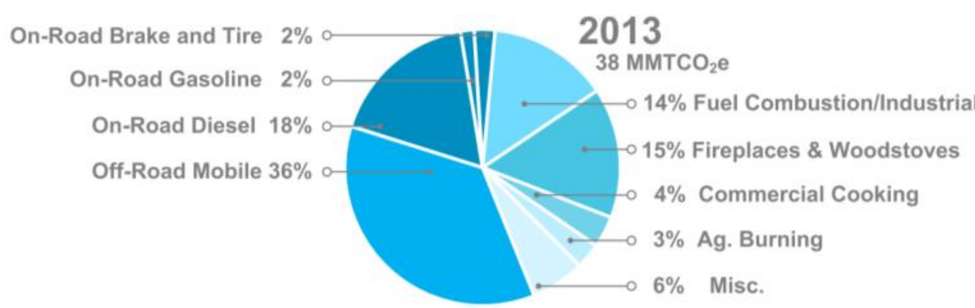
IV. Reducing Anthropogenic Black Carbon Emissions

Black carbon is the light-absorbing component of fine particulate matter (PM) produced during incomplete combustion of fuels. Black carbon does not account for the warming effects of brown carbon. The lifetime of black carbon is very short, from days to weeks, compared to other SLCPs, which may remain in the atmosphere for a few decades.

California has done more than any other jurisdiction in the world to reduce PM and black carbon emissions. As a result, ambient levels of black carbon in California are now 90 percent lower than in the early 1960s, despite the use of diesel fuel more than tripling over the same time period.[85] If the rest of the world achieved similar reductions, it could substantially improve health and slow global warming. California's actions can serve as a blueprint for other jurisdictions to reduce SLCP emissions and improve public health. Existing programs will continue to reduce black carbon emissions. For example, complying with federal air quality standards and reducing localized health risk will require substantial reductions in smog-forming and PM emissions from mobile sources and other source categories.

California's major anthropogenic sources of black carbon include off-road transportation, on-road transportation, residential wood burning, fuel combustion, and industrial processes (Figure 1). The fuel combustion and industrial source categories include a variety of stationary and portable equipment such as boilers, turbines, and steam generators, as well as process emissions from industrial operations, such as cement and asphalt production and pulp and paper mills. Sources in the miscellaneous category include dust, waste disposal, unplanned structure and car fires, residential natural gas combustion, and non-agricultural open burning (mostly residential green waste burning).

Figure 1: California 2013 Anthropogenic Black Carbon Emission Sources*



*Using 20-year GWP

Wildfire is the largest source of black carbon in California. Prescribed fires also emit black carbon, but are an important tool for forest managers. However, since the

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[85] V. Ramanathan et al. 2013. Black Carbon and the Regional Climate of California. Report to the California Air Resources Board No. 08-323. http://www.arb.ca.gov/research/apr/past/08-323.pdf

legislative direction and intent of SB 1383 is to include only non-forest sources of black carbon in the target, a target for forest-derived black carbon emission reductions is not included in this SLCP Strategy. For reference, estimates for 10-year annual average black carbon emissions from fires that occurred in forests and other lands are provided in Table 6. Emissions from fires in forests and other lands vary dramatically from year-to-year, and these inventories contain higher uncertainty[86] than the anthropogenic sources in Figure 1.

Table 6: 10-Year Average California Black Carbon Emissions: Wild and Prescribed Fire

Source	10-Year Average Emissions (MMTCO2e)*
Prescribed Burning	3.6
Wildfire	86.7

*Using 20-year GWP

In general, forests are burning at increasing rates and at increasing levels of severity.[87] This trend raises concern over the long-term health of these forests and ability to sequester carbon and provide resource amenities.[88] Many studies have demonstrated net benefits for fuel treatments and forest management activities designed to reduce both fire spread and fire severity at the experimental unit or stand level, both in modeled and real world scenarios.[89,90,91,92,93,94,95,96,97,98,99] Fuel treatments are key

[86] California Air Resources Board 2015 Edition of California's Black Carbon Emission Inventory. https://www.arb.ca.gov/cc/inventory/slcp/doc/bc_inventory_tsd_20160411.pdf

[87] Hurteau, M. D., Westerling, A. L., Wiedinmyer, C. and Bryant, B. P. 2014. Projected effects of climate and development on California wildfire emissions through 2100. *Environmental Science & Technology*, 48(4), pp.2298-2304.

[88] North, M. P. and Hurteau, M. D., 2011. High-severity wildfire effects on carbon stocks and emissions in fuels treated and untreated forest. *Forest Ecology and Management*, 261(6), pp.1115-1120.

[89] Finney, M. A., McHugh, C. W., & Grenfell, I. C. (2005). Stand-and landscape-level effects of prescribed burning on two Arizona wildfires. Canadian Journal of Forest Research, 35(7): 1714-1722.

[90] Ritchie, M. W., Skinner, C. N., & Hamilton, T. A. (2007). Probability of tree survival after wildfire in an interior pine forest of northern California: effects of thinning and prescribed fire. Forest Ecology and Management, 247(1), 200-208.

[91] Safford, H. D., Schmidt, D. A., & Carlson, C. H. (2009). Effects of fuel treatments on fire severity in an area of wildland–urban interface, Angora Fire, Lake Tahoe Basin, California. Forest Ecology and Management, 258(5), 773-787.

[92] Schwilk, D. W., Keeley, J. E., Knapp, E. E., McIver, J., Bailey, J. D., Fettig, C. J., Fiedler, C. E., Harrod, R. J., Moghaddas, J. J., Outcalt, K. W. and Skinner, C. N. (2009). The national Fire and Fire Surrogate study: effects of fuel reduction methods on forest vegetation structure and fuels. Ecological Applications, 19(2): 285-304.

[93] Ager, A. A., Vaillant, N. M., & Finney, M. A. (2010). A comparison of landscape fuel treatment strategies to mitigate wildland fire risk in the urban interface and preserve old forest structure. Forest Ecology and Management, 259(8), 1556-1570.

[94] Moghaddas, J. J., Collins, B. M., Menning, K., Moghaddas, E. E., & Stephens, S. L. (2010). Fuel treatment effects on modeled landscape-level fire behavior in the northern Sierra Nevada. Canadian Journal of Forest Research, 40(9), 1751-1765.

[95] Collins, B. M., Stephens, S. L., Roller, G. B., & Battles, J. J. (2011). Simulating fire and forest dynamics for a landscape fuel treatment project in the Sierra Nevada. Forest Science, 57(2): 77-88.

[96] Safford, H. D., Stevens, J. T., Merriam, K., Meyer, M. D., & Latimer, A. M. (2012). Fuel treatment effectiveness in California yellow pine and mixed conifer forests. Forest Ecology and Management, 274, 17-28.

[97] Stephens, S. L., McIver, J. D., Boerner, R. E., Fettig, C. J., Fontaine, J. B., Hartsough, B. R., Kennedy, P. L. and Schwilk, D. W. (2012). The effects of forest fuel-reduction treatments in the United States. BioScience, 62(6): 549-560.

elements of forest restoration strategies,[100] and are embedded in management strategies at local, state and national levels.[101,102] The Forest Carbon Plan, as well as the 2030 Target Scoping Plan Update, will continue to explore the interrelation of climate change and natural lands.

A. Progress to Date

California's program to reduce emissions from transportation sources of black carbon can serve as a blueprint for other jurisdictions seeking to address both the climate change and public health impacts of mobile sources, particularly diesel engines. Over the last few decades, ARB has employed a variety of strategies that has drastically reduced black carbon emissions from mobile sources, including lower emission standards, clean fuel requirements, in-use rules, incentives, and investments in research and new technology. Diesel particulate filters have been instrumental in reducing black carbon in on-road and major portions of the off-road sector. Today's diesel particulate filter-equipped trucks are more than 99 percent cleaner than those manufactured in 1990. Measures have also been implemented on the State and local level to reduce PM, and thus black carbon, emissions from non-mobile sources, including residential burning, commercial cooking, and agricultural burning. Existing measures are projected to cut mobile source emissions by 75 percent and total anthropogenic emissions by nearly 60 percent between 2000 and 2020 (Figure 2).

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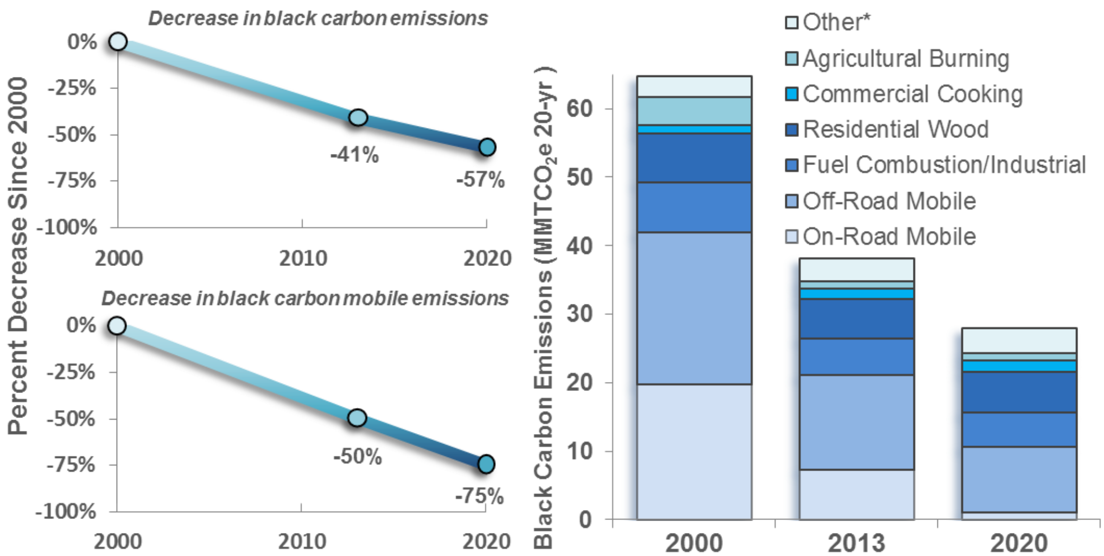
[98] Martinson, E. J., & Omi, P. N. (2013). Fuel treatments and fire severity: a meta-analysis. USDA For Service Research Paper RMRS-RP103.
[99] Stevens, J. T., Safford, H. D., & Latimer, A. M. (2014). Wildfire-contingent effects of fuel treatments can promote ecological resilience in seasonally dry conifer forests. Canadian Journal of Forest Research, 44(8), 843-854.
[100] Hessburg, P. F., Churchill, D. J., Larson, A. J., Haugo, R. D., Miller, C., Spies, T. A., North, M. P., Povak, N. A., Belote, R. T., Singleton, P. H. and Gaines, W. L. (2015). Restoring fire-prone Inland Pacific landscapes: seven core principles. Landscape Ecology, 30(10): 1805-1835.
[101] Wildland Fire Leadership Council. (2014). National Cohesive Wildland Fire Management Strategy. Available at: https://www.forestsandrangelands.gov/strategy/ (Accessed 8/30/2016).
[102] State of California. (2010). 2010 Strategic Fire Plan for California. Available at: http://cdfdata.fire.ca.gov/fire_er/fpp_planning_cafireplan (Accessed 8/30/2016)

Figure 2: California's Anthropogenic Black Carbon Emissions between 2000 and 2020 with Existing Measures



California has highlighted our accomplishments in discussions with other jurisdictions, including a SLCP-focused side event, jointly hosted with Mexico, at the Conference of Parties in Lima in 2014 and at international climate conferences in 2015. We will continue to work closely with our partners in other states, in the federal government, and internationally to highlight the successful actions California has taken, and will continue to take, to reduce black carbon from mobile sources.

Mobile Sources

In 2000, ARB approved a Diesel Risk Reduction Plan, calling for an 85 percent reduction in diesel PM emissions by 2020.[103] Diesel engines often operate for decades after they are purchased, so while lower emission standards provide major emission reductions, those reductions can take time to materialize as older engines are replaced with new ones meeting the standard. To reduce risk and speed emission reductions, ARB implemented in-use rules for on-road and off-road fleets to meet performance standards through the use of alternative fuels, after-treatment retrofits, or replacement of older vehicles with newer vehicles manufactured to current emission standards. In-use on-road rules are expected to reduce black carbon emissions from on-road sources by 80 percent between 2000 and 2020. ARB's off-road rules apply to approximately 150,000 off-road vehicles and are expected to reduce diesel PM emissions by 20 percent between 2009 and 2023.

These regulations provide significant reduction in diesel PM exposure in communities located near California's major ports and intermodal rail yards and contribute to a larger coordinated effort to reduce black carbon and PM emissions from all sources at

[103] Final Diesel Risk Reduction Plan available at: http://www.arb.ca.gov/diesel/documents/rrpapp.htm

ports and rail yards.[104] Overall, since 2005, California has reduced diesel particulate emissions, along with the associated health risks, by 70 percent at the largest ports and 50–70 percent at the highest-risk rail yards.

Incentive programs, including the Carl Moyer Memorial Program, AB 923, AB 118 Air Quality Improvement Program (AQIP), Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP), and Proposition 1B, have provided the means to transform California's mobile fleet into one of the cleanest in the world. These programs have provided more than $1.6 billion over the past 15 years to clean up diesel engines and simultaneously reduce black carbon.

Cleaner fuels have been a cornerstone of ARB efforts to reduce mobile emissions, enabling cleaner vehicle technologies that have reduced smog-forming emissions by 15 percent and reduced cancer risks from vehicle pollution by 40 percent. The Low Carbon Fuel Standard provides a strong financial incentive to develop clean fuel alternatives, which may also reduce black carbon. For example, renewable diesel and biodiesel may reduce both PM and black carbon emissions compared to conventional diesel, especially in engines where diesel particulate filter technology is not available.

California has also paved the way for increased penetration of zero-emission vehicles (ZEV) through incentive programs and investment in new technology. The ZEV regulation was first adopted in 1990, as part of the Low Emission Vehicle Program. Today California is the world's single largest market for light-duty passenger ZEVs, accounting for 20 percent of all ZEVs on the road.[105] ARB will continue to lead in this area with the Governor's ZEV action plans to accelerate use of ZEVs and deploy 1.5 million passenger ZEVs in California by 2025. Providing financial and technological pathways to accelerating growth in ZEVs and other advanced engine technologies within California will push market development for clean and zero-emission vehicles throughout the world, providing additional black carbon emission reductions outside of California.

ARB is developing an integrated mobile source strategy to meet California's air quality and climate mandates, reduce petroleum use, and reduce near source risk. Accomplishing this will require a transformation to near-zero and zero emission technologies, cleaner renewable fuels, greater system and operational efficiencies, and new approaches to passenger and freight mobility. These coordinated efforts will provide California a clear path forward to reduce the State's impacts on climate change including reductions in black carbon emissions.

In April 2015, ARB released the *Sustainable Freight Pathways to Zero and Near-Zero Discussion Document* that outlines initial steps ARB is taking to accelerate progress

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[104] Dallmann et al. 2011. Effects of Diesel Particle Filter Retrofits and Accelerated Fleet Turnover on Drayage Truck Emissions at the Port of Oakland, Environmental Science & Technology, 45, 10773-10779.

[105] Draft 2015 ZEV Action Plan available at: http://gov.ca.gov/docs/DRAFT_2015_ZEV_Action_Plan_042415.pdf

toward zero and near-zero emission freight vehicle and equipment technology in California.[106] In July 2015, the Governor signed Executive Order B-32-15, which directs the Secretaries of Transportation, Environmental Protection, and Natural Resources to lead staff from the California Department of Transportation (Caltrans), ARB, CEC, and the Governor's Office of Business and Economic Development (GO-Biz), in the development of the California Sustainable Freight Action Plan (Action Plan). The Action Plan, released in July 2016, includes a long-term 2050 vision and guiding principles for California's future freight transport system along with targets for 2030:

- Improve freight system efficiency 25 percent by 2030;
- Deploy over 100,000 zero-emission vehicles/equipment and maximize near-zero by 2030; and
- Foster future economic growth within the freight and goods movement industry.

The Action Plan also identifies opportunities to leverage State freight transport system investments, pinpoints actions to initiate over the next five years to meet goals, and lists possible pilot projects to achieve concrete progress in the near term.

In April 2016, ARB released the Mobile Source Strategy, which includes a comprehensive plan to control emissions from mobile sources in order to meet critical air quality and climate goals over the next fifteen years.[107] In May 2016, ARB released the *Proposed 2016 State Strategy for the State Implementation Plan* (SIP),[108] which represents the elements of the Mobile Source Strategy necessary for the State to meet federal air quality standards for ozone and fine particulate matter (PM2.5). The State SIP Strategy contains measures to reduce particulate matter and, thus, black carbon emissions from mobile sources including implementation of low emission diesel fuel, transitioning to zero-emission technologies and implementing additional emission standards for some engine types. Particulate matter and black carbon emission reductions will be realized from this and other proposed SIP measures, but have not yet been quantified.

As emissions from mobile sources decrease, non-mobile sources will become an increasingly important fraction of the black carbon inventory. The main non-mobile, anthropogenic emission sources include residential wood combustion, fuel combustion from stationary and small portable equipment, and industrial sources. Commercial cooking and agricultural burning make up a smaller portion of emissions.

Residential Wood Combustion

A number of local air districts have residential wood combustion rules, and are working to make further progress in this category to meet air quality standards and protect

[106] http://www.arb.ca.gov/gmp/sfti/sustainable-freight-pathways-to-zero-and-near-zero-emissions-discussion-document.pdf
[107] http://www.arb.ca.gov/planning/sip/2016sip/2016mobsrc_dd.pdf
[108] https://www.arb.ca.gov/planning/sip/2016sip/2016sip.htm

public health.[109] Strategies in place to reduce emissions from residential wood combustion include winter burning curtailment, opacity emission limits, incentives to replace old wood burning devices with more efficient models, and banning or limiting wood burning devices in new and existing housing. Recently signed legislation allocated $5 million of Cap-and-Trade revenue towards an incentives program to reduce emissions from residential wood smoke. The U.S. EPA has recently introduced a new source performance standard requiring manufacturers of residential wood stoves, pellet stoves, forced air furnaces, and hydronic heaters to meet new lower emission standards. Statewide black carbon emissions from residential wood combustion have declined by nearly 20 percent between 2000 and 2013 in response to existing district rules.

Stationary Fuel Combustion and Industrial Sources

Emissions from stationary fuel combustion will be addressed by a number of State and federal planning efforts, including the SIP, Cap-and-Trade Program, increased building energy efficiency and renewable energy goals, and the federal Clean Power Plan (promulgated under Clean Air Act Section 111(d)). California's Cap-and-Trade regulation and the LCFS create market signals to incentivize efficiency improvements as well as the use of biomass-derived liquid fuels that would emit lower levels of PM and black carbon than traditional fossil fuels. The federal Clean Power Plan, which accelerates the transition from coal towards lower carbon-intensive fuels for electricity production, will reduce black carbon emissions, and emissions of other GHGs, across the nation. Further emission reduction opportunities from stationary fuel combustion and industrial processes may also be identified as part of the SIP process.

Commercial Cooking

Commercial cooking emissions are primarily from charbroiling. The two types of charbroilers include chain-driven, where food moves mechanically through a semi-enclosed broiler, and under-fired, where food is cooked on a grill similar to a home barbeque. A number of local air districts require air pollution control technologies for chain-driven broilers, reducing particulate emissions from these charbroilers by over 80 percent. Under-fired charbroilers are a larger source of PM, but no cost-effective air pollution control technology has been identified to date. Air districts are working to develop air pollution control devices for under-fired charbroilers. Demonstration projects for emerging control technologies are in progress and it is anticipated that large districts

[109] Yap and Garcia 2015. Effectiveness of residential wood-burning regulation on decreasing particulate matter levels and hospitalizations in the San Joaquin Valley Air Basin, Am J Public Health, 105(4), 772-778.

will develop rules for these emissions once cost-effective control technologies have been identified.

Agriculture

Agricultural burning was historically used as a cost-effective way to remove agricultural residue left behind on fields, help control weeds and pests, and prevent the spread of plant disease, but emissions impacted local air quality and prompted concern for public health. Various programs are currently administered by the local air districts in coordination with ARB to reasonably regulate agricultural burning as required by state law. The Sacramento Valley Rice Straw Burning Phasedown Program, local district Smoke Management Programs, and San Joaquin Valley agricultural burning phase down efforts have resulted in an approximately 70 percent reduction in black carbon emissions from agricultural burning between 2000 and 2013.

Agricultural burning is controlled by the air districts whose programs must consider the cost-effectiveness of alternatives (e.g., SB 705, H&SC 41855.5). Some agricultural waste that was previously burned went to bioenergy facilities; however, many of these facilities have shut down over the last few years due to their inability to procure long-term power purchase contracts. The reduction in bioenergy capacity has already resulted in some increase in agricultural burning due to a lack of cost-effective alternatives.[110] ARB staff is targeting spring 2017 for a series of summits to elevate the discussion on these and other waste-related issues. The challenges with reducing agricultural waste burning, bioenergy production, and related issues specific to the Central Valley will be explored as part of a Central Valley Ag-Waste Burning Summit. Further, staff is planning with sister agencies to hold a Bio-Economy Summit on the broader discussion of how to establish a California bioeconomy based on a holistic approach to processing woody waste (forest and agriculture), dairy manure, wastewater effluent, landfills, and other organic waste streams, and capturing from these organic waste streams economically valuable bioenergy, biofuels, engineered lumber, soil amendments including uniform fertilizer products, and other beneficial products while maintaining or improving environmental and public health protections.

In the short term, districts are forming working groups and evaluating additional funding opportunities to help limit agricultural burning to the extent possible. However, there are few proven cost-effective alternatives that can be deployed in the short term. One option is to chip and grind the material for compost, incorporation into the soil, or to provide to the public with mulch to replace lawns and reduce water consumption. In the long term, advanced low emission technologies such as gasification or transportation fuels production should be explored to provide beneficial use for agricultural residues. Programs to support clean energy and fuel production and markets for wood products, would help provide opportunities for alternative beneficial uses for this waste material.

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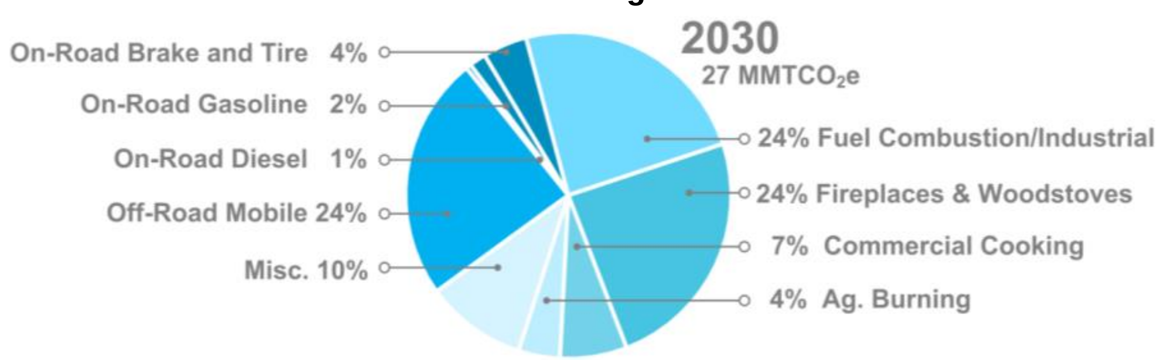
110 http://www.valleyair.org/Board_meetings/GB/agenda_minutes/Agenda/2016/May/StudySession/final/i5.pdf

Agriculture irrigation pumps are a small source of black carbon on a statewide level, but may be an important local source. Multiple federal, state, and local governments have provided incentives to convert agricultural diesel irrigation engines to either newer cleaner diesel engines or to electric motors. This has led to black carbon emissions from irrigation pumps declining by half between 2000 and 2013, with additional reductions expected going forward in response to existing measures.

California has achieved tremendous reductions in black carbon emissions, especially in the mobile sector, and even more reductions are expected as current measures are fully implemented. In 2000, on-road mobile sources contributed a third of anthropogenic black carbon emissions, but are projected to account for only a small fraction of total emissions by 2030. Off-road mobile emissions, including aircraft, watercraft, trains, small equipment, forklifts and farm equipment, have declined by over a third since 2000, and are projected to decrease by another half by 2030.

However, meeting the 2030 anthropogenic black carbon emission target identified in this SLCP Strategy requires additional emission reductions across multiple sectors. Off-road mobile sources, along with stationary fuel combustion and residential wood burning, will make up the majority of emissions by 2030 (Figure 3). Additional 2030 reductions will be realized through implementation of measures identified in plans currently being developed, including the State Implementation Plans (SIPs). Additional reductions are also expected through a district-lead commercial cooking regulation, but the magnitude of emission reductions is currently unknown.

Figure 3: California's 2030 Anthropogenic Black Carbon Emission Sources with Existing Measures*



*Using 20-year GWP

B. Recommended Actions to Further Reduce Black Carbon Emissions

This section describes proposed new measures (summarized in Table 7 below) to assist the State in meeting the proposed 2030 anthropogenic black carbon emission target.

Table 7: Proposed New Black Carbon Emission Reduction Measures and Estimated Emission Reductions ($MMTCO_2e$)[1]

Measure Name	2030 Annual Emission Reductions	2030 Annual Emissions
2030 BAU[2]		**26**
Residential Fireplace and Woodstove Conversion	3	
State Implementation Plan Measures, and Clean Energy Goals[3]	4	
2030 BAU with new measures		**19**

[1]Using 20-year GWPs from the 5th Assessment report of the IPCC
[2]Business As Usual (BAU) forecasted inventory includes reductions from implementation of current regulations
[3]Additional black carbon reductions will be realized from planned measures and are expected to help the State meet the black carbon target. However, an estimate of emission reductions is not currently available, but will be developed as part of these planning efforts.

Residential Fireplace and Woodstove Conversion Measure

Residential wood combustion is forecast to be the largest individual anthropogenic source of black carbon in 2030 if no new programs are implemented, accounting for a quarter of anthropogenic black carbon emissions. Reducing 2030 residential wood combustion black carbon emissions by half (3 $MMTCO_2e$) would set California on a path toward meeting the 2030 target in this SLCP Strategy.

Removal of old fireplaces and woodstoves and replacement with EPA-Certified wood-burning devices, electric heaters, or gas fireplaces can provide long lasting reductions in emissions of black carbon, criteria pollutants, and air toxics in residential neighborhoods. Conversion to electric heating or gas fireplaces provides more certain emission reductions than conversion to certified wood-burning devices. While certified wood-burning devices reduce fine particulate emissions, certification values may not correlate well with in-home performance of wood heaters,[111] and emission reductions are not as large as for non-wood technologies. Electric heating or gas devices (including central HVAC) ensure local reductions of particulate matter, black carbon and air toxics. To protect public health and use incentive dollars efficiently, non-wood burning devices should be prioritized where possible. If wood burning devices are used, they should be the cleanest available technologies, currently those adhering to the 2020 EPA emission standard. Some areas may require the use of wood burning equipment for safety, especially areas that experience heavy snow which traps residents in homes, and where distributed natural gas is not available or electricity loss is frequent. Additionally, natural gas, propane, or electricity may cost

[111] U.S. EPA (2016). Process for developing improved cordwood test methods for wood heaters. https://www.epa.gov/burnwise/process-developing-improved-cordwood-test-methods-wood-heaters

more than wood in some regions, placing an additional financial burden on homeowners.

Monetary incentives to stimulate removal of old wood burning devices are popular and can achieve significant emission reductions. Incentive programs should prioritize replacing the highest emitting devices used for primary sources of residential heating. Removed wood burning devices should be destroyed and recycled to ensure permanent emission reductions. Multiple air districts have invested in incentive programs, but additional funding is necessary to continue to realize emission reductions in this category. In addition, programs should be expanded to include all regions of California. Incentive funding to support further district efforts could come from a variety of national, State, and local resources. Assembly Bill 1613 includes Cap-and-Trade expenditures of $5 million from the Fiscal Year 2016-2017 budget for a residential woodstove replacement incentive program.

The ARB is proposing to work with the air districts to determine the most effective approach to avoid new residential wood combustion emissions in California. This could include encouraging the installation of non-wood burning centralized heating in new construction. In areas where central heat is cost-prohibitive, the cleanest available burning technology could be required.

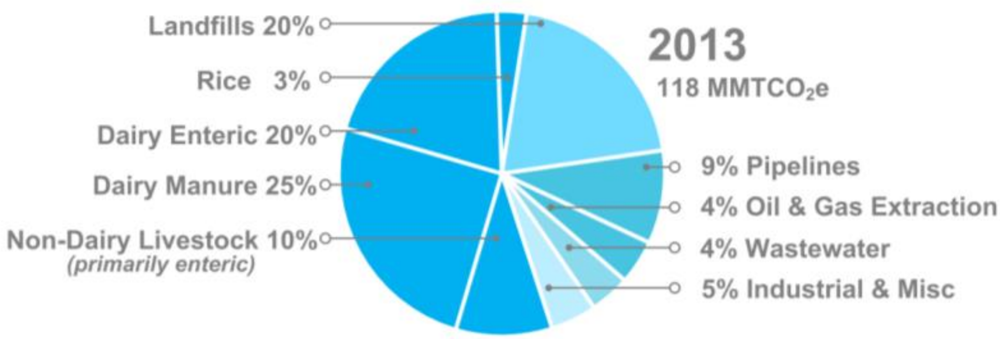
Education and outreach are important tools to reduce emissions from residential wood combustion. A broader public understanding of the health and environmental impacts of wood smoke may cause voluntary changes in behavior to use other heating sources and may cause individuals to avoid unnecessary burning both indoors and outdoors. Education on proper burn practices may reduce emissions when wood is used, and is essential to achieve full emission reductions from EPA-Certified wood burning devices. Some districts have already implemented education programs, which should be expanded to all parts of the State as part of this measure.

V. Reducing Methane Emissions

Methane is emitted from a wide range of fugitive sources and biological processes, and is the second largest source of GHG emissions globally. Methane emissions are growing globally as a result of human activities related to agriculture, waste handling and treatment, and oil and gas production. Agriculture represents the largest methane source in California, accounting for nearly 60 percent of methane emissions (Figure 4). Landfills are the next largest source of methane, accounting for a fifth of statewide methane emissions. Pipeline leaks, oil and gas extraction, wastewater, and other industrial and miscellaneous sources make up the remainder of emissions. As California relies on natural gas for a large fraction of its energy supply, it is critical to increase supplies of renewable natural gas and minimize fugitive emissions of methane from natural gas infrastructure.

In California, where natural gas may increasingly fuel trucks and heavy-duty vehicles, we must ensure that the use of natural gas provides a climate benefit compared to the diesel fuel it displaces. As we increase the number of facilities producing and using renewable supplies of natural gas, hydrogen, or other fuels in a cleaner energy economy, we must also take steps to minimize potential methane leaks from those facilities. ARB and other agencies are funding research to identify high-methane "hot spot" emitters in the oil and natural gas sector and other sectors throughout California.

Figure 4: California 2013 Methane Emission Sources*



* Using 20-yr GWP

California can cut methane emissions by 40 percent below current levels in 2030 by avoiding or capturing methane from manure at large dairies, pursuing opportunities to reduce methane emissions from enteric fermentation, significantly reducing disposal of organics in landfills, and reducing fugitive methane emissions by 40 percent or more from other sources.

A. Progress to Date

The State has taken important steps to reduce methane emissions from all its major sources, but more needs to be done to control methane emissions, especially from organic waste streams going to landfills and at dairies. In addition to reducing methane emissions from these sources, capturing methane can provide fuel for power plants, buildings, vehicles and industrial operations to displace fossil-based natural gas use.

Technologies to recover methane are already widely available and used in key sectors. For example, some methane emissions from landfills, wastewater treatment facilities or from manure at dairies are already captured and used as a renewable source of natural gas to fuel vehicles or generate electricity. Some organic materials, such as food waste and yard trimmings, are being redirected from landfill disposal to anaerobic digestion and composting facilities to produce renewable energy, fuel and soil amendments. Steps are also being taken to reduce natural gas leaks from oil and gas wells, pipelines, valves, and pumps to improve safety, avoid energy losses, and reduce methane emissions associated with natural gas use.


Gas flow meter for natural gas made at a dairy digester

In addition to ongoing efforts and practices to reduce and use captured methane for beneficial purposes, several recent legislative and regulatory actions will further support the reduction or capture of methane within these sectors. These actions prioritize diverting organic material from landfills and include incentivizing the use of biogas for transportation fuel, pipeline injection, or electricity generation. For example, aside from the provisions in Senate Bill 1383:

- California has established clear goals to reduce waste disposal, and divert organic material from landfills for beneficial purposes. AB 341 (Chesbro, Chapter 476, Statutes of 2011) established a State target to reduce the amount of solid waste sent to landfills by 75 percent by 2020, through recycling, composting, and source reduction practices. The 2014 Scoping Plan Update calls for eliminating the disposal of organic materials at landfills, which would potentially eliminate future methane emissions from landfills.

- The Legislature recently took steps to further increase the diversion of organic materials from landfills. AB 1826 (Chesbro, Chapter 727, Statutes of 2014) requires businesses generating specified amounts of organic wastes to begin arranging for the recycling and diversion of those wastes from landfill disposal beginning in 2016. CalRecycle will provide an annual public update on the disposal, diversion, and recycling of organics, beginning in 2016, pursuant to this mandate. AB 1594 (Williams, Chapter 719, Statutes of 2014) re-classifies the use of green waste for landfill “alternative daily cover” as disposal, beginning in 2020. AB 876 (McCarty, Chapter 593, Statutes of 2015) requires local governments, beginning August 2017, to assess the amount of organic waste that will be generated in a region during a 15-year period and identify locations for new or expanded organic waste recycling facilities capable of handling this material. AB 1045 (Irwin, Chapter 596, Statutes of 2015) directs CalEPA and CalRecycle to coordinate with ARB, the State Water Resources Control Board, and CDFA to develop and implement policies to aid in diverting organic waste from landfills by promoting the composting of organic waste and by promoting the appropriate use of that compost throughout the State. SB 1383 requires CalRecycle to develop regulations that will reduce disposal of organic waste by 50 percent of 2014 levels in 2020 and by 75 percent of 2014 levels in 2025.

- Methane emissions from landfills are controlled under ARB's Landfill Methane Control Measure, which was approved in 2009. The regulation complements previously existing federal and local air district landfill rules by requiring owners and operators of certain previously uncontrolled municipal solid waste landfills to install gas collection and control systems, and requires existing and newly installed gas and control systems to operate in an optimal manner. The regulation allows local air districts to voluntarily enter into agreements with ARB to implement and enforce the regulation and to assess fees to cover costs.

- Senate Bill 1122 (Rubio, Chapter 612, Statutes 2012), directs the California Public Utility Commission (CPUC) to require the State's investor owned utilities to develop and offer 10 to 20 year market-price contracts to procure an additional 250 megawatts of cumulative electricity generation from biogas facilities that commence operating on or after June of 2013. Eligible projects and sources include biogas-generated electricity from wastewater treatment, municipal organic waste, food processing, dairy manure and agricultural organic material, and sustainable forest materials.

- The Low Carbon Fuel Standard (LCFS) requires transportation fuel providers to procure clean fuels to reduce the carbon intensity of California's fuel mix. In doing so, it provides a market signal to incentivize developing clean fuel options, including capturing or avoiding methane emissions and using associated renewable natural gas as a transportation fuel. Some LCFS pathways related to renewable natural gas have the lowest carbon intensities of pathways to date. Specifically, the production of biomethane from high solids anaerobic digestion of organic (food and green) wastes has a carbon intensity of -15 gCO_2/MJ, and a recently approved pathway for biogas from a dairy digester project has a carbon intensity of -276 gCO_2/MJ. If LCFS credit prices are $100/MT, as they have been recently, the value of LCFS credits from these pathways is about $1.50 per diesel-gallon equivalent and $5.00 per diesel-gallon equivalent, respectively (or about $11/MMBtu and $36/MMBtu of natural gas, respectively). Transportation fuel derived from biogas may also qualify for Renewable Identification Number (RIN) credits as part of the U.S. EPA Renewable Fuel Standard 2, which could add additional value to these types of projects.

- Assembly Bill 1900 (Gatto, Chapter 602, Statutes of 2012) directed the CPUC to adopt natural gas constituent standards (in consultation with ARB and the Office of Environmental Health and Hazard Assessment). The legislation is also designed to streamline and standardize customer pipeline access rules, and encourage the development of statewide policies and programs to promote all sources of biomethane production and distribution. It also directs the CEC to identify constraints to the use and interconnection of biomethane and offer solutions in its Integrated Energy Policy Report. The CPUC has adopted natural gas constituent standards and created a program to offset a portion of gas producers' costs of connecting to utility pipelines. This program is currently funded at $40 million, and may offset half of interconnection costs, up to $3 million per project or $5 million for a dairy cluster project, per Assembly Bill 2313 (Williams, Chapter 571, Statutes of 2016). Assembly Bill 2313 also requires the CPUC to extend this program through December 31, 2016.

- Pursuant to Assembly Bill 1257 (Bocanegra, Chapter 749, Statutes of 2013), the CEC has released a report identifying strategies for maximizing the benefits obtained from natural gas as an energy source.[112] The report examines strategies and recommendations regarding natural gas, including low emission resources such as biogas and biomethane; the use of natural gas as a transportation fuel; centralized and distributed electricity generation; cooking, cooling, and space heating; engine and appliance applications; its role in the development of zero net energy buildings; and GHG emissions associated with the natural gas system. The report also examines infrastructure and storage needs and pipeline and system reliability concerns.

- ARB's Cap-and-Trade Program will reduce demand of fossil fuels and provide incentives to accelerate efficiency and clean energy. Compliance Offset Protocols under the Cap-and-Trade Program provide methods to quantify, report, and credit GHG emission reductions from sectors not covered by the Cap-and-Trade Program. The Offset Protocols include a livestock protocol, rice cultivation protocol, and mine methane capture protocol.[113] The livestock protocol credits operators who voluntarily install manure biogas capture and destruction technologies. The rice protocol allows compliance offset credits to be issued for emission reductions achieved by switching to rice cultivation

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[112] *AB 1257 Natural Gas Act Report: Strategies to Maximize the Benefits Obtained from Natural Gas as an Energy Source*, California Energy Commission, September 2015. https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=15-IEPR-04

[113] As is discussed in more length in the CEQA document accompanying this document, the livestock offset protocol would likely cease accepting new projects for offset credits after the effective date of substantive regulations controlling agricultural methane from dairies; however, existing projects could continue generating credits throughout their crediting periods. ARB expects this continued funding stream, along with increased focus on regulatory and incentive measures in this area, to mean many projects now receiving offsets to continue functioning at the end of the crediting period; this, along with new regulations, will produce significant net reductions in methane even if some offset projects cease to function. This transition from offset protocols towards regulations has long been ARB policy.

practices that reduce methane emissions. The mine methane capture protocol incentivizes capturing methane that would otherwise be vented into the atmosphere from active and abandoned mines.

A broad array of these and other state programs reducing dependence on fossil fuels are also already working to reduce methane emissions, especially from the oil and gas sector. Ultimately, fugitive methane emissions in the oil and gas sector are a function of our demand for these products. As state policies continue pushing reductions in overall energy use and our evolution away from conventional oil and natural gas, they will also help to reduce emissions of methane from the production and distribution of fossil fuels. In particular, efforts to improve efficiency or electrify appliances, buildings, and vehicles will not only reduce energy use and CO_2 emissions, but also serve to reduce or avoid fugitive methane emissions from the production, and potentially transmission and distribution, of oil and natural gas.

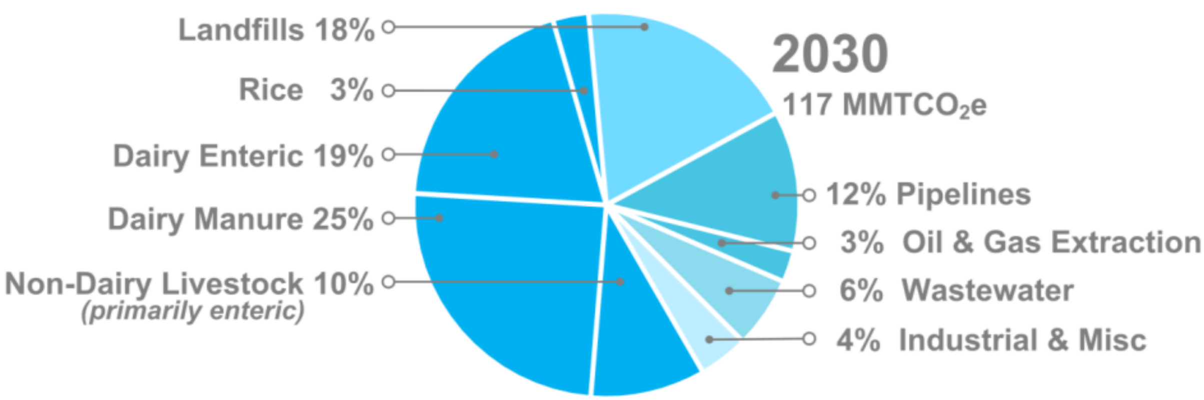
The State has strong targets to reduce the use of natural gas and petroleum by 2030, and several studies show that California must virtually eliminate the use of all fossil fuels to meet its 2050 climate targets. Notably, Governor Brown has called for reducing on-road petroleum use by up to 50 percent by 2030, and Senate Bill 350 (De León, Chapter 547, Statutes of 2015) requires the State to procure 50 percent of its electricity from renewable resources by 2030 and double the rate of natural gas and electricity efficiency savings. ARB's 2016 Mobile Source Strategy describes actions to achieve the State's air quality and climate targets from the transportation sector, and cut petroleum use by 50 percent by 2030. The State's Low Carbon Fuel Standard is sending a clear signal to the market that is leading to investment and use of a broad spectrum of cleaner transportation fuels in California including electricity, biogas, as well as biodiesel and renewable diesel, all of which are displacing petroleum. Further, the State's Cap-and-Trade Program encourages efficiency and use of non-fossil energy sources across all sectors of the economy, and various programs provide billions of dollars in incentives to support energy efficiency throughout the State.

Effectively implementing these actions and programs will significantly cut demand for fossil fuels and associated CO_2 emissions on trajectories we need, while further reducing methane emissions from oil and gas systems. As State agencies implement and refine these programs and plans, they will seek opportunities to better align them with these objectives. Additionally, State agencies will support research to inform appropriate approaches to continue its transition away from fossil fuels.

Further, several efforts are underway at the CEC and ARB to improve emissions monitoring to help identify sources of fugitive methane emissions and reduce them. For example, the CEC provided research funding for operation of a mobile leak detection platform. In 2017, ARB will release a Request for Proposal (RFP) to collect emissions data from oil production wastewater ponds. Results from this contract are expected in 2018-2019, and if they indicate that these ponds are significant sources of methane, ARB may initiate a regulatory process to reduce those methane emissions. Additionally, ARB and NASA's Jet Propulsion Laboratory are collaborating to identify large "hot spot" methane sources through a systematic survey of high methane emitters throughout California. This project will use aerial and ground measurement to survey oil and gas fields and infrastructures, dairies, feedlots, digesters, landfills, rice fields, and wastewater treatment facilities to provide a greater understanding of methane sources. Additionally, Assembly Bill 1496 (Thurmond, Statues of 2015, Chapter 604) requires ARB to undertake monitoring and measurements of high-emission methane "hot spots" and conduct lifecycle GHG emission analysis for natural gas produced in and imported into California. Finally, ARB is actively participating in the Megacities Carbon Project being conducted in the South Coast Air Basin, which is developing and testing methods for monitoring various GHG emissions to link monitored concentrations to emission activity. These efforts will help identify significant fugitive methane sources in California and improve leak detection.

Collectively, these measures will help to keep methane emissions in California fairly steady through 2030. However, the science-based pathway to limiting global warming below 2^{o}C—including meeting the State's goal to reduce GHG emissions by 40 percent below 1990 levels by 2030—requires further reducing methane emissions in California. Significant opportunity remains to further reduce methane emissions from the major sources in the State (Figure 5). Doing so will require overcoming various economic and institutional barriers, but will provide a wide range of economic and environmental benefits throughout the State, especially where they are most needed.

Figure 5: California's 2030 Methane Emission Sources with Existing Measures*



*Using 20-year GWP

B. Recommended Actions to Further Reduce Methane Emissions

California can reduce methane emissions by 40 percent below current levels through a collaborative and mixed approach that combines incentives, public and private investment and partnerships, systematic planning, and regulatory efforts. California's strategy to reduce methane emissions reflects and supports the variety of approaches and options available to achieve the goal in the most efficient, cost-effective, and environmentally-sensitive manner. This SLCP Strategy promotes and encourages opportunities for industry innovation, the efficient use of existing infrastructure and facilities, and supports the development of integrated systems across various sectors to handle, process, and reuse waste materials and captured methane. For example, significant anaerobic digestion and additional composting infrastructure capacity needs to be established and expanded, and appropriate market opportunities need to be developed for compost and captured methane before the State can fully use existing organic waste streams for beneficial purposes. State agencies will work with industry and other stakeholders to support and accelerate new project development and activities to maximize methane emission reduction at existing facilities. The State will also work with communities and regional stakeholders to plan and develop integrated infrastructure systems and markets to reduce wastes and associated emissions in the most environmentally-sensitive manner. By investing early and committing to the immediate resolution of issues that hinder progress, California can make significant progress in the near-term, and capture associated benefits.

There are a host of activities underway at the State and Federal level, and by gas utilities, to reduce methane emissions from the natural gas system. In particular, regulations are being developed to reduce fugitive methane emissions from the oil and gas production, processing and storage sector, and from the natural gas transmission and distribution system. By effectively implementing these policies, and supporting them with continued and improved emissions monitoring, California can match the federal government's goals to reduce methane emissions from the oil and gas sector by 40-45 percent by 2025. The State will aim to extend successful approaches to reduce emissions from the oil and gas sector to other sectors, and overall, to reduce fugitive methane emissions from all sources by similar levels by 2030.

Table 8, below, identifies emission reductions by sector to reduce economy-wide methane emissions by 40 percent below current levels by 2030. The expected 2030 annual emission reductions for each sector are based on: 40 percent reduction in dairy and livestock sectors' emissions from 2013 levels by 2030; 50 percent diversion of organic waste by 2020 and 75 percent diversion of organic waste by 2025 from 2014 levels; 40 percent reduction of wastewater and other industrial sources methane by 2030; and 45 percent reduction of oil and gas methane by 2030. The emission estimates in the table are based on currently available information and projections. They may change as new information becomes available or as measures are more fully developed.

Table 8: Proposed New Methane Emission Reduction Measures and 2030 Estimated Emission Reductions ($MMTCO_2e$)[1]

Measure	2030 Annual Emission Reductions	2030 Annual Emissions
2030 BAU[2]		**117**
Dairy and Other Livestock (Manure and Enteric Fermentation)	26	
Landfill	4	
Wastewater, Industrial and Other Miscellaneous Sources	7	
Oil and Gas Sector	8	
2030 BAU with new measures		**71**[3]

[1] Using 20-year GWPs from the 4th Assessment report of the IPCC
[2] "Business As Usual" (BAU) forecasted inventory includes reductions from implementation of current regulations
[3] The specific annual reduction values shown above do not sum exactly to the total shown due to rounding error.

1. Dairy Manure

California's dairy and livestock industries account for more than half of the State's total methane emissions and for about five percent of the State's GHG inventory, based on 100-year GWPs (using 20-year GWPs, the industries account for about 12 percent of California's GHG emissions). Twenty-five percent of the State's methane emissions comes from manure management practices at dairies, primarily from lagoon storage of flushed manure from the State's milking cows. Nearly 20 percent of the State's methane emissions come from enteric fermentation (mostly belching) of dairy cows, and another ten percent comes from enteric fermentation of non-dairy livestock (primarily other cattle).

California has the most dairy cows in the country and the highest aggregated (from manure management and enteric fermentation) dairy methane emissions. The State also has higher per-milking cow methane emissions than most of the rest of the United States, due to the widespread use of flush water lagoon systems for collecting and storing manure. Milk production feed efficiency at California dairies, however, is among the best in the world, making enteric fermentation emissions per gallon of milk from California dairy cows relatively low.

Senate Bill 1383 directs ARB to develop a manure management strategy that will reduce dairy and livestock sector methane emissions by up to 40 percent from 2013 levels by 2030. In doing so, SB 1383 recognizes the importance of addressing California's largest source of methane and the opportunity presented by modifications to manure management practices (See Appendix B). Manure management at dairies offers one of the greatest opportunities to reduce methane emissions from these sectors (methane from manure management at California's non-dairy livestock operations comprise less than five percent of overall manure methane). Accordingly, California will aim to structure incentives, policies, regulations, and research to support significant methane emission reductions from dairy manure management. The extent to which regulations will be needed in achieving these reductions will be evaluated and may be adjusted as necessary, commensurate with the SB 1383 provisions.

Through this SLCP Strategy and related efforts, we have a tremendous opportunity to work with the industry to reduce methane emissions from the State's largest source, while creating economic value in farming communities. If markets are fully enabled, efforts to reduce methane from manure management at California dairies could lead to billions of dollars of investment and thousands of new jobs, concentrated in the Central Valley. Depending on the strategies pursued to reduce emissions, individual dairies may be able to reduce emissions while generating new revenue streams, and the industry as a whole may be able to meet the targets established in this SLCP Strategy at little or no net cost (see Chapter VIII).

However, revenues in some cases are highly dependent on environmental credit and energy markets, as well as on improving access to the common carrier natural gas pipeline system. Recent legislation, including SB 1383 and AB 2313, establish frameworks and priorities to help address these potential barriers. SB 1383 requires ARB, CPUC, and CEC to institute measures to increase the economic certainty associated with environmental credit generation and to encourage development of dairy RNG projects and associated infrastructure. Additionally, AB 2313 increases utility incentives to help offset costs of pipeline interconnection, especially for projects from dairy clusters. And AB 1613 commits $50 million in Cap-and-Trade funds to support methane reductions at dairies during the 2016/2017 fiscal year.

Ultimately, a mix of tools will be used to reduce methane emissions from dairy and livestock manure management. The process for developing strategies will be built around extensive stakeholder involvement, consistent with SB 1383, AB 32 and other relevant laws. Among other factors, the process to develop recommended strategies will require close coordination with the dairy industry and will consider public input; available financial incentives; technical, market, and regulatory barriers to the development of dairy methane emission reduction projects; research on dairy methane emission reduction projects; and the potential for emissions leakage, as well as steps to minimize any leakage that might otherwise occur.

Among the emission reduction measures ARB, CDFA, and stakeholders will consider in developing these strategies are the following:

Switching from Flush Water Lagoon Systems

Dairy methane emissions may be significantly reduced by switching from flush water open lagoon systems to anaerobic digesters or other systems such as solid manure management practices. Using solid (e.g. slurry vacuum or scrape) manure systems with a digester (e.g. plug-flow, above ground tank) can enable easier transport and storage of manure off-site or to centralized digester systems. The benefits can include improved economies of scale, biogas production efficiencies, nutrient management, water efficiency, and water quality compared to flush systems paired with flood irrigation systems. Dairy manure can also be mixed with other organic materials—such as those diverted from landfills or processed at wastewater treatment plants—to improve digester performance and economics. Centralized digesters designed and sited so as to efficiently process these waste streams can play a key role in helping California meet its organic diversion and climate goals.

Dairies with flush water lagoon systems typically flood irrigate dairy feed crops, such as corn silage and alfalfa, to dilute and disperse nutrients from manure in the lagoon. This practice can lead to soil and groundwater contamination despite being subject to regulation by regional water quality control boards, including the Dairy General Order in the Central Valley. Some agricultural practices have historically led to legacy pollutants contaminating groundwater, which could continue if unabated. To address this, regional water boards issue waste discharge requirements that include development and implementation of nutrient management plans, water quality monitoring, and corrective actions when impairments are found. Switching to systems such as solid manure management may lead to air or water quality challenges, however, which need to be fully considered. Ultimately, the optimal mix of technologies and manure management practices to reduce methane emissions, protect air and water quality, and support dairy economics will depend on dairy- and location-specific factors.

Pasture-Based Dairy Management

In some instances, pasture-based systems may be a viable option, but tradeoffs can limit their feasibility. In a pasture system, manure decomposes aerobically, avoiding all but trace amounts of methane emissions, though potential nitrogen impacts may arise. Many organic milk producers rely on pasture systems, and pasture systems are commonly used in other states and at smaller dairies in the coastal and northern parts of California. For larger dairies and those in the Central Valley, pasturage would require using significantly more irrigated land, may require supplemental feed, and (in the case of Central Valley dairies) may require construction of shade structures and other infrastructure to alleviate heat exposure-related impacts on animal welfare. Pasture dairies may face potential nutrient management and water quality issues, and are required to maintain the capacity to store liquids from milking parlor operations (chilling milk, cleaning facilities, etc.) for a 100-year stormwater event. Additionally, milk production and feed efficiencies are lower in pasture systems, requiring more cows to produce the same amount of milk. Pasture systems also limit the ability to manage manure as a valuable organic waste resource.

While there are potential limitations to using pasture dairy models, there may also be potential benefits associated with these systems that need further evaluation. Among these potential benefits are improved animal welfare, lower on-farm air emissions, improved aesthetics, and reduced impacts to water quality. Further evaluation of pasture systems can fully characterize their potential benefits, costs and limitations relative to conventional dairy models. Additionally, hybrid models that employ aspects of both pasture and conventional systems should also be investigated for their potential benefits and impacts for dairy and livestock operations.

Installing Anaerobic Digestion Systems

Dairy operators may determine that capturing and utilizing manure methane by installing an anaerobic digestion system is more advantageous than avoiding methane emissions through conversion to practices such as a pasture-based dairy model, providing the current barriers can be sufficiently addressed. Captured biogas from dairy manure can be used to power farm trucks and equipment, upgraded for injection into natural gas pipelines, used as a transportation fuel, or used to generate on-site renewable electricity and heat. However, tapping into this resource in California has been complicated in part due to air quality constraints, especially in the Central Valley and Southern California. Utilizing newer, cleaner technologies can help to overcome the air quality permitting issues that have previously hindered project development. In particular, technologies or strategies that reduce or eliminate criteria pollutant and toxic emissions should be encouraged in both incentive and regulatory programs, particularly in areas with severe or extreme air pollution. Using ARB-certified distributed generation technologies, such as microturbines or fuel cells, can significantly cut NO_x emissions compared to internal combustion-based power generation. Injecting upgraded biomethane into the natural gas pipeline can avoid most new combustion or associated emissions. As part of an integrated strategy that includes replacing diesel trucks and equipment with certified ultra-low NO_x equipment, fueling vehicles with dairy-derived biomethane could help to reduce criteria pollution in impacted air basins.

Given existing incentives and complementary climate and energy programs, manure-management conversions that produce electricity and vehicle fuel are potentially profitable; however, most require significant up-front capital investment. Among the most promising are those that produce biomethane for injection into a common-carrier pipeline. This approach involves construction of connecting pipeline segments, and installation of biogas upgrading equipment capable of meeting the pipeline-quality biomethane standards developed in response to AB 1900 (Gatto, Chapter 602, Statutes of 2012). While these barriers have not been overcome completely, AB 2313 and SB 1383 clearly demonstrate the State's commitment to developing policies to encourage infrastructure development and procurement of biomethane from dairy biogas projects.

In consideration of potential emission reduction measures, including those described above, the State will encourage and support research and near-term actions by dairies to reduce emissions through market support and financial incentives. Initially, as the recently appropriated $50 million in Cap-and-Trade funds become available, the State will incorporate lessons learned from previous incentive programs to improve the effectiveness and efficiency of new incentives, while overcoming persistent barriers and challenges. At the same time, ARB will initiate a rulemaking process, pursuant to SB 1383, to develop regulations for reducing dairy and livestock manure emissions in California. The process will include considering research on manure management practices and developing reporting and recordkeeping regulations to improve California-specific data and ARB's GHG emission inventory. This information will shape the emission control regulations pursuant to this SLCP Strategy, along with information obtained through other collaborative efforts. This coordinated approach will aim to develop a competitive, low-carbon dairy industry in California and avoid emissions leakage.

Specifically, California will take the following steps to significantly cut methane emissions from manure management at dairies:

Accelerate Early Project Development through Incentives and Market Development

As provided under SB 1383, the State will support efforts to accelerate project development and help the industry reduce emissions before regulatory requirements take effect. In particular, the State will work to support improved manure management practices through financial incentives, collaboration to overcome barriers, and other market support.

Continued State funding or incentives should support initial infrastructure investments to secure methane emission reductions, support future low-carbon biomethane utilization goals, increase resource use efficiency (e.g. conserve water), improve nitrogen application precision, and support market opportunities for the use of biomethane and soil amendment products. CDFA estimates that at least $100 million will be needed for each of the next five years to support the development of necessary manure management infrastructure in the form of grants, loans, or other incentives. The economic analysis in Chapter VIII suggests that this level of funding could significantly accelerate project development by offsetting capital costs and economic risks. The SB 1383 requirement that ARB develop a pilot financial mechanism to reduce the economic uncertainty associated with the value of environmental credits from dairy-related transportation fuel projects should further accelerate project development. Different types of funding mechanisms and levels of support may be appropriate for different types of projects.

ARB, CDFA, State Water Resources Control Board, and Regional Water Quality Control Boards' staff will establish a working group with other relevant agencies and stakeholders to focus specifically on developing measures to overcome the barriers that have constrained dairy manure projects in the past. The group will aim to monitor, ensure, and accelerate market and institutional progress and report its findings to the Legislature. It may cover several topics, including: project finance, permit coordination, CEQA, feed-in tariffs, simplified interconnection procedures and contracts, credits under the LCFS, increasing the market value of manure products, and uniform biogas pipeline standards. This group will be coordinated with similar working group efforts related to anaerobic digestion, composting, energy, healthy soils, and water. Additionally, State agencies will coordinate activities with federal agencies, including the U.S. Department of Agriculture and U.S. Department of Energy, to align common efforts and attract federal investment to California. Further, ARB will work with State and regional water quality agencies to capitalize on opportunities for joint development of measures that conserve water and improve water quality. Similarly, ARB will work with the air districts to ensure opportunities for air quality efforts are developed jointly.

In many cases, converting to solid manure management systems or installing anaerobic digesters at dairies may not yet be cost-effective if the only marketable products are renewable electricity and/or renewable natural gas. If these revenue streams can be augmented with revenues from compost or other soil amendment products, and from environmental credits, these conversions may offer attractive rates of return for farmers and investors.[114] However, markets for these other products need further support before they can offer returns that are reliable enough to help secure project financing. CalRecycle, CDFA, and other agencies are working together to support healthy soils through composting and building markets for soil amendment products in the State. Enabling pipeline injection of biomethane and minimizing associated costs will help direct dairy biogas into the transportation sector and allow for the generation of LCFS and RIN credits, which could provide an especially valuable revenue stream.[115] The State will continue to support these efforts.

Research the Reduction Potential of Manure Management Practices

While the need and potential to reduce methane emissions from dairy manure is clear, some potentially effective strategies are still in the development stage. ARB will work with other state agencies through the Climate Action Team Research Working Group, the dairy industry, and other stakeholders to establish mechanisms to identify and fill information gaps, as required by SB 1383. In particular, SB 1383 directs the agencies to consider research about the emissions-reduction potential of solids separation, enteric fermentation, and conversion of flush systems to solid manure management

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[114] For example, one report estimates that the average internal rate of return for dairy digester projects in the U.S. that only capture value from energy production would be about 8 percent in a mid-valuation scenario, but would increase to 38 percent if value can be captured from soil amendments and markets for environmental credits.
Informa Economics (2013) National Market Value of Anaerobic Digester Products, Prepared for the Innovation Center for U.S. Dairy, February.
[115] Under the LCFS, ARB recently approved a dairy digester fuel pathway with a carbon intensity of -276 gCO_2e/MJ. http://www.arb.ca.gov/fuels/lcfs/2a2b/apps/calbio-sum-122115.pdf
At credit prices of $100/MT, these credits could be worth about $5 per diesel gallon equivalent.

systems. However, little data exists to quantify costs and benefits associated with these practices. Additionally, some uncertainty remains regarding cross-media impacts and appropriate emissions-accounting methods. ARB and CDFA will continue to support research to eliminate information gaps and improve understanding of potential manure management practices and their associated methane reduction benefits, as well as potential air quality or water quality impacts.

Develop Regulations to Ensure Emission Reductions

In coordination with CDFA and local air quality and water quality agencies, ARB will initiate a rulemaking process to reduce manure methane emissions from the dairy sector consistent with the objectives in this SLCP Strategy. As noted earlier, the rulemaking process will involve extensive stakeholder engagement and consideration of multiple factors. The regulations are to be implemented on or after January 1, 2024. Pursuant to SB 1383, ARB, in consultation with CDFA, will analyze the progress dairies are making in achieving the goals in the Strategy by July 1, 2020, and may make adjustments to those goals if sufficient progress has not been made.

The rulemaking process will first focus on developing measures to require regulated parties to both report and maintain records covering the parameters that affect GHG emissions at California dairies and other livestock operations. Reported information will be used to refine inventory quantification, evaluate policy effectiveness, assess methane reduction progress, and aid in future policy planning and regulatory development. ARB will work with other State agencies and industry groups to improve outreach on new reporting requirements, as well as merge reporting activities with current forms and requirements to avoid duplicative reporting wherever feasible.

Emission control regulations will be designed to support and complement existing programs. In particular, regulatory requirements to achieve large emission reductions from the sector will affect incentives for methane reduction projects, such as the availability and amount of credits under the Cap-and-Trade Program and LCFS. Once the regulatory requirements are in effect, credits for avoided methane emissions under the LCFS or the Cap-and-Trade Programs would not be available for new projects as the reductions would not be additional to regulation (which becomes the business-as-usual case). However, projects in place before the new requirements take effect would still be able to generate credits for avoided methane emissions for their current crediting period, which is ten years of operation. After a regulation takes effect, credits for new projects under the LCFS would still be available, but would be based only on the displacement of petroleum fuel. ARB will clarify the impact of potential regulations and provide guidance on LCFS credits by January 1, 2018, as required by SB 1383, and will make appropriate adjustments to the Cap-and-Trade Program to ensure only reductions that meet the AB 32 offset criteria are credited. Sufficient lead time will be provided before regulatory requirements take effect to allow the market to react.

2. Dairy and Livestock Enteric Fermentation

Methane is also produced by the microorganisms involved in the digestive processes in the stomachs of dairy cows and other ruminants, such as sheep, goats, buffalo and cattle. This process is referred to as enteric fermentation. These emissions account for approximately 30 percent of California's methane inventory, making it important to explore strategies to reduce emissions from these sources to meet the State's 40 percent economy-wide methane emission reduction target.

Strategies that have been investigated to reduce enteric fermentation include increasing production efficiencies to reduce the amount of methane produced for a given amount of product, breeding animals for lower methane production, gut microbial interventions, and changes to nutrition and animal management. Various studies are pointing to new feed supplements or dietary changes that show potential for reducing enteric fermentation emissions significantly without affecting milk production.[116,117] However, further research is needed to validate initial findings, fully evaluate the viability of these strategies to California, assess their associated costs and co-benefits, potential impacts on animal productivity, effects on animal and human health, other environmental impacts, and GHG and air toxic emissions associated with feed lifecycles.

The Legislature recognized the important role of enteric fermentation emission reductions in meeting the goals in SB 1383 by requiring consideration of enteric fermentation research, allowing voluntary reductions to be considered in the design of dairy and livestock emission reduction measures, and by providing that these reductions count towards economy-wide methane emission reductions targets. It also recognized the limited available information and potential impacts associated with achieving enteric fermentation emission reductions, allowing only incentive-based approaches to these reductions until ARB, in consultation with CDFA, determines that cost-effective and scientifically validated methods for reducing enteric emissions are available. In addition, adoption of an enteric emission reduction method must not compromise animal health, public health, or consumer acceptance of dairy products.

Research Mitigation Strategies for Enteric Fermentation

Federal and State agencies, industry, and academia will collaborate on research and demonstration projects through available funding mechanisms (e.g. ARB's annual research solicitation program and CDFA's Dairy Digester Research and Development Program). As with research on manure management practices, the Climate Action Team Research Working Group can coordinate with other state agencies, the dairy industry, and other stakeholders to develop research on methane reductions from

[116] Hristov et al (2015) An inhibitor persistently decreased enteric methane emission from dairy cows with no negative effect on milk production, *Proceedings of the National Academy of Sciences,* 112**(34)**:10663-10668. www.pnas.org/cgi/doi/10.1073/pnas.1515515112

[117] Moate et al (2014) Grape marc reduces methane emissions when fed to dairy cows, *Journal of Dairy Science,* 97**(8)**:5073-5087. http://dx.doi.org/10.3168/jds.2013-7588

enteric fermentation. In addition, progress will continue to be monitored to develop strategies that can help to reduce enteric fermentation emissions from dairy cows and livestock in the California context. Once mitigation strategies have been successfully evaluated, long-term emission reduction potential and goals can be established on a broader scale.

The schedule for implementing the dairy- and livestock-related directives in SB 1383 is summarized in Table 9.

Table 9: Timeline for Dairy and Livestock Methane Reduction Measures

Action	**Deadline**
ARB approves SLCP Strategy and begins Implementation Expected Approval Date Statutory Date	 First Quarter 2017 By January 1, 2018
ARB, CDFA, State Water Resources Control Board and Regional Water Quality Control Boards in coordination with the energy agencies, will work with the dairy industry to establish a dairy workgroup to identify and address barriers to development of dairy methane emission reduction projects	First Quarter 2017 and ongoing
CDFA announces awardees for GGRF grant program for achieving early and extra methane emission reductions from dairy and livestock manure	June 2017 (funds encumbered June 2018)
ARB, in consultation with CPUC and CEC, develops policies to encourage development of infrastructure and biomethane projects at dairy and livestock operations	By January 1, 2018
ARB develops a pilot financial mechanism to reduce LCFS credit value uncertainty from dairy-related projects and makes recommendations to the Legislature to expand the mechanism to other biogas sources	By January 1, 2018
ARB provides guidance on the impact of regulations on LCFS credits and compliance offsets	By January 1, 2018
CPUC, in consultation with ARB and CDFA, directs utilities to develop at least 5 dairy biomethane pipeline injection projects	By January 1, 2018
ARB, in consultation with CDFA, evaluates the feasibility of enteric fermentation methane reduction incentives and regulations and develops regulations as appropriate	Ongoing
ARB, in consultation with CDFA, analyzes and reports on the methane reduction progress of the dairy and livestock sector	By July 1, 2020
ARB begins developing and considers for adoption a manure management methane reduction regulation	Before January 1, 2024
ARB implements a manure management methane reduction regulation	On or after January 1, 2024

3. Landfills

Landfilling organic materials leads to the anaerobic breakdown of these materials into methane, which can work its way out of the landfill as a fugitive emission. Organic waste constitutes a significant portion of California's waste stream, and as with dairy manure, a holistic approach is needed to effectively divert and manage it. This means not only keeping organics out of landfills, either through source reduction or recycling, but also improving the infrastructure for diverting and/or recycling organics, including minimizing and rescuing edible food wastes, composting, anaerobic digestion and other novel processes for energy recovery. In particular, California must have enough in-state composting and in-vessel digestion or other organics processing and recycling capacity to maximize the benefits from this waste stream and effectively minimize the spreading of unprocessed organic waste on open lands, which can have adverse environmental impacts. It also means having markets for this material that are robust and resilient whether as food rescue/recovery, compost, soil amendments, mulch for erosion control, transportation fuels, energy, or other uses. The State can accelerate progress by providing more consistent financial and institutional support for these efforts, and taking steps to align tipping fees, financial incentives, and cross-media regulatory structures in the sector with its organics diversion goals.

Diverting organic wastes can provide a variety of environmental and economic benefits. Food rescue or recovery is the practice of using edible foods that would otherwise go to waste from restaurants, grocery stores, dining facilities, food packing facilities, and produce markets, and distributing it to local food programs. Food recovered from farms, which would otherwise be plowed under, is typically gathered by volunteers. The main benefit of food rescue programs is that they provide healthy foods to those in need, but they also reduce organic waste disposal. Food wastes that may not be easily used for human consumption may alternatively be used as animal feed if it meets all regulatory requirements. Composting returns nutrients to the soil, builds soil organic matter, improves water holding capacity, increases carbon sequestration in the landscape, and avoids the use of fossil fuel-intense inorganic fertilizers. Anaerobic digestion can support the State's efforts to obtain at least 50 percent of its electricity from renewable resources, aid in reducing the carbon intensity of transportation fuels, and displace fossil natural gas consumption. As described in Chapter II, significantly reducing the disposal of organics in landfills as part of a broad effort to put California's organic waste streams to beneficial use can generate thousands of jobs and provide billions of dollars in value, much of it concentrated in the Central Valley and other rural areas.

Eliminating the disposal of organics in landfills would align California with a growing range of efforts to do so in other states and countries. In California, San Francisco and Alameda County require that food waste be separated and kept out of the landfill, and both Los Angeles and San Francisco, along with other cities, have plans in place to achieve zero-waste.

The State has already established its intent to phase out the disposal of organics from landfills. Existing law sets a goal to source reduce, recycle, or compost 75 percent of solid waste by 2020 and provides other measures and requirements to support diverting organics from landfills. California will build on that intent and progress, with market and institutional support, and reduce disposal of organics by 50 percent of 2014 levels by 2020 and 75 percent by 2025. Due to the multi-year timeframe required to breakdown landfilled organic material, emissions avoided by diverting organic material in one year are realized over several decades to come. These actions would reduce landfill emissions by 4 $MMTCO_2e$ in 2030,[118] but one year of waste diversion in 2030 is expected to avoid 14 MMTCO2e of emissions over the lifetime of waste decomposition.

Still, waste-in-place will continue to emit methane for decades to come. California has a Landfill Regulation in place that requires owners and operators of certain uncontrolled municipal solid waste landfills to install gas collection and control systems. This effort has improved management of landfills in California and reduced methane emissions. There may be additional opportunities to employ best practices and further reduce methane emissions from landfills over time.

However, quantifying emissions from landfills is difficult, due to their area-wide nature and several landfill-specific factors (size, age, materials deposited, local atmospheric conditions, soils, landfill cover, and gas collection system). In the GHG inventory, and its climate programs, ARB assumes a methane capture efficiency of 75 percent at landfills. This conforms with common practice nationally. In its Landfill Regulation, ARB estimated that the landfill regulation may increase the collection efficiency at regulated landfills to 80-85 percent.

Estimates of methane collection efficiency at landfills vary widely. In the U.S. EPA landfill database, the weighted average of collection efficiencies at California landfills is 78 percent.[119] However, this data is self-reported and the emission estimation method does not incorporate emission changes due to California's regulation. Additionally, various studies suggest that California's methane inventory is underestimating methane emissions in the State. The source(s) of potential incremental methane emissions has not been identified. Continuing evaluation of major sources of methane in the State is necessary, and this includes landfill emissions.

The State is currently pursuing research opportunities to improve understanding of emissions from landfills and landfill gas collection efficiencies, and will engage stakeholders in potential opportunities to further control emissions from landfills in the

[118] Methane emission reductions from landfills (Table 8) are calculated assuming regulated landfills achieve methane capture efficiencies of 80 percent by 2030, and that an annual organics tonnage amount equal to 50 percent of the organics deposited in landfills in 2014 is diverted from the organics waste stream sent to landfills by 2020, and an annual organics tonnage amount equal to 75 percent of the organics deposited in landfills in 2014 is diverted from the organics waste stream sent to landfills by 2025 (i.e, meeting the organics diversion targets identified in this SLCP Strategy).

[119] The average collection efficiency at California landfills in 2013, according to EPA's database is 76 percent. When weighted by methane generation, the average is 78 percent. http://www3.epa.gov/airtoxics/landfill/landflpg.html

future. Once more is understood about emissions from California's diverse set of landfills, ARB may update the assumptions regarding collection efficiency used in its inventory and various programs and consider whether additional actions, including a "phase 2" of the landfill regulation, would deliver further cost-effective GHG emission reductions.

Uncertainty around landfill emissions does not suggest that the existing Landfill Regulation is not reducing emissions or that steps to divert organics from landfills should be delayed. To the contrary, what is certain is that best management practices at landfills reduce methane emissions, diverting organics from landfills can provide a wide range of economic and environmental benefits in California, and that doing so is the only reliable way to avoid methane emissions from landfills on a lasting basis.

The State will take the following actions to reduce methane emissions from landfills in California:

Require Organics Diversion from Landfills

Food recovery program (City Harvest) delivering produce in New York

CalRecycle, in consultation with ARB, will develop regulations to reduce disposal of organic waste by 50 percent of 2014 levels by 2020 and 75 percent by 2025, as required by SB 1383. These regulations shall take effect on or after January 1, 2022. CalRecycle is planning to adopt the regulations by the end of 2018, so that regulated entities (e.g., jurisdictions, generators, facilities and haulers) have a long lead time to plan budgetary and programmatic changes that will be needed to meet the requirements effective in 2022. Of the edible food in the organic waste stream, not less than 20 percent is to be recovered to feed people in need by 2025. This goal could be met through local food waste prevention and rescue programs, which may be independent of or through partnerships with haulers and jurisdictions. The regulations also will cover this provision. Food waste prevention includes activities such as education regarding food preparation and storage, refining food purchasing practices, and software that can help inform food ordering and menu selections. Rescue includes local organizations such as homeless shelters, food banks, and community kitchens that provide food for people in need.

Material that cannot be effectively recovered would be diverted to organics recycling facilities to make useful products, including compost, fertilizer, fuel or energy. These facilities may be developed at existing landfills, other waste management sites, or at new stand-alone sites. Some organic wastes could also be diverted to regional wastewater treatment plants or dairies that have excess capacity for co-digestion. Local governments must play an important role in diverting organics both as land use and permitting authorities for recycling facilities and as partners in implementing SB 1383 and other statutory requirements. The State will work with its local partners to explore development of helpful tools such as programmatic EIRs or guidance documents. Community engagement, outreach and education in the planning and environmental review processes are critical, both for understanding and mitigating potential negative health and environmental impacts and for understanding the positive economic and health and environmental benefits afforded by such projects.

Align Financial Incentives with Organics Diversion

Eliminating organics disposal in landfill will require additional infrastructure capacity to process and reuse diverted organic waste destined for landfills—through composting (including chipping and grinding), anaerobic digestion, or other methods. Continued, increased State funding is critical to building this necessary infrastructure. An increase in California's Integrated Waste Management Fee is also needed to support the establishment of food rescue programs, discourage the landfilling of organic waste and other recyclables, and provide funding to support organics recycling infrastructure and markets. CalRecycle estimates that State support of at least $100 million per year for five years, in the form of grants, loans, or incentive payments, will be needed to leverage private sector financing and local rate structure changes to support the development of necessary organic infrastructure and help to foster markets. However, as disposal in landfills decreases per the goals of this SLCP Strategy, so too would the funding from the Integrate Waste Management Fee. One option for stabilizing funding would be to establish a charge for waste generation, decoupling funding from landfill disposal.

Collaborate to Overcome Barriers

State agencies, including the AB 1045 working group and the Interagency Waste Working Group, are currently collaborating to evaluate and resolve existing constraints in the planning, siting, and permitting process, to provide clear standards and compliance pathways for all public health and environmental goals, and to quantify co-benefits. The beneficial use of methane produced at organic waste processing facilities faces many of the same obstacles described for dairy manure or wastewater treatment, and working groups are collaborating to address barriers to beneficial use of organic waste streams. Also, appropriate standards should be developed to guide the direct application of organic materials on land and ensure this activity does not pose a threat to human or environmental health.

Foster Recovery Programs and Markets

CalRecycle will work collaboratively with other agencies and departments to help establish food rescue programs and to identify, develop, and expand markets for the use of compost, mulch, and renewable fuels and energy. CalRecycle and CDFA will continue their efforts to incentivize the use of compost on agricultural lands in support of the Healthy Soils Initiative, including developing best management practices for agricultural use. They will also work with the State Water Resources Control Board to evaluate potential mechanisms to account for the use of compost and its impacts on nitrogen budgets in the Irrigated Lands Program as well as the potential impacts of land application of uncomposted organic materials. CalRecycle will continue to work towards strengthening State procurement requirements relative to compost and mulch. Finally, building on the existing use of mulch and compost as a water conservation practice that is essential for climate adaptation with respect to drought, State agencies will support research to quantify strategic water conservation (e.g. seasonal groundwater recharge) and other potential benefits and consider developing mechanisms to account for and value them. If new funding sources are developed, as described above, then CalRecycle could also develop an incentive payment program to overcome the marginal costs associated with most beneficial end-uses of organics.

Improve Understanding of Landfill Emissions

ARB and CalRecycle are currently pursuing research opportunities to improve understanding of emissions from California landfills and landfill gas collection efficiencies and will support future research to identify opportunities to further reduce emissions from existing waste-in-place. ARB will consider the latest science and whether adjustments to emissions accounting in the inventory or other programs is warranted. Based on this information, ARB, in collaboration with CalRecycle, may consider additional actions to further reduce and capture methane emissions from landfills in the future.

Evaluate Progress towards Organic Diversion Goals

To evaluate progress towards meeting the 2020 and 2025 organics waste reduction goals, CalRecycle, in consultation with ARB, will complete a detailed analysis by July 1, 2020. This analysis will evaluate:

- The status of new organics infrastructure development;
- The status of efforts to reduce regulatory barriers to the siting of organics recycling facilities;
- The effectiveness of policies aimed at facilitating the permitting of organics recycling infrastructure; and
- The status of markets for products generated by organics recycling facilities.

The analysis may result in making additional requirements and/or incentives in the regulations, as required by SB 1383.

4. Wastewater Treatment and other Miscellaneous Sources

Wastewater treatment, industrial operations, rice cultivation, septic tanks, and other sources of methane account for about nine percent of the State’s methane inventory.

Wastewater treatment plants provide a promising complementary opportunity to help divert a portion of organic wastes from landfills and create useful byproducts such as electricity, biofuels, fertilizers, and soil amendments. Wastewater treatment plants are designed to remove contaminants from wastewater, primarily from household sewage, but with infrastructure improvements could increase acceptance of food waste and fats, oils, and grease (FOG) for co-digestion. Anaerobic digestion is a typical part of the wastewater treatment process employed at most of the larger plants, with many plants capturing the methane they currently generate for on-site heating or electricity needs.


Sewer manhole cover manufactured and installed in Oakland, California

Many of these plants may have spare capacity, and can potentially take in additional sources of organic waste for anaerobic digestion. Existing or new digesters at these facilities can be designed to co-digest materials such as food waste and FOG from residential, commercial, or industrial facilities. Many of the largest plants are ideally located close to population centers and could potentially obtain and process significant amounts of food and other suitable waste streams within the region. The State proposes to take the following actions to evaluate this opportunity:

Develop Regional Opportunities to Co-Digest Waste

ARB will work with CalRecycle, the State Water Resources Control Board, Regional Water Quality Control Boards, and others to determine opportunities to support the co-digestion of food-related waste streams at existing and new digester facilities, including wastewater treatment plants.

Align Financial Incentives with Methane Capture and Reuse at Wastewater Treatment Facilities

A program that relies on financial incentives and/or regulatory actions could be implemented to ensure that new and existing wastewater treatment plants in California fully implement methane capture systems (ideally to produce on-site renewable electricity, transportation fuel, or pipeline biogas), and maximize digestion of regional organic materials. The potential actions would need to be tailored to each wastewater treatment plant based on size or capacity, and other factors such as potential for co-digestion expansion, proximity of organic waste streams, and regional air quality standards and rules. The Water Boards could develop permit terms and other regulatory tools to support the program while achieving water supply, water quality, and related co-benefits.

Collaborate to Overcome Barriers

Many wastewater treatment plants are permitted to burn digester biogas through flaring and are classified as industrial facilities. Capturing the biogas to produce electricity, such as through a combined heat and power (CHP) system may result in re-classifying the facility's purpose as "electricity generation" and subject the plant to more onerous emission compliance and abatement equipment rules. In addition, the beneficial use of methane generated at wastewater treatment facilities faces many of the same hurdles faced by dairy digesters and organic waste composting facilities. Support for technologies and strategies to capture biogas to generate electricity, supplement natural gas pipeline fuel, or for use as a transportation fuel, is needed to overcome some of these barriers and may open up more valuable fuel and credit markets. ARB will work with other relevant State and local agencies to identify and remove financial and regulatory barriers that hinder the productive use of waste streams processed at wastewater treatment plants.

5. Oil and Gas

California has a large oil and gas industry with more than 50,000 active oil wells, including off shore platforms, about 1,500 active natural gas wells and nearly 500 underground natural gas storage wells. The majority of the oil wells are located in Southern California with most of the gas fields located in Northern California. An extensive network of oil and gas pipelines within the State transport California's crude oil from import terminals and on- and off-shore oil fields to refineries, and distributes finished fuels to more than 70 product terminals throughout the State.

California also has about 215,000 miles of natural gas transmission and distribution pipelines; 22 compressor stations; and 25,000 metering and regulating stations (M&R) stations. Natural gas is currently California's largest source of fuel for electricity generation, and supplies most of the energy used for industrial operations. Natural gas is also a primary source of energy used for residential and commercial space heating and cooking, and represents the primary source of GHG emissions from the residential and commercial sectors.

Much of the equipment in the oil and gas industry has been regulated for decades by the local air districts. The districts have rules and regulations to limit VOC and NO_x emissions because they are precursors of ground-level ozone. Many of the VOC controls also reduce methane as a co-benefit. In 2015, U.S. EPA proposed additional federal measures that could address methane primarily at new oil and natural gas sources, with coverage at some existing sources. Additional actions to reduce methane from the oil and gas sector should also reduce VOC and toxic air contaminant emissions, although those co-benefits have not yet been estimated.

California has an emerging, comprehensive framework in place to reduce methane emissions from oil and gas infrastructure. Effectively implementing this framework can reduce methane emissions from oil and gas systems by 40-45 percent in 2025, matching federal commitments.[120] Additional opportunities may emerge to further reduce emissions from infrastructure and will be considered when they do. But further reducing methane emissions from the oil and gas sector will ultimately require reducing in-state demand. A rapid decline for demand for oil and natural gas is also necessary to meet the State's 2030 and 2050 climate targets, more broadly.

About 90 percent of California's natural gas comes from out of State, and ultimately, action by other jurisdictions is needed to minimize leaks associated with our natural gas use. The federal government has taken steps to address oil and gas sector methane emissions, especially at the point of production, but more may need to be done to reduce emissions from pipelines and other equipment out-of-state. There may be steps that California agencies or utilities can take to ensure that infrastructure supplying gas to the state has minimal leakage, and to ensure that natural gas is providing environmental benefits compared to use of other fossil fuels in the State.

The State's framework on oil and gas methane emissions includes the following elements:

Adopt and Implement a Regulation for Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities

In July 2016, the Board directed staff to continue working with local air districts and other stakeholders to develop a regulation for final Board consideration by early 2017. The proposed regulation will likely require:

- Vapor collection on uncontrolled oil and water separators and storage tanks with emissions above a set methane standard;
- Vapor collection on all uncontrolled well stimulation circulation tanks;
- Leak Detection and Repair (LDAR) on components, such as valves, flanges, and connectors, currently not covered by local air district rules;
- Vapor collection of large reciprocating compressors' vent gas, or require repair of the compressor when it is leaking above a set emission flow rate;
- Vapor collection of centrifugal compressor vent gas, or replacement of higher emitting "wet seals" with lower emitting "dry seals";
- "No bleed" pneumatic devices and pumps; and
- Ambient methane monitoring and more frequent well head methane monitoring at underground natural gas storage facilities.

This regulation would build upon some existing air districts' volatile organic compound based rules and include additional areas and infrastructure components (such as valves, flanges, and seals) that are not currently covered by local district programs. ARB staff is investigating ways to ensure that any combustion-based controls will not interfere with efforts to achieve and maintain compliance with ambient air quality

[120] For the purposes of calculating emission reductions in 2030, Table 8 assumes a 45 percent reduction below current levels by 2030.

standards in cases where methane and VOC emissions cannot be sent into existing sales lines, fuel lines, or reinjection wells, and are instead captured by installing new vapor collection on existing storage tanks, with the collected vapors being sent to a low-NOx incinerator that will replace an existing flare.

Improve Monitoring and Standards to Detect and Minimize Emissions

ARB and DOGGR are working together to ensure that both above and below ground monitoring of storage facilities is improved. As mentioned above, ARB is considering improved above-ground methane monitoring of underground storage facilities in its upcoming Oil and Gas Production, Processing, and Storage Regulation. In February 2016, DOGGR adopted emergency regulations to implement protective standards specifically designed to ensure that operators of underground gas storage facilities are properly minimizing risks and taking all appropriate steps to prevent uncontrolled releases, blowouts, and other infrastructure-related accidents. The emergency regulations will ensure that operators of existing underground gas storage facilities monitor for and report leaks to DOGGR, function test all safety valve systems, perform inspections of wellheads and surrounding area and equipment, develop risk management plans that require verification of mechanical integrity and corrosion assessment and monitoring, and provide DOGGR with complete project data and risk assessment results. In July 2016 DOGGR released a pre-rulemaking draft that will replace its emergency rulemaking; public comment for the discussion draft ended on August 22, 2016. The discussion draft contains much of the content included in the emergency rulemaking with the addition of, among other things, stricter well construction standards and mechanical integrity testing requirements to reduce the risk of wells leaking. DOGGR anticipates that the formal rulemaking process will conclude in the early part of 2017. Immediate implementation of these standards will ensure that underground gas storage facilities are properly operated, minimizing the potential that an incident such as the gas leak at the Aliso Canyon Natural Gas Storage Facility does not recur.[121] ARB and DOGGR will coordinate on the monitoring provisions to ensure consistency and comprehensiveness while limiting duplication.

Additionally, Assembly Bill 1496 requires ARB, in consultation with scientific experts and other state, local, and federal agencies, to undertake monitoring and measurements of high-emission methane “hot spots” and conduct lifecycle GHG emission analysis for natural gas produced in and imported into California. Pursuant to this bill, ARB will continue its efforts related to hot spots monitoring and lifecycle greenhouse gas accounting for fuels, and hosted a scientific workshop in June 2016 to collect the best available knowledge on these topics. ARB will update relevant policies and programs to incorporate any new information gathered as a result of these efforts.

[121] Preliminary estimates suggest the incident resulted in about 8 $MMTCO_2e$ (AR5 20-year GWP) of methane emissions, an approximately 20 percent increase in statewide methane emissions for the duration of the leak (October 23, 2015–February 17, 2016). Governor Brown's January 2016 Aliso Canyon Proclamation directs the ARB to develop a mitigation plan for the leaked methane emissions by March 31, 2016. It can be accessed at: http://www.arb.ca.gov/research/aliso_canyon/arb_aliso_canyon_methane_leak_climate_impacts_mitigation_program.pdf

Effectively Implement SB 1371 to Reduce Emissions from Pipelines

Senate Bill 1371 (Leno, Chapter 525, Statutes of 2014) directs the CPUC, in consultation with ARB, to adopt rules and procedures to minimize natural gas leaks from CPUC-regulated intrastate transmission and distribution gas pipelines and facilities. Among other requirements, SB 1371 directs the CPUC to adopt rules and procedures that provide for the maximum technologically feasible and cost-effective avoidance, reduction, and repair of leaks and leaking components. In January 2015, the CPUC launched a rulemaking proceeding (R.15-01-008) to carry out the intent of SB 1371. Under this proceeding, CPUC published a report that identifies new gas leak detection technologies that can be used to optimize methane reductions from transmission, distribution, and storage processes. CPUC also required utility companies and gas suppliers to report natural gas emission data annually and best leak management practices. To date, the industry has submitted two consecutive emission inventories in 2015 and 2016, respectively. In June 2015, CPUC conducted a prehearing conference to discuss the draft scoping memo of relevant topics to be deliberated during the 24-month timeframe of the proceeding. In addition, several public workshops and workgroup meetings have been held in San Francisco and Sacramento.

ARB continues to actively participate in the proceeding and will lead efforts to analyze collected utility emission data, develop quantification protocols, and identify potential mitigation strategies. In particular, ARB will focus on the emission reduction potential of the proceeding in keeping with the objectives of AB 32 as they pertain to:

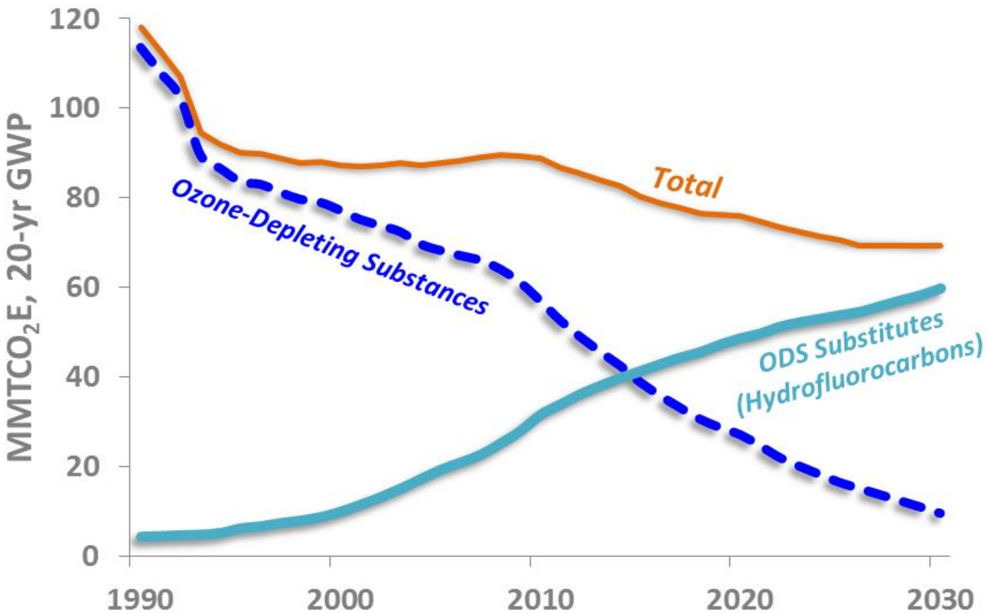
- Comparing the data collected under SB 1371 with the Mandatory Reporting Regulation;
- Analyzing emission data to determine potential mitigation strategies. For example, the proceeding may require the replacement of older pipelines or pipelines constructed of a certain material;
- Identifying any remaining data gaps;
- Establishing procedures for the development and use of metrics to quantify emissions;
- Reviewing and evaluating the effectiveness of existing practices for the operation, maintenance, repair, and replacement of natural gas pipeline facilities to determine the potential to reduce methane leaks and where alternative practices may be required;
- Provide input on cost-effectiveness; and
- Funding studies to update emission factors from important leak sources, such as pipelines and customer meters.

The final decision on potential rules and procedures by the CPUC, including ratemaking and financial incentives to minimize gas leaks, is anticipated in the fall of 2017. Upon evaluation of the industry’s compliance with the decision, ARB will determine whether additional regulatory actions or incentives are required to further reduce methane emissions from this source.

VI. Reducing HFC Emissions

Hydrofluorocarbons (HFCs) are the fastest-growing source of GHG emissions both globally and in California. HFCs are fluorinated gases (F-gases), which also include the ozone-depleting substances (ODS) that are being phased out under the Montreal Protocol. HFCs currently comprise four percent of all GHG emissions in California, and without a phasedown and additional emission reduction measures, annual HFC emissions would increase 60 percent under business-as-usual by 2030 as HFCs continue to replace ODS (Figure 6).

Figure 6: Emission Trends of ODS and ODS substitutes (hydrofluorocarbons) – (as ODS are phased out, HFCs increase).*

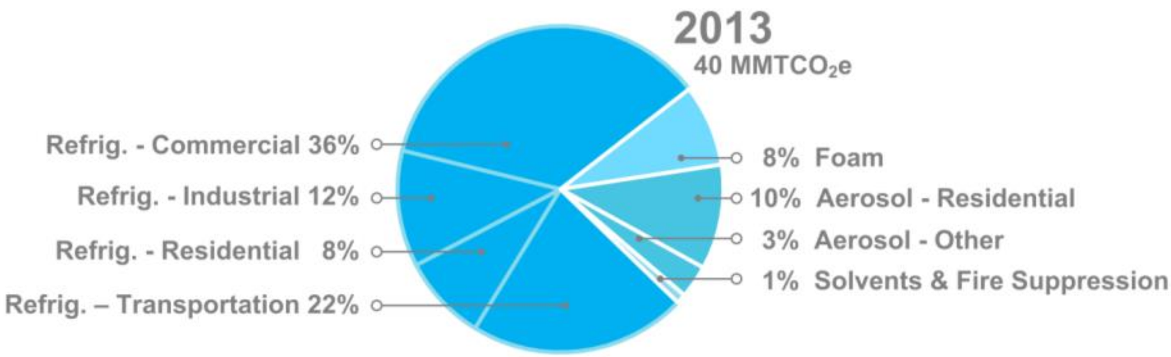


* Further analysis is needed to reflect the impact of the Kigali Amendment on HFC emission reductions in California

The majority of HFC emissions come from fugitive emissions of refrigerants used in refrigeration and air-conditioning (AC) systems. The largest uses of HFCs are in commercial and industrial refrigeration and air-conditioning, which comprise 48 percent of HFC emissions. More than half of refrigeration and air-conditioning equipment currently uses HCFC-22, a high-GWP ODS which is scheduled for a complete phase-out of new production and import in the U.S. by 2020. The HCFC-22 refrigerant is being replaced with HFCs that have higher GWPs, thus increasing the GHG impact of refrigerants. We expect that in anticipation of the HCFC-22 phase-out by 2020, most owners of equipment using HCFC-22 will either replace the equipment by 2020, or at a minimum replace the HCFC-22 refrigerant in the same equipment (retrofit) with a high-GWP HFC refrigerant. A window of opportunity exists in the next five years to accelerate the transition of refrigeration and air-conditioning equipment to lower-GWP refrigerants, before another generation of equipment is locked into using higher-GWP refrigerants over their average lifetimes of 15 to 20 years.

HFC emissions from transportation are largely from mobile vehicle air-conditioning (MVAC), and as California and the U.S. EPA implement the MVAC credits programs under their light-duty vehicle GHG emission standards, and the MVAC leakage standards under their heavy-duty vehicle GHG emission standards, the share of HFC emissions from the transportation sector will decline. Aerosol propellants (industrial, consumer, and medical dose inhalers) comprise 13 percent of HFC emissions, and insulating foam expansion agents contribute another eight percent of HFC emissions. Solvents and fire suppressant emissions contribute one percent of all HFC emissions. Figure 7 shows the emissions sectors that contribute to California's overall HFC emissions. (ODS emissions are not shown because they are being completely phased out under the Montreal Protocol and are not included in the AB 32 GHG emission reduction targets.)

Figure 7: California 2013 Hydrofluorocarbons (HFCs) Emission Sources*



*Using 20-year GWP

This SLCP Strategy identifies measures that can reduce HFC emissions by 40 percent in California by 2030. They represent a reasonable path forward for California, and will complement the global HFC supply phasedown, agreed to in October 2016. Although the global phasedown will result in significant HFC emission reductions, the phasedown by itself will not be sufficient for California to reach the 40 percent HFC emission reduction goal by 2030.

A. Progress to Date

California is among the world's leaders in reducing HFCs and other F-gas emissions. Measures adopted under AB 32 have reduced emissions from a variety of sources. The State's Cap-and-Trade offset protocol for ozone depleting substances incentivizes the capture and destruction of ODS refrigerants and foam expansion agents. The biggest reductions of high-GWP F-gases are coming from ARB's Refrigerant Management Program, which requires facilities with refrigeration systems to inspect and repair leaks, maintain service records, and in some cases, report refrigerant use. The Refrigerant Management Program has helped change industry practices to become more proactive in preventing refrigerant leaks, which has helped businesses save money by avoiding system repairs and downtime as well as the cost of replacement refrigerant. Other measures already in place include low-GWP requirements for consumer product aerosol propellants and a self-sealing valve requirement for small cans of automotive refrigerants purchased by “do-it-yourself” mechanics.

California’s efforts to reduce emissions of F-gases are part of a broader set of national and international commitments.

A Global Phasedown in HFC Production and Consumption

On October 15, 2016, an historic agreement was reached in Kigali, Rwanda, by nearly 200 countries to adopt a global phasedown in the production and consumption of HFCs. The international agreement was an outcome of the 28^{th} Meeting of the Parties to the Montreal Protocol, the 1987 agreement that initiated a phase-out of ODS. The HFC phasedown agreement is expected to prevent up to 0.5 degrees Celsius of global warming by the end of this century.

Developed countries must begin to phasedown HFC production and consumption in 2019, with an increasing cap until only 15 percent of production and consumption remains by 2036. Developing countries will begin a phasedown in 2029, and developing countries in hot ambient climates will have until 2032 to begin a phasedown. The phasedown schedule is shown in Table 10 below:

Table 10: Global HFC Phasedown Schedule

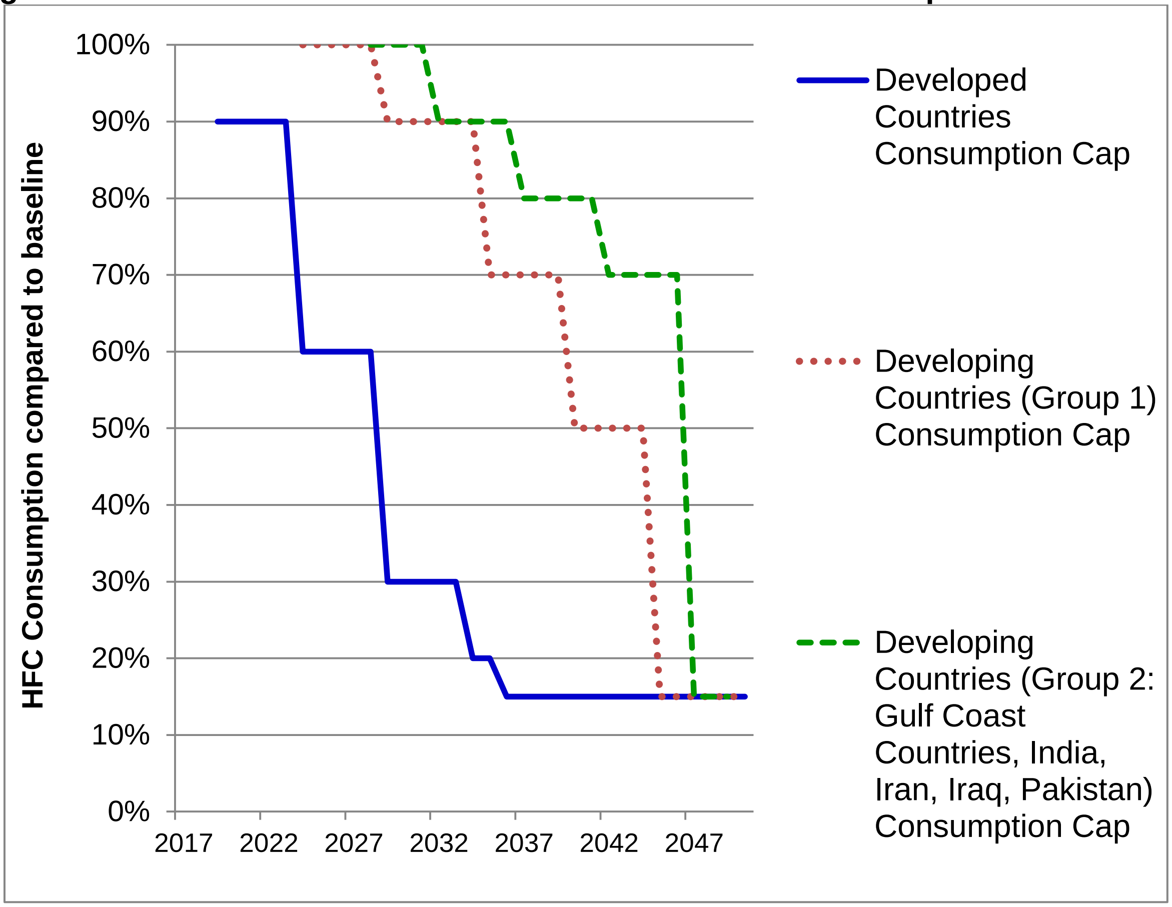
	HFC Production/Consumption Cap* Phasedown Schedule		
Year	**Developed Countries**	**Developing Countries Group 1**	**Developing Countries Group 2****
2017-2018	No Freeze		
2019	90%		
2024	60%	Freeze	
2028			Freeze
2029	30%	90%	
2032			90%
2034	20%		
2035		70%	
2036	15%		
2037			80%
2040		50%	
2042			70%
2045		15%	
2047			15%

* The baseline to calculate a production/consumption cap for developed countries is the annual average of HFC consumption (CO_2-equivalents) in 2011, 2012, and 2013, plus 15 percent of the annual average consumption of HCFCs in 2011-2013.

**Group 2 countries include the Gulf Coast Countries (Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, Bahrain, and Oman), India, Iran, Iraq, and Pakistan.

The phasedown schedule is also shown in graph form in Figure 8 below.

Figure 8: Global HFC Phasedown Schedule for the Three Groups of Countries



As shown by the successful ODS phase-out, an HFC phasedown allows industry the flexibility to make market-based decisions on when and where to continue to use high-GWP HFCs before transitioning to lower-GWP options.

<u>Additional State, National, and International Efforts to Reduce HFC Emissions</u>

In addition to the Kigali Amendment to phasedown HFC production and consumption globally, other developments in the U.S. and internationally will further reduce HFC emissions as described below. The U.S. EPA can impose federal bans on F-gases under the Significant New Alternatives Policy (SNAP) Program. In July 2015, the U.S. EPA adopted future bans on specific HFCs with very high GWPs used in new commercial refrigeration systems, the manufacture of polyurethane foam, and new light-duty motor vehicle air-conditioning systems.[122] In many cases, these national bans copied programs that were first demonstrated in California. The U.S. national bans are expected to decrease HFC emissions in California by ten percent annually below business as usual by 2025. The European Union (EU) has adopted the world's

[122] Protection of Stratospheric Ozone: Change of Listing Status for Certain Substitutes Under the Significant New Alternatives Policy Program; Final Rule. Federal Register. Volume 80, Number 138, Monday, July 20, 2015. Part II. Environmental Protection Agency. 40 CFR Part 82. http://www.epa.gov/ozone/snap/regulations.html

leading F-gas regulation that will phase down the production and import of HFCs by almost 80 percent from 2014 levels by 2030.[123,124]

Additionally, in response to the federal Climate Action Plan, in September 2014, and again in October 2015, the private sector made commitments and executive actions were taken to reduce emissions of hydrofluorocarbons (HFCs).[125,126] U.S. industry is leading the way by investing billions of dollars to develop and deploy the next generation of HFC alternatives that are safer for the environment. These investments span the entire HFC supply chain—from where the chemicals are produced, to where they are used in manufacturing, to where consumers see them in stores.

Further private sector commitments were made in February 2016, when both the Air Conditioning Heating & Refrigeration Institute (AHRI) and the Association of Home Appliance Manufacturers (AHAM) made voluntary commitments to phase down the use of high-GWP HFCs in new equipment.[127,128]

In March 2016, the U.S. EPA proposed additional bans on high-GWP HFCs in new retail food refrigeration, cold storage, chillers used for air-conditioning, and household refrigerator-freezers.[129] The proposal was adopted in September 2016.

In July 2016, ARB and CEC committed $500,000 to fund the completion of a research project to assess the feasibility and safety of low-GWP refrigerants, adding to the existing $5.3 million venture research funded by the Department of Energy (DOE), the AHRI, and the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). A goal of the study is to accelerate research and consideration

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[123] Velders et al (2014) "Growth of climate change commitments from HFC banks and emissions", G. J. M. Velders, S. Solomon, and J. S. Daniel. *Atmospheric Chemistry and Physics*, 14, 4563–4572, 2014. doi:10.5194/acp-14-4563-2014. www.atmos-chem-phys.net/14/4563/2014/.

[124] EC (2014) European Commission (EC), April 16, 2006 "Regulation (EU) No 517/2014 of the European Parliament and of the Council on fluorinated greenhouse gases and repealing Regulation (EC) No 842/2006". http://ec.europa.eu/clima/policies/f-gas/legislation/documentation_en.htm

[125] Fact Sheet: Obama Administration Partners with Private Sector on New Commitments to Slash Emissions of Potent Greenhouse Gases and Catalyze Global HFC Phase Down. September 16, 2014: http://www.igsd.org/documents/20140916HFCFactSheet.pdf

[126] Fact Sheet: Obama Administration and Private-Sector Leaders Announce Ambitious Commitments and Robust Progress to Address Potent Greenhouse Gases. October 15, 2015. https://www.whitehouse.gov/the-press-office/2015/10/15/fact-sheet-obama-administration-and-private-sector-leaders-announce.

[127] AHRI and Natural Resources Defense Council (NRDC) February 1, 2016 petition to U.S. EPA Significant New Alternatives Policy (SNAP) Program to remove high-GWP HFCs from the list of acceptable substitutes in new air-cooled and water-cooled chillers using centrifugal, screw, scroll, and all other compressor types.

[128] "Home Appliance Industry Sets Goal to Eliminate Use of HFC Refrigerants", Press Release February 9, 2016 from Association of Home Appliance Manufacturers (AHAM). http://www.prnewswire.com/news-releases/home-appliance-industry-sets-goal-to-eliminate-use-of-hfc-refrigerants-300217501.html.

[129] Fact Sheet. Proposed Rule - Protection of Stratospheric Ozone: New Listings of Substitutes; Changes of Listing Status; Reinterpretation of Unacceptability for Closed Cell Foam Products under the Significant New Alternatives Policy Program; and Revision of Clean Air Act Section 608's Venting Prohibition for Propane. U.S. EPA, March 29, 2016. https://www.epa.gov/snap/snap-regulations

by these bodies by up to three years sooner than the normal deliberative pace of standards and codes research. Commercial refrigeration and air conditioning are included in the research project, while domestic refrigeration is not within the project scope. The project is on an aggressive, tiered schedule to assess the safety of mildly flammable and flammable refrigerants, in order to update building codes and safety standards.[130] The study is critical for national and international HFC mitigation policies and will accelerate the time frame for low-GWP refrigerants that are necessary for the California to meet its SLCP emission reduction goals.

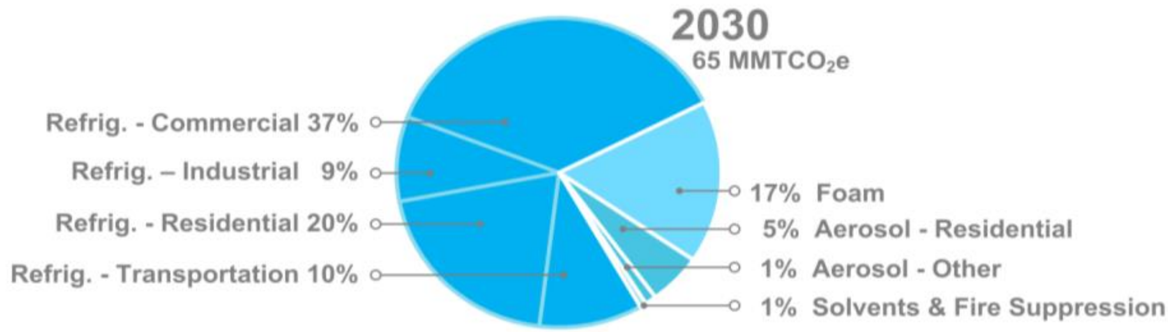
Substantial progress has also been made to safely use natural refrigerants (such as CO_2, ammonia [NH_3], and hydrocarbons [HCs]), with GWPs at or near zero) all over the world, especially in Europe and Asia. The refrigeration and air-conditioning industry is looking closely at which applications suit which natural refrigerants. Reports summarizing the progress made in North America show nearly 300,000 pieces of light commercial equipment using CO_2 or hydrocarbons, more than 250 stores using CO_2 systems, and over 250 “next-generation” small-charge ammonia systems in industrial installations. Large companies investing in natural refrigerants include end users, and a wide range of equipment manufacturers.

In addition to the natural refrigerants, a new generation of fluorinated refrigerants known as hydrofluoro-olefins (HFOs) have been developed that are non-ODS and have GWP values less than six. HFOs can be used in pure form for some cooling applications, such as motor vehicle AC, and are also used in blends with HFCs for other cooling applications, such as commercial and industrial refrigeration. Initial results indicate that the newest generation of fluorinated refrigerants performs as well as the high-GWP HFCs they replace.

These State, national, and international efforts will lead to significant reductions in HFC emissions in California through 2030, compared to where they would be otherwise. With the global HFC phasedown agreement in place, HFC emissions in California will decrease significantly, but not enough to meet the reduction goal of 40 percent below 2013 levels by 2030 (Figure 9).

[130] White House Office of the Press Secretary June 2, 2016, “FACT SHEET: U.S. Hosts World's Energy Ministers to Scale Up Clean Energy and Drive Implementation of the Paris Agreement” Available at: https://www.whitehouse.gov/the-press-office/2016/06/02/fact-sheet-us-hosts-worlds-energy-ministers-scale-clean-energy-and-drive (accessed 2 June 2016).

Figure 9: California's 2030 HFC Emission Sources with Existing Measures*



*Using 20-year GWP

B. Recommended Actions to Further Reduce HFC Emissions

The State supports strong, national, and international actions to reduce HFC emissions. The U.S. EPA has already taken a number of steps to prohibit the use of new high-GWP HFCs in consumer product aerosol propellants, polyurethane insulating foam, and light-duty mobile vehicle air-conditioning. An international agreement was reached in October 2016 to phase down the production and use of HFCs under the Montreal Protocol. The proposed Montreal Protocol HFC phase down amendments will reduce HFC emissions significantly by 2050.

However, if additional measures can be applied in California to achieve further GHG emission reductions in the near-term and at low cost, California will consider them to support the State's 2020 and 2030 GHG targets.

For example, the State should consider developing an incentive program to encourage the use of low-GWP refrigerants, which could lead to very low-cost emission reductions and could be implemented while further regulations are considered or developed. This would provide long-term avoided emissions by countering the current trend of replacing HCFC-22, the most common refrigerant for both refrigeration and air-conditioning, with higher-GWP HFCs. This trend is accelerating in the U.S. in response to the 2020 phase-out of HCFC-22 under the Montreal Protocol.

Even with the strong international agreement to phase down the use of HFCs, under a best-case scenario, the currently proposed global phasedown schedule will not achieve the reductions needed to meet the 2030 HFC emission reduction goal for California. Therefore, additional opportunities may remain to reduce their emissions in California in the near-term and through 2030 at low cost. Early action, ahead of some of the phase down schedules being proposed internationally, can avoid locking-in the use of high-GWP refrigerants in new or retrofitted systems in the coming years.

For example, as effective alternatives become available, ARB will consider developing limitations on the use of high-GWP refrigerants in new refrigeration and air-conditioning equipment where lower-GWP alternates are feasible and readily available. ARB will focus on measures that can move low-GWP alternatives and technologies forward both nationally and internationally. California has a wide range of climate zones from alpine conditions to hot desert environments. As such, California could be instrumental as a proving ground for low-GWP refrigeration and air-conditioning technologies that can be used in extreme environments across the world.

All refrigerants and substitutes to high-GWP F-gases must first be approved by the U.S. EPA's SNAP Program to ensure the alternatives meet health and safety criteria. The approval process is designed to minimize the risk of using newer alternatives to F-gases by identifying substitutes that offer lower overall risks to human health and the environment.

This SLCP Strategy describes a set of potential measures that can reduce HFC emissions by 40 percent in California by 2030 (see Table 11). This set of measures has been designed to minimize regulatory requirements and achieve fast and assured emission reductions. Additional analysis is needed to determine the impact of the global HFC phasedown on future HFC reductions in California. When this analysis is complete, further evaluation will be conducted on the scope of the additional emission reduction measures identified in Table 11.

Table 11: Proposed New HFC Emission Reduction Measures and Estimated Emission Reductions ($MMTCO_2e$)[1]

Measure Name	2030 Annual Emission Reductions	2030 Annual Emissions
2030 BAU[2]		**65**
Financial Incentive for Low-GWP Refrigeration Early Adoption	2	
HFC Supply Phasedown (to be achieved through the global HFC phasedown)[3]	19	
Prohibition on sales of very-high GWP refrigerants	5	
Prohibition on new equipment with high-GWP Refrigerants	15	
2030 BAU with new measures		**24**

[1]Using 20-year GWPs from the 4th Assessment report of the IPCC

[2]"Business as Usual" (BAU) forecasted inventory includes reductions from implementation of current ARB and U.S. EPA regulations

[3] A global HFC production and consumption phasedown was agreed to on October 15, 2016, in Kigali, Rwanda. ARB is currently evaluating the impact upon HFC emission reductions in California and plans to utilize the results from the assessment to inform future updates to BAU projections for HFC emissions.

Incentive Programs

A voluntary early action measure recommended is an incentive program to defray the potential added cost of installing new low-GWP refrigeration equipment or converting existing high-GWP systems to lower-GWP options. This program could provide immediate and ongoing emission reductions. A loan or grant program would support qualifying facilities that take action to reduce emissions prior to any national or state requirements to do so.

Data reported under the existing Refrigerant Management Program indicates that more than 2,400 facilities with large commercial refrigeration systems in California currently use HCFC-22 refrigerant. This refrigerant has not been allowed in new equipment since January 2010, and all new production and import will cease by January 1, 2020. Therefore, these facilities must either buy increasingly scarce recycled HCFC-22 to maintain their systems, or replace or retrofit their existing systems with another refrigerant within five years.

Although lower-GWP options are currently available and can be cost effective, in most cases with improved energy efficiency, there are two main barriers to more widespread adoption of low-GWP commercial refrigeration: 1) potentially higher up-front costs, and 2) lack of familiarity with low-GWP refrigeration. The incentive program could remove the added initial cost barrier and build familiarity with low-GWP refrigeration systems to help them scale throughout the sector.

One of the advantages of an incentive program is that it could fund early adoption of low-GWP technologies, with substantial long-term effects on avoided emissions. The incentive program would “lock in” early and permanent GHG emission reductions prior to any mandatory measures.

Phasedown in Supply of HFCs

Due to the global HFC phasedown agreement, a California-specific HFC phasedown will not be necessary. However, as previously noted, there is a long time lag between reductions in HFC production and actual emission reductions, due to the slow turnover of existing equipment that continue to emit high-GWP HFCs throughout their useful life. For example, a 40 percent reduction in HFC production may take 10-20 years to be realized in reduced emissions.

ARB will continue to assess the impact of the Kigali Amendment on HFC emission reductions in California. Additional reduction measures are likely to be needed to reach the 2030 HFC emission reduction goals set forth in SB 1383.

Prohibition on the Sale of New Refrigerant with Very-High GWPs

This measure would prohibit the sale or distribution of refrigerants with 100-year GWP values of 2500 or greater. Refrigerants that are certified reclaimed or recycled would be exempt from the sales ban.

In July 2015, the U.S. EPA adopted a ban on using refrigerants with a very-high 100-year GWP of 2500 or greater in new and retrofitted refrigeration systems at retail food facilities beginning in the second half of 2016. Several refrigerants are currently available with a 100-year GWP of less than 1500 that can be used in existing equipment designed for higher-GWP refrigerants.

A sales ban on very high-GWP refrigerants is enforceable and provides immediate reductions. Such a ban facilitates a much faster transition from very high-GWP refrigerants to lower-GWP alternatives in existing equipment (thus avoiding the ongoing high-GWP emissions from equipment that typically lasts for 15 years or longer).

High-GWP Refrigerant Prohibitions in New Stationary Systems

This measure would prohibit the use of high-GWP refrigerants in new commercial, industrial, and residential stationary refrigeration and air-conditioning equipment, as follows:

Stationary Refrigeration or Stationary Air-Conditioning Sector	**Refrigerants Prohibited in New Equipment with a 100-year GWP Value:***
Non-residential refrigeration	150 or greater**
Air-conditioning (non-residential and residential)	750 or greater
Residential refrigerator-freezers	150 or greater

*The need for specific GWP limits and the proposed start dates for each end-use sector will be further evaluated as ARB assesses the impact of the global HFC phasedown agreement (Kigali Amendment) on future HFC emissions and reductions in California.
**Does not apply to small HFC/HFO central charge (with GWP less than 1500) used in hybrid refrigeration such as secondary loop and cascade systems.

GWP limits for specific air conditioning equipment types could be made more stringent if low-GWP technologies develop more quickly than anticipated, such as the continued development of low and medium-pressure air-conditioning chillers that use refrigerants with a GWP less than 150.

Certain exceptions could be made to any maximum GWP limit if no low-GWP refrigerants are technically feasible in a specific application. Additionally, high-GWP prohibition dates could be extended for specific end-use sectors where codes and standards do not allow the use of feasible low-GWP refrigerants.

In addition to current safety testing of residential appliances, significant research is underway to assess the safety and feasibility of low-GWP refrigerants in commercial refrigeration, commercial AC, and residential AC. While not every end-use sector has low-GWP options commercially available today, rapid development of low-GWP options is expected to continue.

Energy efficiency of low-GWP refrigeration and AC is one of the most important factors in the transition from high-GWP to low-GWP technology. If energy consumption increases, the additional GHG emissions from electricity generation will defeat the purpose of the low-GWP requirements. Therefore, energy efficiencies and "energy penalties" of low-GWP technologies are taken under consideration in the development of HFC emission reduction measures. According to refrigerant manufacturers, the new low-GWP synthetic refrigerant hydrofluoro-olefin (HFO) blends are as energy efficient as the HFC refrigerants they replace. In some cases, the HFO blends exhibit better energy efficiency than baseline HFC refrigerants. Among the "natural" refrigerants, hydrocarbon and ammonia refrigerants exhibit well-known energy efficiencies compared to HFC refrigerants. Carbon dioxide refrigerant is generally the same efficiency or more energy-efficient in cooler climates, and less efficient in warmer climates compared to HFCs. Improving the efficiency of CO_2 refrigeration in warmer climates is currently the subject of a great deal of research and development by equipment manufacturers. We expect the end of the "energy penalty" of CO_2 refrigeration in the next few years as equipment is designed for increasingly warmer climate zones, including desert climates. Additional details on low-GWP refrigerants and energy efficiency are included in Appendix F.

Low-GWP commercial refrigeration using ammonia is already extensively used in food processing and cold storage. Additionally, more than 250 retail food stores in the U.S. have begun using CO_2 as the primary or secondary refrigerant. In Europe, CO_2 refrigeration is used in more than 5,200 retail food stores, and generally is cost neutral compared to HFC refrigeration systems. In the hotter climate zones of California, using 100 percent CO_2 refrigeration may not be as energy-efficient as HFC refrigerants, although newly demonstrated adiabatic cooling technology has promise to neutralize energy efficiency concerns. Alternatively, manufacturers are currently developing blends of HFC refrigerants combined with a new class of very-low GWP synthetic refrigerants known as hydrofluoro-olefins (HFOs). The HFO-HFC blends have

100-year GWPs between 88 and 1400, and their use would reduce GHGs in these systems by more than 75 percent compared to business as usual.[131] Hybrid refrigeration such as secondary loop and cascade systems, using a small HFC central charge and a larger CO_2 charge, experience no energy penalty, even in hotter climates.

With respect to air-conditioning, in September 2014, the AHRI, an industry association representing 90 percent of U.S. air-conditioning manufacturing and 70 percent of the global industry, made a commitment through the White House Council on Environmental Quality to spend $5 billion over the next ten years to develop low-GWP options for refrigeration and air-conditioning. Many commercially available lower-GWP air-conditioning options are expected by 2020. In order to comply with the EU F-gas regulation that went into effect January 1, 2015, manufacturers are already developing air-conditioning systems that use refrigerants with a 100-year GWP of less than 750. Large chillers used primarily for office building air-conditioning are already commercially available that use an HFO refrigerant with a GWP of one.

Current fire and appliance codes do not allow the use of hydrocarbon refrigerants, which are flammable, unless the system is below a small charge size threshold of 150 grams for commercial refrigerators, and 57 grams for household refrigerators. Experience in Europe and other jurisdictions demonstrates that these codes can be designed to allow for the use of these refrigerants while ensuring safety, where current limits are 150 grams for household refrigerators and up to 1.5 kg for commercial uses. More work is required to update the safety codes in the U.S. before slightly flammable refrigerants can be used in more applications while maintaining safety.

A prohibition, or ban on the use of high-GWP HFCs in new equipment would result in certainty of reductions in applications where alternatives are readily available, and immediate HFC reductions that the global phasedown would not achieve until many years later. By requiring equipment manufacturers to sell only ARB-compliant equipment in California, the enforcement focus is on the manufacturers and is not placed on the end-user.

Additional measures that may be more effectively addressed at the Federal level include prohibitions on high-GWP HFCs in the following sectors: consumer product aerosol propellants, insulation spray foam, heavy-duty motor vehicle air-conditioning, transport refrigeration units (TRUs), and refrigerated shipping containers. ARB will continue to work with the U.S. EPA on reducing HFC emissions from these sectors, and may pursue state-level measures if progress is not made on the Federal level.

[131] HFOs are hydrofluoro-olefins, an emerging class of F-gas with very low GWPs of 1-5, but which are classified as slightly flammable (A2L). By blending HFOs with HFCs, refrigerant blends which are non-flammable have been created and U.S. EPA SNAP-approved for certain applications.

C. Sulfuryl Fluoride

Sulfuryl fluoride (SO_2F_2) is a pesticide fumigant and one of the most common replacements for methyl bromide, an ozone-depleting substance whose use is being phased out. Sulfuryl fluoride is regulated by the California Department of Pesticide Regulation (DPR), and was listed as a toxic air contaminant (TAC) in 2006. As a pesticide and TAC, sulfuryl fluoride's use is strictly controlled. In December 2015, DPR submitted a report to the Legislature, which provided an update on adopted control measures for sulfuryl fluoride,[132] as required by AB 304 (Williams, Chapter 584, Statutes of 2013). DPR plans to develop additional mitigation measures by September 2016, to address unacceptable exposures of sulfuryl fluoride to bystanders and residents. Sulfuryl fluoride is not registered for use as a field soil fumigant and is not used on agricultural fields.

Until 2009, sulfuryl fluoride was believed to have a negligible GWP. Further research concluded that SO_2F_2 has a 20-year GWP of 6840, with a lifetime of several decades. According to the DPR, 3 million pounds of sulfuryl fluoride were used in California in 2013 (most recent data available).[133] Its main use is as a structural pest control fumigant to kill drywood termites in homes and buildings, accounting for 82 percent of all usage in 2013. Sulfuryl fluoride is also a common fumigant for dried fruits, nuts, and other agricultural commodities that must be kept pest-free during storage prior to shipping (15 percent of all usage in 2013). The remaining three percent of sulfuryl fluoride application was for other fumigation uses. A complete listing of sulfuryl fluoride usage in California by commodity is listed in Appendix C.

Because sulfuryl fluoride was not identified as a high-GWP gas by the time AB 32 was enacted, it was not initially included as a part of ARB's statewide GHG inventory. However, the annual usage of sulfuryl fluoride is inventoried by DPR as a highly-regulated pesticide and ARB uses this data to track emissions. In 2013, the 3 million pounds of SO_2F_2 usage was equivalent to 9.4 $MMTCO_2E$ emissions (using 20-year GWP values), or approximately 20 percent of all F-gas emissions.

Identifying less toxic or lower-GWP alternatives to sulfuryl fluoride remains problematic. Methyl bromide (CH_3Br), with a 20-year GWP of 17, was the pesticide fumigant of choice for many applications until its use was almost completely phased-out by the Montreal Protocol because of its ozone-depleting potential. Currently, sulfuryl fluoride is the only fumigant registered for treating structural pests in California. Termites or other wood-destroying pests are detected in over 250,000 California homes each year, with the cost of control and repair of damage from dry-wood termites in California

[132] Report to the Legislature Required by AB 3014 (2013) Food & Agricultural Code Section 140124(c)(2)(A): Update on the Adoption of Control Measures for the Toxic Air Contaminant Sulfuryl Fluoride. Report submitted by the California Department of Pesticide Regulation to the California Legislature, December 22, 2015.

[133] Summary of Pesticide Use Report Data 2013 - Indexed by Commodity, California. California Department of Pesticide Regulation, May 2015. Available at: http://www.cdpr.ca.gov/docs/pur/pur13rep/13_pur.htm.

exceeding $300 million annually (with 80 percent of fumigations occurring in Southern California).

For agricultural commodity fumigation storage (primarily dried fruits and nuts), methyl bromide is still used on a limited basis through special use exemptions, although its use is decreasing annually. An alternative fumigant, phosphine (PH_3), with a GWP of 0, is also used as an alternative to methyl bromide and sulfuryl fluoride. However, reported insect tolerance to phosphine has limited its widespread usage.[134] Non-chemical commodity treatment has been studied since 1995, including irradiation, and controlling the atmosphere to "suffocate" insects in either low-oxygen or high carbon dioxide environments.[135] Chemical treatment remains dominant due to cost and feasibility issues of non-chemical alternatives.

The effectiveness of less toxic (and lower-GWP) alternatives to sulfuryl fluoride in structural fumigation for drywood termites is the subject of much research, opinion, and disagreement. Structural fumigation generally includes tenting the entire structure and treating it to kill termites, or more rarely, wood-boring beetles and other pests living in the structure. While many termite control companies only use sulfuryl fluoride, many others have begun using alternative termite control methods, including orange oil, structure heating or extreme cooling, microwaves, and electricity. Additional research is required before sulfuryl fluoride mitigation measures can be proposed. ARB will continue working with the DPR to assess mitigation measures to sulfuryl fluoride emissions. Additional discussion on potential research of sulfuryl fluoride mitigation is included in Appendix D

[134] Phosphine Fumigation of Stored Agricultural Commodity - Programmatic Environmental Assessment. November 2013. United States Agency for International Development (USAID), prepared under USAID's Global Environmental Management Support (GEMS) project. Available at: http://www.usaidgems.org/documents/fumigationpea/fumigationpeafeb24_2014.pdf.

[135] Alternatives to Methyl Bromide: Research Needs for California - Report of the Methyl Bromide Research Task Force To The Department of Pesticide Regulation and The California Department of Food and Agriculture. September, 1995. Available at: http://www.cdpr.ca.gov/docs/emon/methbrom/mb4chg.htm.

VII. Achieving Success

Successfully implementing a strategy to reduce SLCP emissions will require integrated planning to achieve multiple objectives, coordination and collaboration among agencies at all levels of government, and focused investments and market support.

A. Integrate and Coordinate Planning

The SLCP Reduction Strategy fits within a wide range of ongoing planning efforts throughout the State to advance economic and environmental priorities. Integrated planning to achieve multiple objectives requires coordination among planning agencies and across sectors, systems, and government jurisdictions. Development of a strategy to reduce emissions of SLCPs is being closely coordinated with other relevant planning efforts. For example, this SLCP Strategy acknowledges that further reductions in black carbon from California's freight system will be realized through strategies identified in the California Sustainable Freight Action Plan. That plan was developed by ARB and other state agencies, and will accelerate emission reductions and implementation of zero and near-zero technology in California's freight transport system. Also, ARB staff and local air districts will develop additional strategies through the upcoming SIPs process, which is expected to reduce black carbon emissions from both mobile and non-mobile sources.

The 2014 Scoping Plan Update identified the important role of SLCPs to reduce climate change impacts and provided suggested recommended actions for further emission reductions. Those recommendations were evaluated and expanded upon in this SLCP Strategy.

State Plans that will Assist the State in Meeting SLCP Emission Reduction Goals
CalRecycle AB 341 Report to the Legislature
California Sustainable Freight Action Plan
2030 Target Scoping Plan Update and Subsequent Updates
2016 California State Implementation Plan
Auction Proceeds Investment Plan
Caltrans Strategic Management Plan for 2015-2020
Funding Plan for Low Carbon Transportation Investments and the Air Quality Improvement Program
Mobile Source Strategy
ARB Annual Research Plan
Climate Change Research Plan for California
California Water Action Plan
CEC Electric Program Investment Charge Program
Annual Investment Plan for Alternative and Renewable Fuels and Vehicle Technology Program
DWR Climate Action Plan
Bioenergy Action Plan
Healthy Soils Initiative
Forest Carbon Plan

The ARB is embarking on the next update to the Scoping Plan to describe how the State can meet the State's goal of reducing total GHG emissions by 40 percent by 2030. This SLCP strategy is a forerunner to the Scoping Plan, providing justification for accelerated action on SLCP. The next Scoping Plan will augment the strategies presented in this document with measures focused on CO2, providing a balanced portfolio of near-term and long-term measures.

Other concurrent planning efforts in the State could also identify additional activities that may serve to reduce SLCP emissions. For example, CEC's Integrated Energy Policy Report, the Healthy Soils Initiative, and the Forest Carbon Plan are all ongoing efforts that intersect with many of the concepts described in this SLCP Report. ARB is collaborating with other agencies developing those plans to identify and prioritize activities to reduce SLCP emissions that would also support other State priorities and integrated planning efforts. Climate action planning efforts by city, county, and other local government entities will also play a key role in reducing SLCP emissions, especially if these action plans begin to incorporate SLCP emission inventories and mitigation actions.

B. Support Local and Regional Leadership

State policy is most effective with the support, engagement, and complementary actions of regional and local efforts. As the State shifts its climate-protection focus to the long-term and increases its efforts to reduce SLCP emissions, regional and local governments and agencies will play an increasingly important role in achieving California's GHG goals. The efforts of regional agencies, such as air districts, water districts, and municipal solid waste authorities, to incorporate GHG emission reduction strategies into their respective jurisdictions increases the State's leverage to further reduce SLCP emissions from various sources.

Local air districts have a key role to play in reducing regional and local sources of SLCP emissions, because air pollution reduction strategies employed by air districts often also reduce GHG emissions. For example, the local air districts are participating in the Interagency Waste Working Group to find regulatory and permitting solutions that allow for new and expanded organics processing facilities that are protective of public health as well as reducing GHG emissions due to avoided landfill methane emissions. City and county governments also play a pivotal role in reducing emissions of SLCPs. Many GHG emission reduction strategies identified by cities and counties in their local Sustainability or Climate Action Plans directly correlate to strategies necessary for SLCP emission reductions, such as improved waste management (increased recycling and composting), use of alternative and renewable fuels, and simply reducing vehicle miles traveled. These local government Climate Action Plans encourage, and sometimes mandate at the local level, actions taken by households and businesses within a community. Often times, these actions involve behavior change by individuals, which leads to increased conservation and sustainability, ultimately driving both community-scale GHG and SLCP emission reductions.

Below are examples of local and regional government efforts that are helping the State reduce SLCP emissions.

Methane

In California, agriculture and landfills are the primary sources of methane emissions. Aside from air district rules to reduce methane emissions at landfills, upstream efforts by cities, counties, and regional agencies to both reduce and divert food waste and other organic materials from the waste stream have the potential to greatly reduce landfill-related methane emissions. Additionally, local municipalities and solid waste agencies are working collaboratively with air districts to foster renewable fuel opportunities, such as waste-to-energy and waste-to-fuel projects. For example, through its leadership role with Clean Cities, the Sacramento Metropolitan Air Quality Management District is working closely with numerous partners to build awareness and increase separation and diversion of organic waste to a local anaerobic digester.

Local agencies also play a role in utilizing methane beneficially at wastewater treatment plants. Many local agencies own and operate wastewater treatment facilities and are implementing strategies for on-site energy production. Local strategies to improve management and utilization of organic waste throughout the State may also have the ability to help reduce methane emissions throughout the agricultural sectors. Wastewater treatment plants offer a tremendous opportunity to divert organics from landfills and utilize them for producing energy, transportation fuel, and soil amendments. Many treatment plants are located near population centers and could potentially utilize significant amounts of food and other organic waste streams that come from cities and towns. Collaboration amongst local and regional agencies, such as solid waste management and wastewater agencies, is the key to success.

Anthropogenic Black Carbon

Local air districts have worked with ARB to develop programs to comply with federal air quality standards for PM (that will also reduce black carbon), such as mandatory and voluntary rules to restrict residential wood-burning in fireplaces and wood stoves, along with incentive programs to switch to cleaner burning devices. Districts have also enacted rules regulating commercial cooking and smoke management programs addressing agricultural and rangeland burning operations, which have reduced black carbon and PM emissions.

Particulate matter visible in the air located in the Los Angeles Basin area

In addition to air district efforts, metropolitan planning organizations, in coordination with city and county governments, can be credited with efforts to reduce vehicle emissions, and ultimately on-road related emissions, particularly through their

Sustainable Community Strategy planning and implementation efforts. Local governments have stepped up by beginning with their own fleets. For example, in Sonoma County, the Board directed County staff to reduce emissions from the County's on-road fleet by 20 percent by 2010.

Local efforts to reduce diesel particulate matter, such as farm and construction equipment rules and incentive programs by air districts, play a significant role in the reduction of black carbon emissions such as the San Joaquin Valley Air Pollution Control District's program to replace diesel agricultural irrigation pump engines with electric motors. In addition, efforts by local port authorities, such as the San Pedro Bay Standards, have resulted in the establishment of more aggressive targets to reduce black carbon emissions, health risks, and further improve air quality, particularly for those in nearby disadvantaged communities.

HFCs and other F-gases

Local air districts can play an instrumental role in aiding the reduction of HFC emissions, including developing regulations to require low-GWP replacements. For example, the South Coast Air Quality Management District has three regulations to reduce refrigerant emissions from stationary air conditioning and refrigeration systems and motor vehicle servicing, as well as restrictions on CFCs and halons from sterilization, fumigation, and fire extinguishing equipment. In addition, many local governments are also tracking emissions of refrigerants, and some have adopted policies to reduce refrigerant emissions from city-owned air conditioning units, vehicles, and refrigerators.

C. Investments

Investments in financial incentives and direct funding are critical components for successful implementation of SLCP emission reduction strategies. Many existing State funding programs work in tandem to reduce emissions from GHGs (including SLCPs), criteria pollutants, and toxic air contaminants, and are helping foster the transition to a clean energy economy. In particular, State law (Senate Bill 535, De León, Chapter 830, Statutes of 2012) requires focused investment in communities disproportionately impacted by pollution. Many of these communities, especially in the Central Valley, along freight corridors, and in rural parts of the State, stand to benefit from dedicated action and investment to reduce emissions of SLCPs.

Russian Ridge Open Space Preserve (San Mateo County), photo by Steve Jurvetson / CCBY 2.0

Although California has a number of existing incentive programs, the pool of funds is limited and it is critical to target public investments in ways that encourage system-wide solutions to produce deep and lasting public benefits. Significant investments of private capital, supported by targeted, priority investments of public funding, are necessary to scale deployment and to maximize benefits. Public investments can help incentivize early action to accelerate market transition to cleaner technologies, which can then be supported by regulatory measures. The State must coordinate funding sources such as the California Climate Investments, supported by the Greenhouse Gas Reduction Fund (GGRF), Alternative and Renewable Fuel and Vehicle Technology Program (AB 118), Electric Program Investment Charge (EPIC) Program, Carl Moyer Program, Air Quality Improvement Program, and Proposition 39 to expand investments in California's clean economy and further reductions in SLCPs and other GHG emissions. Current activities and funding allocations for a few of these programs are described herein.

The GGRF is an important part of California's overall climate investment efforts to advance the goals of AB 32, SB 32, and SB 1383 and target investment in disadvantaged communities. To guide the investment of Cap-and-Trade auction proceeds, the Department of Finance, in consultation with the ARB and other State agencies, is required to submit a triennial Investment Plan to the Legislature. The Investment Plan identifies priority investments that will help California achieve its GHG emission reduction goals while realizing additional health, economic, and environmental benefits. The Investment Plan is required to identify near-term and long-term GHG emission reduction goals and targets, analyze gaps in current State funding for meeting these goals, and identify priority investments that facilitate GHG emission reduction. The second Investment Plan for Fiscal Years 2016-17 through 2018-19 was submitted to the Legislature in January 2016. The Second Investment Plan identifies potential State investment priorities to help achieve GHG emission reduction goals, benefit disadvantaged communities, and yield valuable co-benefits within the Transportation & Sustainable Communities, Clean Energy & Energy Efficiency, and the Natural Resources and Waste Diversion categories. The priorities identified in the Second Investment Plan would reduce a range of GHGs, including short-lived climate pollutant emissions. The Second Investment Plan informed Governor Brown's 2016-2017 Proposed Budget, which included $215 million of Cap-and-Trade expenditures specifically targeting SLCP emission reductions. These expenditures were revised in SB 1613, which appropriates $5 million for black carbon residential wood smoke reductions, $40 million for waste reduction and management, $7.5 million for Healthy Soils, and $50 million for methane emission reductions from dairy and livestock operations.

A critical piece of the State's investment strategy, which is overseen by ARB and focused on clean transportation incentives, is the Low Carbon Transportation Investments and the Air Quality Improvement Program (AQIP). Consistent with the First Investment Plan, these programs have identified zero-emission passenger transportation and low-carbon freight transport as investment priorities, which reduce criteria pollutant and toxic emissions with concurrent reductions in GHG emissions, including black carbon. ARB has focused AQIP investments on technology advancing projects that support long-term air quality and climate change goals in addition to providing immediate emission benefits. In recent years, funding has included rebates for zero and near-zero emission passenger vehicles through the Clean Vehicle Rebate Project (CVRP), vouchers for hybrid and zero-emission trucks and buses through the Hybrid and Zero-Emission truck and Bus Voucher Incentive Program (HVIP), and the Truck Loan Assistance Program for small business truck owners in need of truck replacements or retrofits.

The CEC administers an additional key GHG emission reduction investment program for the transportation sector—the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP). Funds that are collected from vehicle and vessel registration fees, vehicle identification plates, and vehicle smog fees provide up to $100 million per year for projects that will transform California's fuel and vehicles to help attain the State's climate change policies. Investments in alternative fuel production and infrastructure, and vehicle projects can contribute to SLCP emission reductions through reduced diesel consumption, capture and use of biogas from waste management activities as a transportation fuel, demonstration and early commercialization of advanced technology trucks that utilize biogas, and avoided fugitive methane emissions from fossil fuel production and distribution operations.

Another CEC-administered program, the Electric Program Investment Charge (EPIC) Program, supports investments in clean technologies and strategies to improve the State's electricity systems. The program provides opportunities to support SLCP emission reductions from reduced or avoided fugitive methane emissions stemming from fossil fuel production and distribution via investments such as improved energy efficiency technologies in building, industrial, agricultural and water sectors; demand response; distributed renewable generation; electric vehicle infrastructure; demonstration of biomass-to-energy conversion systems; advanced energy storage interconnection systems; and vehicle-to-grid power transfer for electric vehicles.

CDFA administers the Dairy Digester Research and Development Program. This incentive-based program supports digester development in California and can provide grants for research and demonstration projects that improve scientific and technical understanding of technologies and practices that reduce methane and other GHG emissions on dairies. CalRecycle administers GHG emission reductions grant and loan programs that include incentives for infrastructure supporting organics diversion. Finally, ARB is developing an incentive program to replace residential wood burning devices in the State with cleaner, more efficient devices, thereby reducing GHG, black carbon, particulate matter and other air toxics emissions.

These programs represent just a portion of opportunities that exist at the federal, State, and local levels to incentivize SLCP and GHG emission reductions. The availability of dedicated and long-lasting funding sources is critical to help meet AB 32, SB 32, and SB 1383 objectives and help provide certainty and additional partnership opportunities at the national, State, regional, and local levels for further investing in projects that have the potential to reduce emissions of SLCPs.

D. Coordinate with Subnational, Federal, and International Partners

California is working with a set of national and subnational partners throughout the world to fight air pollution and climate change. This includes signatories to the Under 2 MOU, as well as others in Mexico, China, India, the U.S., Canada, and elsewhere. Many of the efforts underway through these collaborations will help reduce emissions of black carbon from the transportation sector and emissions of other SLCPs.

At the 2014 United Nations (UN) Climate Summit, ARB became the first state-level entity to sign onto action statements of the Climate and Clean Air Coalition to Reduce Short-Lived Climate Pollutants. At the 2014 UN Conference of Parties in Lima, California co-sponsored an event with Mexico on SLCPs and their role in an international framework to contribute to national commitments to reduce emissions. At UN climate meetings in New York and Paris in 2015, Governor Brown presented the targets described in this SLCP Strategy, and suggested that action on SLCPs may be the most important and most immediate need to address climate change. The State continues to be committed to acting both bilaterally and multilaterally to cooperate with other jurisdictions to cut SLCP emissions, and will explore additional opportunities to further reduce air pollution, greenhouse gas, and SLCP emissions through partnerships.

Building on leadership around SLCPs can provide an important example for action in other countries and jurisdictions, and is one of the most significant opportunities to accelerate international progress to fight climate change. California is in a unique position to serve as a model for action for other countries and jurisdictions to accelerate their progress to reduce emissions of both SLCPs and CO_2, based on the State's demonstrated leadership on air quality and climate change, commitments to set stringent, science-based targets to reduce emissions of both CO_2 and SLCPs, and integrated planning efforts, like this one, to develop a comprehensive policy framework to achieve those goals.

As we have done for decades already, California's actions on SLCPs can demonstrate win-win opportunities for both the most developed countries, where reducing SLCP emissions is an important element of broad efforts to cut GHG emissions, as well as for the least developed countries, where SLCP emission reductions have tremendous benefits for air quality and human health.

Ultimately, each state, region, or country has its own mix of SLCP sources, needs, and opportunities to reduce emissions. Coordinated planning to meet scientific-based emission targets, like this SLCP Strategy does, is important to successfully reducing emissions and maximizing local and global benefits.

California will share this planning effort with others, and encourage them to adopt specific SLCP emission reduction targets and plans to achieve them. A few already have; the federal government has set specific targets to cut methane emissions from the oil and gas sector, Mexico has included targets to cut black carbon emissions in its

Intended Nationally Determined Contribution to the United Nations Framework Convention on Climate Change, Europe and other countries have taken steps to phase down the use of HFCs, Australia and Brazil are working to reduce methane from agriculture, and Norway has developed an SLCP action plan of its own.[136] These types of commitments and planning efforts need to be adopted more broadly. By developing a comprehensive plan to achieve necessary SLCP emission reductions in an effective and beneficial way, California can foster broader action beyond its borders and demonstrate effective processes and strategies to address climate change.

[136] NEA (2014) Summary of Proposed Action Plan for Norwegian Emissions of Short lived Climate Forcers, Norwegian Environment Agency, March. http://www.miljodirektoratet.no/en/Publications/2014/March-2014/Summary-of-proposed-action-plan-for-Norwegian-emissions-of-shortlived-climate-forcers/

VIII. Evaluations

This chapter discusses the economic, public health, and environmental justice evaluations of the proposed new measures in this SLCP Strategy. It also discusses the environmental analysis that was prepared for the SLCP Strategy. It should be noted that to the extent that any of the proposals in the SLCP Strategy result in regulatory action, each proposed regulation will be subject to its own public process with workshops, opportunities for stakeholder discussion, consideration of environmental justice, and legally required analyses of the economic and environmental impacts. Staff will track the progress of implementation of the SLCP measures and provide periodic updates to the Board. This information, as well as updates to the SLCP emission inventory, will be posted to ARB's SLCP website.

A. Economic Assessment of Measures in the SLCP Strategy

This section presents the economic analyses for the new measures identified in this SLCP Strategy. Supporting documentation for this analysis is presented in Appendix F. Activities already underway separately—including development of the California State Implementation Plan to meet federal health-based air quality standards, the California Sustainable Freight Action Plan, the 2030 Target Scoping Plan Update, and implementation of Senate Bill 1371 (Leno, Chapter 525, Statutes of 2014)—will have important impacts on SLCP emissions in California, but are not evaluated here.

The analyses presented here consider direct economic costs associated with new technologies and management strategies that can help to reduce SLCP emissions. They also consider direct economic benefits in the form of savings as a result of efficiency improvements or revenue from marketable products. This analysis does not include a macroeconomic analysis at the statewide level, nor does it include a monetary accounting of societal benefits, such as the value of reducing exposure to fine particulate pollution or reducing the impacts of climate change.

While there are potentially significant market opportunities associated with some of the proposed measures, including putting organics to beneficial use, there are also substantial costs and funding needs. These include costs to increase market penetration of existing technologies and research and development of innovative advanced technology. Initial analyses and various literature sources suggest that SLCP emissions from several sources, including those identified in this SLCP Strategy, can be reduced at low, and sometimes negative, lifetime costs.

Long-term regulatory signals can play a vital role in facilitating low cost SLCP emission reductions. The LCFS and the federal Renewable Fuel Standard (RFS) incentivize the use of renewable natural gas as a transportation fuel, creating large revenue potential within the dairy manure and organic diversion measures. These programs in particular can help support cost-effective projects to reduce methane from the dairy and waste sectors. Without the LCFS or RFS programs, additional sources for financial incentives and funding may be needed.

The measures laid out in this SLCP Strategy are transformative, leading to uncertainty in the potential costs and revenue of proposed measures as well as the ultimate pathway to compliance. There is a wide range of potential costs and savings, uncertainty in how the strategies will be met, and uncertainty in some cases for how costs in literature translate in the California context. In conjunction with State agencies, ARB will continue to work closely with stakeholders and manufacturers to evaluate the feasibility and costs of existing and developing technologies to determine the best approaches to meeting the targets in the SLCP Strategy.

The measures included in the SLCP Strategy will also strengthen California's environment and the economy by developing infrastructure, generating cost savings, and creating jobs. Measures that reduce methane emissions through waste digestion will have a large impact on the California economy, including disadvantaged communities.

The dairy manure measure has the potential to create jobs in California's Central Valley. These jobs include construction jobs to build digesters and farm and waste management jobs to operate and maintain the facilities. In this analysis, it is assumed that the construction of an anaerobic digester for a 2,000 head dairy farm can result in 25 to 60 construction jobs and 2 to 5 full-time farm jobs.[137] If digesters were built on farms accounting for about 1 million dairy cows, many in the San Joaquin Valley, it could result in over 30,000 construction jobs and 2,500 permanent jobs potentially providing employment opportunities in disadvantaged communities.

Diverting organic waste can also result in increased employment, providing an estimated additional 2 jobs per 1,000 tons of diverted organic material.[138] In 2025, this could result in 25,000 additional jobs in waste management and garbage collecting, food recovery and distribution. As demonstrated in the CalRecycle funded Food to Share project, food waste prevention programs not only produce emission reductions, but employment and nutritious meals to California's most vulnerable populations.[139]

The proposed measures will also build on and support existing California efforts related to climate change and air quality. Measures will support infrastructure, research, development, and deployment of advanced technologies that will help achieve California's near- and long-term climate and air quality goals. Encouraging the collection of methane gas from waste streams, for example, can provide renewable fuel to reduce the carbon footprint of the transportation sector. Associated efforts

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[137] Sample of industry information relied upon for the estimate: http://www.gundersenenvision.org/renewable-energy/turning-cow-waste-into-energy-middleton and http://www.usda.gov/oce/reports/energy/Biogas_Opportunities_Roadmap_8-1-14.pdf.
[138] http://www.calrecycle.ca.gov/publications/Documents/1463%5C20131463.pdf
[139] More information available at: http://greenlining.org/wp-content/uploads/2015/10/CAClimateInvestmentsCaseStudies.pdf.

related to the 2030 Target Scoping Plan Update, the California State Implementation Plan, and California's Sustainable Freight Action Plan stand to benefit from activities to cut SLCP emissions

The 2030 Target Scoping Plan Update, expected to be finalized in 2017, will include a detailed macroeconomic assessment of California's complete climate change mitigation strategy, including those contained in the final SLCP Strategy. While this SLCP Strategy begins to explore the costs and benefits of proposed measures, the 2030 Target Scoping Plan Update will contain a detailed economic analysis including a comprehensive assessment of the impact of California's climate strategy on Californians, businesses, Disadvantaged Communities, and the California economy.

All proposed SLCP strategies that are implemented as regulations will also be subject to the economic requirements of the Administrative Procedures Act (APA) as part of the public regulatory process. Prior to finalization, regulatory measures will be analyzed in a public process including an Economic Impact Statement, Economic Impact Assessment, and a Standardized Regulatory Impact Assessment for major regulations. Therefore, there will be many opportunities for stakeholders to assess the economic impact of measures in the SLCP Strategy as they are being developed.

The costs, savings, and potential revenue streams of the five measures are assessed in the following sections, 1 through 5. Collectively, implementing these measures would require several billion dollars of investment in clean technologies and strategies that would lead to significant reductions in SLCP emissions. Potential revenues and efficiency gains could also be significant—potentially outweighing the costs of some measures. In other cases, there may be net costs, but associated SLCP emission reductions may come at relatively low cost or provide other environmental and health benefits. While uncertainties remain—especially for costs and revenues associated with some strategies that utilize either emerging technologies or those that have not been widely deployed already in California—these measures can help to significantly cut SLCP emissions in California at reasonable cost. With ongoing, targeted financial and market support, coordinated with regulatory development and other economic and environmental priorities where appropriate, California can meet the targets identified in this SLCP Strategy while delivering a broad range of benefits.

1. Residential Wood Combustion Black Carbon Emission Reductions

Residential wood combustion (RWC) constitutes 15 percent of California's anthropogenic black carbon (BC) emissions, and is projected to be the largest individual source of BC by 2030. This Strategy recommends a 3.0 MMTCO2e (20-yr GWP) reduction in RWC BC emissions by 2030 to meet the SLCP BC emission reduction target.

There are a variety of ways to reduce RWC emissions, and multiple air districts have already put measures in place. Past incentive programs to replace old polluting wood-burning devices with the cleanest EPA-certified devices have been popular and effective. However, rural districts that rely most heavily on RWC for their primary source of heat are largely located outside of regions that provide incentives. Additionally, past incentive programs have not acquired sufficient funding to achieve the substantial emission reductions proposed in this strategy.

The cost share of this strategy between homeowners and governmental incentives primarily depends on the incentive amount provided per device, and total costs depend on the emission reductions achieved per device. Both of these factors will vary by region and by household, thus incentives funding and homeowners' share of costs are calculated as a range. The cost to replace a device with a certified wood burning or gas device can range between $3,000 and $5,000, while some options, such as full HVAC installation can cost up to $10,000.[140] Purchase and installation of woodstoves was assumed to cost $4,000 while gas or small electric devices were assumed to cost $4,500. Incentives typically cover a portion of the cost, from $1,000[141] up to the full installation price.[142] Many rural areas that rely heavily on wood combustion as a source of heat will require nearly full coverage of the installation price to spur voluntary participation. The range of incentives was assumed to be $1,000 to $4,500 to cover various cases.

The BC emission reduction per household depends on how much wood is burnt per year, the density and moisture content of the wood, the old device type, and the new device type. Emissions were calculated for two replacement cases. The "wood to wood" case assumes conversion of non-certified woodstove to EPA-certified wood stove.[143] This case assumes that new EPA-certified devices work as certified, but real-world use may lead to higher than certified emissions if proper burn practices are not followed. If emissions do not meet certified levels, the level of health benefits and cost effectiveness of incentive dollars may not be realized. Emission reductions are more certain in the "wood to gas or electric" case where a non-certified woodstove is replaced by a gas or electric heating device. Conversion to natural gas or electric heating devices assumes 100 percent reduction in local PM emissions.

Actual incentive programs will likely contain a mixture of different replacement types and these two cases are used to bound potential emission reductions and costs. Other parameters used in emission reduction calculations were provided by the U.S. EPA residential wood combustion replacement calculator, which includes California-specific data when available (Table 12).[144] The calculator was updated to account for

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[140] USEPA (2014). How to Implement a Wood-Burning Appliance Change out Program. Available at: http://www.epa.gov/sites/production/files/2015-08/documents/howtoimplementawoodstovechangeout.pdf

[141] SJVAPCD (2016). Burn Cleaner Program. http://valleyair.org/grants/burncleaner.htm

[142] http://www.epa.gov/sites/production/files/201508/documents/howtoimplementawoodstovechangeout.pdf

[143] Specifically, a woodstove that meets the U.S. EPA 2020 new source performance standard (2.0 grams particulate matter per hour) USEPA (2015). Fact Sheet: Summary of Requirements for Woodstoves and Pellet Stoves. Available at: http://www.epa.gov/residential-wood-heaters/fact-sheet-summary-requirements-woodstoves-and-pellet-stoves

[144] USEPA (2009). Burn Wise Additional Resources - Emission Calculator. http://www.epa.gov/burnwise/burn-wise-additional-resources

replacement with cleaner EPA-certified wood burning devices that will be required by 2020.

Table 12: Emission Summary

Parameter	Wood to Wood	Wood to Gas or Electric
Cords wood burnt per year[145]	1.5	1.5
Wood Density (tons/cord)[146]	1.04	1.04
$PM_{2.5}$ Emission Reductions per device (tons/yr)[147]	0.0218	0.0245
BC Speciation (fraction of $PM_{2.5}$)[148]	0.125	0.125
BC Reduction per device per year (MTCO2e, 20-yr GWP)	7.9	8.9
BC Emissions Target 2030 (MTCO2e, 20-yr GWP)	3,000,000	3,000,000
Number of average replacements needed to meet target	379,000	337,000

The cost of incentives was calculated by multiplying the number of replacements needed to meet the target (Table 12) by the range of incentives that could be provided, from $1,000 to the full cost of replacement.[149] The cost to homeowners was calculated as the total replacement cost, minus the portion covered by incentives. The "low incentives" case in Table 13 is a scenario where only $1,000 in incentives is paid, and homeowners pay a portion of the replacement. In the "high incentives" case, incentives cover 100 percent of replacement costs and homeowners pay no money out of pocket. Costs to oversee and administer the incentives program were assumed to be similar in either case, because a similar number of devices are replaced (Table 12), and were calculated as 10 percent of the lower incentive value.[150] Educational and outreach costs were estimated at one percent of the lower incentives value. Education and outreach includes education about the health effects of wood smoke and educating residents about proper use of their new devices to minimize emissions and maximize the lifetime of the equipment. Studies indicate that education and outreach are vital components of RWC replacement programs.[151] A summary of costs can be found in Table 13. The results show that the total costs for either a low incentives or high incentives case would be the same, but the distribution of costs between incentives and homeowner responsibility is different. These scenarios represent

[145] Based on average California Climate, from USEPA Emission Calculator.
[146] Average California wood density, from USEPA Emission Calculator.
[147] Results are from USEPA Emission Calculator for wood to gas conversion. This result assumes approximately 100% reduction in PM.
[148] ARB (2015). 2015 Edition Black Carbon Technical Support Document. Available at: http://www.arb.ca.gov/cc/inventory/slcp/slcp.htm
[149] $4,000 for woodstove installation and $4,500 for gas devices.
[150] http://www.epa.gov/sites/production/files/201508/documents/howtoimplementawoodstovechangeout.pdf
[151] http://www.epa.gov/sites/production/files/201508/documents/howtoimplementawoodstovechangeout.pdf

extremes use to bound the range of possible costs; actual program implementation may lie between the low and high incentives cases presented in Table 13.

Table 13: Range of Costs (Million Dollars)[152]

Cost	Low Incentives	High Incentives
Incentives	$340	$1,500
Oversight and Administration	$34	$34
Cost to Homeowners	$1,180	$0
Education and Outreach	$3.4	$3.4
Total Cost	**$1,557**	**$1,537**

Savings associated with this strategy include reduced wood use in more efficient devices or any savings (or cost) to convert from wood fuel to natural gas. U.S. EPA estimates that EPA-certified devices burn a third less wood for the same heat output.[153] Table 14 summarizes the range of potential savings depending on the conversion scenario.

Wood to wood total savings were calculated using the average annual amount of wood burnt (Table 12), the fraction of residents who pay for wood,[154] the cost of a cord of wood, and the assumption that a third less wood is used by the replaced devices. This analysis assumes 20 percent of wood is gathered for free, and would not provide a savings to the resident. The cost of a cord of wood will vary from approximately $100 to $480 depending on location and type of wood[155]. This analysis uses the midpoint value of $290 per cord. Reducing annual wood consumption from 1.5 to 1 cord per year would save the average resident $145 per year. Approximately 379,000 wood to wood conversions (Table 12) would result in savings of approximately 44 million dollars per year to consumers receiving incentives to replace their inefficient wood stove.

Wood to gas or wood to electric savings can be calculated assuming 1.5 cords of wood are not purchased (Table 12), the cost of wood is $290 a cord, and that the heat-equivalent amount of natural gas or electricity must be purchased, and assuming 337,000 devices are replaced (Table 12). The price of natural gas was assumed to be $11.51 per thousand standard cubic feet.[156] The price of electricity was assumed to be

[152] Low incentives are $1,000 and high incentives cover 100 percent of device purchase and installation costs ($4,000-$4,500 depending on the device). Under the high incentive there is no out of pocket expense to homeowners.

[153] http://www.epa.gov/sites/production/files/201508/documents/howtoimplementawoodstovechangeout.pdf

[154] A portion of residents who rely on residential wood combustion for heat gather wood from local lands at no cost.

[155] CDFA (2010). California Department of Food and Agriculture News Release. Available at https://www.cdfa.ca.gov/egov/Press_Releases/Press_Release.asp?PRnum=10-074

[156] EIA (2015). California 2014 price of natural gas delivered to residential customers. Available at https://www.eia.gov/dnav/ng/ng_pri_sum_dcu_SCA_a.htm.

16.3 cents per kWh.[157] The savings from not purchasing wood is nearly in balance with the additional cost of purchasing natural gas using these assumptions, while electricity is estimated to cost about four times more than wood (Table 14). Thus, electricity purchase would likely represent an additional cost to homeowners.

Table 14: Savings Associated with Residential Wood Stove Conversion (Million Dollars)

Conversion Scenario	Savings on Purchase of Wood	Increased Cost for Natural Gas or Electricity	Net Fuel Savings
100 % Wood to Wood	$44	$0	$44
100 % Wood to Gas	$117	$109	$8
100 % Wood to Electricity	$117	$464	-$347

2. Methane Emission Reductions from Dairy Manure

The economic analysis investigated a reduction in dairy manure emissions that could come from a mix of voluntary and regulatory efforts to reduce emissions from the equivalent of about 1 million cows, equivalent to an annual methane reduction of 22 $MMTCO_2e$ by 2030, and a cumulative reduction of 166 $MMTCO_2e$ through 2030 using the assumptions in this analysis (7.8 $MMTCO_2e$ and 57.6 $MMTCO_2$, respectively, using a 100-year GWP). This analysis will be further refined in coordination with stakeholders as measures are developed.

The analysis included five potential pathways for dairies to mitigate manure methane. These represent example pathways that could be important to a sector-wide approach to reduce emissions, but they are not meant to rule out other solutions. Not every pathway may be feasible for every dairy, and a variety of pathways will be employed to reach the targets.

This analysis relies on a number of assumptions that may not fully account for all barriers a project could face, such as up-front financing challenges or permitting issues. On the other hand, cost estimates are based on current and past projects, and may over-represent future costs that could come down from economies of scale or learning. Still, this analysis shows the potential for strategies to improve management of dairy manure and produce revenue-positive, value-added products, such as transportation fuels, while providing GHG, and potentially also criteria pollutant, benefits.

The five major pathways analyzed were:

1) Scrape conversion and onsite manure digestion producing:

[157] EIA (2015). Annual Average Retail Price of Electricity to Ultimate Customers by State and Utility. Table 6 - 2014 Utility Bundled Retail Sales – Residential filtered for California. Available at: http://www.eia.gov/electricity/data.cfm#sales

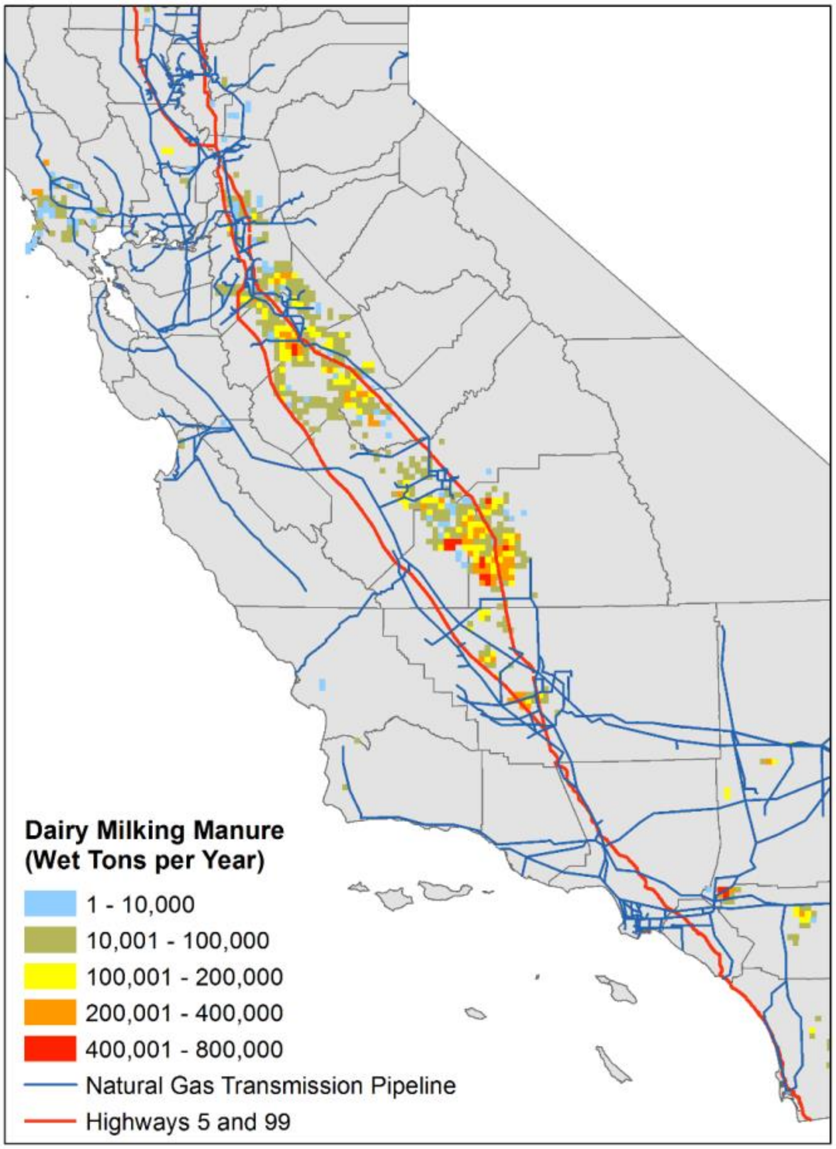
   a) electricity or
   b) pipeline-injected renewable natural gas vehicle fuel
2) Scrape conversion and transport of manure offsite for centralized digestion producing:
   a) electricity or
   b) pipeline injected renewable natural gas as a vehicle fuel
3) Retain existing manure lagoon management with onsite covered lagoon digestion producing:
   a) electricity or
   b) pipeline-injected renewable natural gas vehicle fuel
4) Conversion of dairy operations to pasture-based management
5) Scrape conversion, collection and open solar drying of manure onsite

The first pathway assumes conversion to solid manure management (scrape), and development on digesters onsite at each dairy to produce either electricity using micro turbines or transportation fuel. The second pathway is the same as the first, but captures economies of scale by utilizing centralized digesters for a "cluster" of dairies. In the second pathway, manure is assumed to be trucked to the central digestion point. Pathway 2 only includes a subset of California's dairies that were within reasonable clustering distance using a GIS analysis (within 5 miles on average). The third pathway retains the existing lagoon manure management, utilizes a covered lagoon digester, with the resulting biomethane producing either electricity or transportation fuels. Pathway 3 only includes the subset of dairies practicing flush management. In the fourth strategy, dairies convert to pasture-based operations; no revenue is assumed from this pathway. Finally, the fifth pathway mitigates manure methane emissions by converting from flush management to scrape systems, but is assumed to generate no revenue. There could also be potential revenue (along with added costs) if manure were composted and sold, which is not considered here. This represents a relatively low cost option compared to the other pathways, but low value as well. The cost and efficacy of some mitigation options, such as solids separation, were not yet known with certainty and could not be included in this analysis. Solids separation and other potential mitigation methods deserve additional study of both emission reduction potential and economic feasibility.

Cost Analysis Methodology

Cost analyses were based on a Geographic Information System (GIS) analysis of dairies throughout the State. The GIS analysis used information about the size, associated crop land, and location of dairies to inform feasibility of pipeline injection, pasture-based management, and dairy-specific costs for each pathway listed above. Analyses were also performed to understand the feasibility and cost savings associated with "clustering" dairies to centralize digestion by defining 55 potential central cluster locations and identifying dairies to feed into each cluster. The dairy-specific economics were calculated for each pathway to account for cost differences in dairy herd size and distance from transmission pipelines or central digestion locations. Figure 10 provides a spatial analysis of manure from milking cows in California.

Figure 10: Location of Manure from Milking Cows in California



The economic analysis was informed with consultation from CDFA, academic researchers at UC Davis and elsewhere, project developers, and stakeholders. In particular, as part of developing this SLCP Strategy, ARB supported research at UC Davis to inform cost and performance estimates for dry scrape conversions, anaerobic digesters, and other pathways.[158] Additional research was also used to inform the cost

[158] Kaffka, S. et al (2016) Evaluation of Dairy Manure Management Practices for Greenhouse Gas Emissions Mitigation in California, Final Technical Report to the State of California Air Resources Board, February 2016. http://biomass.ucdavis.edu/wp-content/uploads/2016/06/ARB-Report-Final-Draft-Transmittal-Feb-26-2016.pdf

and performance parameters assumed for this analysis, which are detailed in Appendix F.[159]

Pathways that inject biomethane into the pipeline for use as transportation fuel are assumed to receive revenue for energy sales at the price of wholesale natural gas ($3.46/Mscf), as well as LCFS credits ($100/MT) and cellulosic RIN credits ($1.85/RIN)[160] from the federal Renewable Fuel Standard program. Dairies that receive LCFS credits cannot also receive Cap-and-Trade credits for the same volume of biomethane.[161] Pre-regulation and post-regulation LCFS carbon intensities and associated revenue were calculated using the same assumptions as the 2015 LCFS-certified California bioenergy Dairy Biogas prospective pathway.[162] Pathways that produce electricity assume the use of microturbines to limit NOx emissions and receive revenue from SB 1122 electricity sales subsidies ($0.126/kWh) and Cap-and-Trade offsets ($13/MTCO$_2$e). No revenue was included for soil amendment products that could potentially provide value,[163] because their market remains uncertain. Each pathway was analyzed using LCFS credits both pre and post regulation.

Biogas production for above ground or plug-flow digesters are assumed to use 100 percent of manure volatile solids from milking cows, while covered lagoon digesters are assumed to capture 60 percent of manure volatile solids due to losses during solids separation. In addition, above ground or plug-flow digesters are estimated to be 11 percent more efficient per pound of manure.[164] In balance, biogas production per cow is approximately two times larger for above ground or plug-flow digesters as covered lagoon digesters using these assumptions, though real-world technology implementation may differ from these assumptions. The baseline methane mitigated (destroyed) is similar regardless of technology so LCFS revenues are similar for covered lagoon and above ground tank or plug-flow digesters, while revenue from RIN credits varies in proportion to biogas production.

Example Economic Analysis for a 2,000 Milking Cow Dairy

A full economic analysis was performed for each pathway on a dairy-by-dairy basis to account for cost differences between dairies of different sizes. However, to provide an overview comparison by pathway, the costs and revenues for an example 2,000 cow

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[159] In particular: Sustainable Conservation (2015) Combating Climate Change: Dairies Key in Reducing Methane, July: http://www.suscon.org/blog/2015/07/combating-climate-change-dairies-key-in-reducing-methane/.
[160] The assumed cellulosic RIN credit value of $1.85 includes a D5 RIN ($0.85), cellulosic waiver credit ($0.90) and value from the Blenders Tax Credit ($0.10 per D5 RIN).
[161] ARB (2016). Staff Summary, Method 2B Application: Prospective Pathway Dairy Biogas to CNG. www.arb.ca.gov/fuels/lcfs/2a2b/apps/Calbio-122115.pdf
[162] Id
[163] Soil amendment products from dairy digesters could provide as much as $300 per cow per year in California. Informa Economics (2013) National Market Value of Anaerobic Digester Products.
[164] Kaffka, S. et al (2016) Evaluation of Dairy Manure Management Practices for Greenhouse Gas Emissions Mitigation in California, Final Technical Report to the State of California Air Resources Board, February 2016. http://biomass.ucdavis.edu/wp-content/uploads/2016/06/ARB-Report-Final-Draft-Transmittal-Feb-26-2016.pdf

flush dairy are summarized in Table 15. The table includes the net present value for each pathway over a 10-year time horizon, assuming a 10 year loan on capital at 7 percent interest, and a 5 percent discount rate. Results are presented both pre-regulation, and post-regulation to examine the effects of regulation on LCFS credit generation and net present value of the project. Regulation would increase the carbon intensity of projects producing transportation fuels, reducing the revenue from LCFS credits, and would eliminate carbon offset credits for new projects that generate electricity and are built after the regulation is in place. However, the value of these revenue streams could also be higher than assumed in this analysis, which would increase revenues and net present values beyond those listed in the table. The detailed calculation methodology, assumptions, and references for Table 15 are included in Appendix F.

Table 15: Economic Analysis for Projects at an Example Flush Dairy with 2,000 Milking Cows Over a 10-year Period, considering value pre and post regulation.[165] (All costs and revenue in million dollars)

	Pathway							
	1a	1b	2a	2b	3a	3b	4	5
	Scrape, Onsite Digestion to Electricity	Scrape, Onsite Digestion to Fuel	Scrape, Central Digestion to Electricity	Scrape, Central Digestion to Fuel	Lagoon, Onsite Digestion to Electricity	Lagoon, Onsite Digestion to Fuel	Pasture	Scrape Only
Capital	$6.9	$7.2	$6.8	$5.3	$5.1	$7.2	$7.2	$1.6
O&M	$4.2	$5.3	$4.8	$4.5	$4.1	$5.5	$2.8	$0.4
Carbon Credits	*$1.5*	--	*$1.5*	--	*$1.5*	--	--	--
LCFS pre-reg	--	*$6.7*	--	*$6.7*	--	*$6.4*	--	--
LCFS post-reg	--	*$0.8*	--	*$0.8*	--	*$0.5*	--	--
RINS	--	*$4.1*	--	*$4.1*	--	*$2.2*	--	--
Other Revenue	*$2.1*	*$1.1*	*$2.1*	*$1.1*	*$1.1*	*$0.6*	--	--
Revenue pre-regulation[166]	$3.6	$11.9	$3.6	$11.9	$2.6	$9.2	--	--
Revenue post-regulation[167]	$2.1	$6.1	$2.1	$6.1	$1.1	$3.3	--	--
10-year net present value (NPV) and cost effectiveness pre-regulation								
NPV (million $)	–$7.5	–$0.5	–$8.0	$2.1	–$6.5	–$3.4	–$9.9	–$2.1
$/MT CO_2e (20-yr GWP)	18	1	19	–5	15	8	29	5
$/MT CO_2e (100-yr GWP)	51	3	55	–15	45	23	82	14
10-year net present value (NPV) and cost effectiveness post-regulation								
NPV (million $)	–$9.0	–$6.3	–$9.5	–$3.7	–$8.0	–$9.4	–$9.9	–$2.1
$/MT CO_2e (20-yr GWP)	21	15	23	9	19	22	29	5
$/MT CO_2e (100-yr GWP)	61	43	65	25	55	64	82	14

Table 15 shows the potential for large revenue from transportation fuels production. One pathway that produces transportation fuels and captures economies of scale by clustering dairies, pathway 2b, is potentially revenue positive if LCFS and RIN credits remain near recent prices. However, credit prices under these programs can be volatile, and securing funding for projects with uncertain revenue sources is challenging. Even with LCFS and RIN credits, these projects may need financing assistance, either in the form of up-front grants, or other mechanisms that can help to secure project financing, such as the pilot financial mechanism for diaries required by SB 1383. Regulation reduces the value of LCFS credits and eliminates carbon credits for new dairy projects. Table 15 shows that, with regulation in place, the revenue from

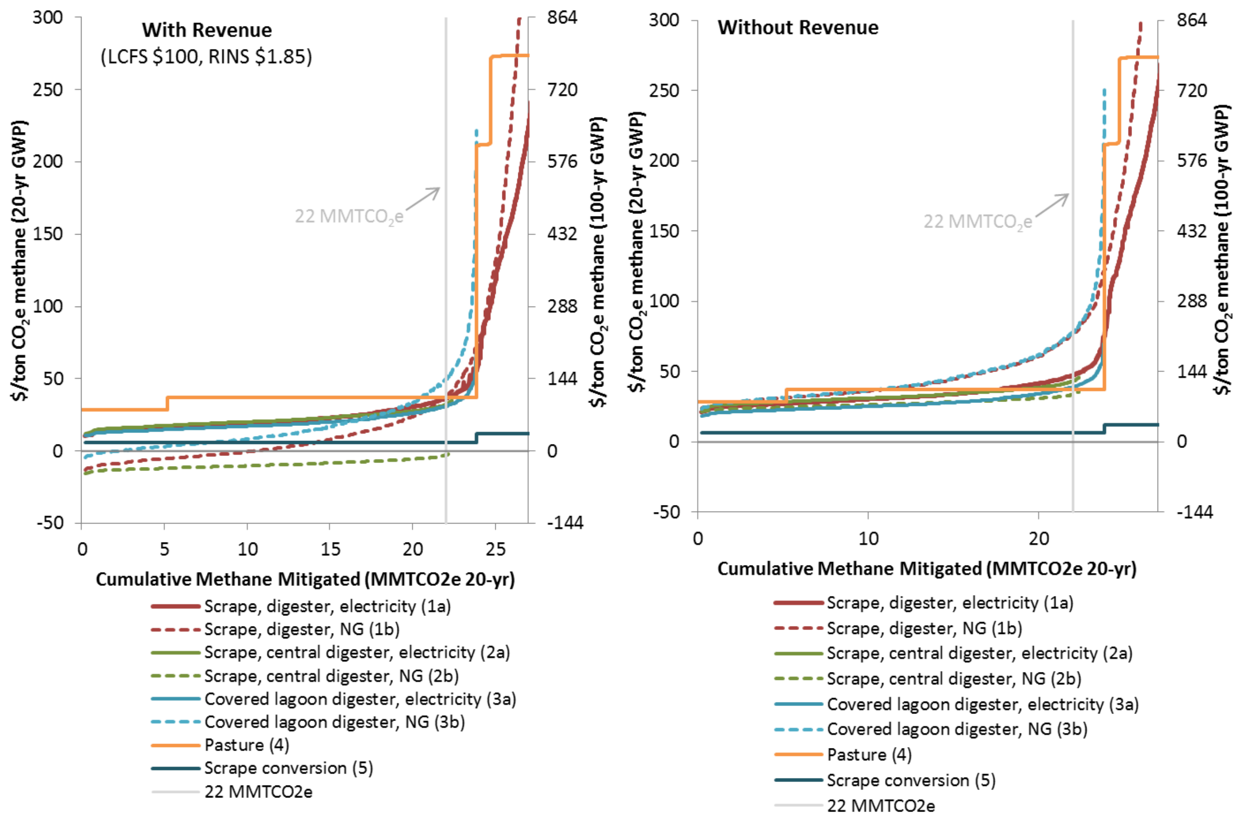
[165] Summation may not be exact due to rounding. Capital costs amortized over 10 years with 7% interest. Discount rate is 5%. Costs normalized to example 2,000 cow dairy.
[166] Pre-regulation revenue includes carbon credits, pre regulation LCFS value, RINS, and other revenue
[167] Post-regulation revenue includes post-regulation LCFS value, RINS, and other revenue

LCFS credits for new projects declines significantly, and the net present value of all projects is negative over their first 10 years.

Cost Curves for California's Dairies

Data in Table 16 represent a 2,000 milking cow dairy to compare the relative costs and revenue by pathway for a dairy, however, costs will not be consistent across dairy sizes or location. A dairy-by-dairy economic analysis was performed to better account for this. Capital, annual operations and maintenance, and annual revenue were calculated for each dairy in California to provide cost curves by pathway (Figure 11). To illustrate costs and cost-effectiveness, cost curves are presented both with and without revenue in Figure 11.

Figure 11: Individual Dairy Cost Curves by Pathway



Based on the assumptions used here, projects at dairies show the potential to reduce manure methane emissions, at fairly low (or negative) costs compared to other sources. However, dairies are unique because milk prices are fixed, thus dairy operations cannot pass on increased production costs. Many dairies in California are currently operating at a loss, so even comparably low-cost emission reduction options such as these could pose a financial burden to the dairy industry.

Projects that generate transportation fuel and capture LCFS credits (1b, 2b, and 3b) have the potential to generate significantly more revenue than other pathways, and have the potential to be revenue positive over 10 years for many dairies in California (Figure 11). All other pathways that do not generate transportation fuels are revenue negative over 10 years for any dairy in California, using the assumptions here, and would need additional financial assistance to be economically viable over that time frame. Additionally, no modeled project is revenue positive in the absence of LCFS and RIN credits.

Costs and Revenues for Sector-Wide Scenarios

The sector-wide total implementation cost to achieve a 22 $MMTCO_2e$ dairy manure methane reduction depends on the pathway utilized by each dairy, which is difficult to predict. To bound potential costs, this analysis assumes that dairies would choose the pathway with the highest net present value if LCFS and RIN credits were available (2b – scrape conversion with central digestion to fuel), or that dairies would choose the lowest cost option in the absence of revenue (5 – scrape conversion only). This provides a likely cost bounding considering scenarios with and without LCFS and RIN credits. It is important to note that these scenarios were selected as an economic bounding exercise, and they are not intended to suggest a preferred or expected path forward. For example, there are still outstanding questions about the costs and feasibility of converting California's dairies from lagoon flush management to scrape, which should be investigated going forward. Actual implementation of any regulatory requirements will likely include a suite of potential mitigation options, which will allow each dairy operation to select their preferred mitigation option.

Sector-wide costs, revenue, and cumulative methane mitigation were calculated through 2030, though additional costs and benefits would accrue after this date. Pathway 5 contains no revenue, while pathway 2b receives revenue from RIN and LCFS credits as well as sale of biogas. RIN credits were assumed to be available for all years through 2030. LCFS credits were calculated for three scenarios to account for the effect of regulation on revenue: no regulation, regulation in 2026, and regulation in 2024. Regulation effective dates were assumed to be January 1st of the regulation year. Any project started before the effective date of the regulation receives LCFS credits for methane destruction for 10 years. After 10 years, it is assumed that the dairy no longer receives credit for methane destruction which increases the carbon intensity score under the LCFS and significantly reduces LCFS revenue for any remaining year through 2030. Some dairies could potentially reapply for methane destruction credits for an additional 10 years but this option was excluded in this analysis for simplicity. Projects started after the regulation date do not receive credit for methane destruction and receive the higher carbon intensity score for LCFS credits through 2030. In the no regulation case, all projects receive the full LCFS credits for up to10 years and the higher CI LCFS credits for any remaining years through 2030. The detailed calculation methodology, assumptions, and references for Table 16 are included in Appendix F.

Table 16: Sector-wide costs for two bounding scenarios through 2030[168]

		Pathway			
		2b Scrape, Central Digestion to Fuel			**5**
		No Regulation	**2026 Regulation**	**2024 Regulation**	Scrape Only
Capital (billion $)		$1.5	$1.5	$1.5	$0.5
O&M (billion $)		$1.3	$1.3	$1.3	$0.1
Revenue (billion $)	**LCFS ($100)**	$2.1	$1.9	$1.6	--
	RINs ($1.85)	$1.4	$1.4	$1.4	--
	Other*	$0.4	$0.4	$0.4	--
NPV (billion $)		$1.1	$0.9	$0.6	–$0.7
$/MT CO_2e (20-yr GWP)		–7	–5	–4	4
$/MT CO_2e (100-yr GWP)		–19	–15	–5	11

*Sale of biogas at $3.46 per 1,000 SCF.

This analysis suggests that the dairy industry in California can cut methane emissions and deliver low-cost GHG reductions. Pathway 5, scrape conversion only, is a relatively low cost option compared to other pathways, but also assumed to be low value. Pathway 2b, cluster and fuel production, represents a potentially high value scenario, but would require significantly more technology and investment (including upfront capital), and relies on potentially volatile revenue sources.

Regulation has a significant effect on potential LCFS credits in pathway 2b. The sector-wide effect of regulation on LCFS revenue depends on the timeline that dairy projects come online. Regulating in 2024 versus 2026 reduces cumulative LCFS revenue to the industry by about $300 million, although the sector-wide net present value (NPV) with a 2024 regulation is estimated to be positive, at $0.6 billion through 2030. However, this positive sector-wide NPV does not mean all dairies are profitable. As exemplified in Table 16, regulation significantly reduces the LCFS revenue a dairy receives. In the 2024 regulation scenario, the 206 dairies that come online before the regulation are profitable without additional financial assistance, while the 337 dairies that come online after the regulation would lose money over a 10 year loan period using these assumptions and without additional financial support. It could make sense, then, for more dairies to pursue earlier project development, which could increase revenues, cost effectiveness, and emission reductions beyond those simulated here.

Table 17 presents the sector-wide cumulative upfront capital costs and implementation assumptions for the two sector-wide scenarios. Upfront capital costs are a measure of investment needed to get projects off the ground and do not include annual operational costs or revenue. As noted previously, actual implementation will utilize a range of mitigation options and these two scenarios provide a possible bounding of upfront

[168] Summation may not be exact due to rounding. Capital costs amortized over 10 years with 7% interest. Discount rate is 5%. All costs and revenues are calculated through 2030, though additional costs and benefits will accrue after 2030.

costs. Cumulative capital investment of between $600 million and $1.7 billion would be needed by 2030 to meet the 22 $MMTCO_2e$ reductions using assumptions in this analysis. In the near term, $200 million to $500 million would be necessary to reduce dairy manure methane by 20 percent in 2020.

Table 17: Sector-wide implementation assumptions, and upfront capital costs[169]

	Pathway 2b Scrape, central digestion, fuel			Pathway 5 Scrape only	
Year	**Cumulative Upfront Capital (Billion $)**	**Number of Clusters**	**Number of Dairies**	**Cumulative Upfront Capital (Billion $)**	**Number of Dairies**
2020	$0.5	11	95	$0.2	56
2025	$1.2	32	294	$0.4	213
2030	$1.7	55	543	$0.6	493

Funding support or incentives will likely be necessary to achieve rapid manure methane mitigation targets under any scenario. Several existing and potential funding sources are available, including those from federal sources, California's Greenhouse Gas Reduction Fund (GGRF), utility programs, private investors, the programs included in this analysis, or other sources. Limited federal grant funding is currently available, and more should be pursued. The legislature appropriated $50 million in GGRF funding for fiscal year 2016-2017 to achieve early and extra methane emission reductions from dairy and livestock operations, and an additional $7.5 million to support the Healthy Soils Program, including compost applications.[170] Additionally, AB 2313 provides utility incentives of up to $3 million to offset utility interconnection costs associated with biomethane projects, and up to $5 million for dairy cluster projects, including the costs of gathering pipelines. It directs the PUC to keep this program in place through December 31, 2021. Senate Bill 1383 directs state agencies to consider or develop additional policies to support dairy biomethane and other renewable gas projects–including energy infrastructure and procurement policies, financial mechanisms to reduce the uncertainty of value under the LCFS, rate-basing pipeline infrastructure for no fewer than five dairy biomethane pilot projects, and other policies and incentives to significantly increase the sustainable production and use of renewable gas in the state. Altogether, these policies provide a strong starting point for developing projects to reduce dairy manure emissions in California.

This analysis provides the initial framework for understanding costs and potential revenue associated with manure methane reductions in California. As mentioned previously, this analysis is purely economic and there are important uncertainties associated with project costs and potential revenues, as well as barriers to implementation that may limit project development without targeted support. State and local governments may wish to support some higher cost strategies for other environmental or health reasons. This document represents a starting point for discussion that should be built upon and bolstered. The working group referenced in

169 Capital costs are discounted at 5%, does not include operating costs or revenue. Cumulative upfront capital represents anticipated financing needs.
170 Assembly Bill 1613 (Chapter 370, Statutes of 2016)

Chapter V may be helpful in recommending ways to leverage private sector investment and scale efforts to rapidly cut methane emissions in California.

3. Methane Emission Reductions from Diversion of Landfill Organic Waste

As noted in Chapter V, meeting the SB 1383 organic diversion targets can reduce landfill emissions by 4 $MMTCO_2e$ in 2030, but one year of waste diversion in 2030 is expected to avoid 14 MMTCO2e of emissions over the lifetime of waste decomposition. Achieving these methane emission reduction targets requires developing infrastructure and markets to optimize the economic and environmental value of California's waste streams across sources.

When considering waste diversion options it is essential to balance environmental and economic benefits with any potential impacts on criteria pollutant emissions and ecosystem and human health, especially in disadvantaged communities. Avoiding organic waste generation entirely is the best option to reduce emissions, protect health, and minimize costs. However, once generated, there are many options for creating environmental and economic benefit through the appropriate utilization organic waste. Organics can be diverted to waste facilities with existing excess capacity, including composting facilities, stand-alone anaerobic digesters (AD), and wastewater treatment anaerobic digesters. New facilities can be also built in optimized locations.

In this analysis three scenarios were considered that can achieve the organic diversion target outlined in this SLCP Strategy. The three scenarios are based on projected waste data and potential diversion outlined in Appendix F. The only difference between the scenarios is the waste utilization of grass and leaves. The three scenarios evaluate the costs and revenues for utilizing food waste and grass and leaves in three pathways:

1. New anaerobic digestion facilities
2. Existing excess capacity at wastewater treatment anaerobic digestion facilities
3. New compost facilities

The actual future utilization of food waste and grass and leaves will most likely be some mix of these options. Since it is not possible to predict the exact mix of utilization pathways, these three scenarios were developed to bound potential costs and revenues. The scenarios considered here aim to balance cost and feasibility, while prioritizing economic and environmental benefits. Although ARB recognizes there are other beneficial uses of renewable natural gas, this analysis focuses on the capture and pipeline injection of renewable natural gas from diverted organic waste. Using renewable natural gas as a transportation fuel can result in significant potential revenue streams and reduce criteria pollutant emissions from the transportation sector. Prioritizing the use of biomethane as a transportation fuel may increase costs relative to scenarios that focus solely on methane mitigation. However, important environmental, health, and economic benefits may be most realized in disadvantaged communities by prioritizing pipeline injection of renewable natural gas.

Within scenario 1, food waste and a portion of grasses and leaves are handled through new centralized AD facilities and the resulting methane is pipeline injected. New AD facilities are assumed to accept 100,000 tons per year of organic waste. The costs of scenario 1 include facility construction and permitting, operating and maintenance (O&M), waste and digestate processing and transportation, and the costs associated with pipeline injection of renewable natural gas. These include pipeline, interconnection, and biogas upgrading costs. Potential revenue streams include tipping fees, the sale of biogas, LCFS credits, and RIN credits, as outlined in Appendix F.

Scenario 2 assumes that food waste is diverted to wastewater treatment facilities with existing excess capacity. The analysis assumes that, with modification, existing wastewater treatment facilities can accept 50,000 tons of organic material per year on average by 2025, with some facilities accepting more or less depending on size. Costs for this scenario include upgrading and permitting costs that may be required for facilities to accept food waste, waste and biosolids processing and transportation, O&M, as well as the costs associated with pipeline injection of renewable natural gas. Potential revenue streams include tipping fees, sale of biogas, LCFS credits, and RINs.

Scenario 3 assumes that all food waste and grasses and leaves are composted at new facilities with a throughput of 100,000 tons per year. Costs within the scenario include facility construction, O&M, and transportation of organic materials to the compost facility. Compost facility revenues are estimated in scenario 3 by only including tipping fees and not revenues associated with the sale of compost. This conservative approach represents the lower bound estimate of compost. However, these revenues vary depending on a number of factors such as seasonality, organic certification, and compost blend type

A principal difference in outcomes from these three scenarios is the number of new facilities needed to achieve the organic diversion targets. Table 18 shows the number of new compost or AD facilities needed for each scenario.[171]

Table 18: Estimated Number of New Facilities

Scenario	Estimated Number of New Compost Facilities		Estimated Number of New AD Facilities	
	2020	2025	2020	2025
1. New AD	15	26	39	47
2. Existing WWTP	22	35	--	--
3. Compost Only	47	65	--	--

[171] This analysis assumes existing wastewater treatment facilities can handle 50,000 wet tons of organic material per year, while new AD facilities and compost facilities have a throughput of 100,000 wet tons per year. Additional information regarding the projected organic waste streams by waste, the assumptions surrounding required facilities, and the handling of residuals are presented in Appendix F

There is uncertainty regarding the costs, savings, and potential revenue streams associated with organic waste diversion. Social welfare impacts, including those related to health, noise, odor, ecosystem benefit, and water impacts, are not included in this analysis but require additional consideration and analysis prior to the implantation of any organic diversion measure. Additional uncertainty related to existing infrastructure and technology development may also create economic impacts not analyzed in this analysis, which relies on available data from California agencies, academic researchers, and industry to estimate the direct economic impact, including costs, fuel and energy savings, and potential revenue streams, of achieving the organic waste diversion target in this SLCP Strategy.

Net present value calculations were used to estimate the potential profitability of the three scenarios. By calculating the present value of future cost and organic diversion over a 10-year financing period, the net present value calculation provides insight into the feasibility of projects at the facility level, including the need for upfront grants and incentives as well as the significant opportunities and uncertainty surrounding revenue streams based on existing regulations.

Costs and revenues for the three scenarios are summarized in Table 19. The table includes the net present value for each scenario over a 10-year financing period

Table 19: Cumulative Estimated Costs and Revenues by Scenario Over 10-Year Accounting Period (Million Dollars)

Scenario 1: New AD	Component	Capital Cost	O&M	Revenue
New AD	47 Facilities	$1,700	$2,600	$7,000
New Compost	26 Facilities	$400	$700	$1,300
Total		**$2,100**	**$3,300**	**$8,300**
10-Year Net Present Value		**$2,700**		
Scenario 2: WWTP	**Component**	**Capital Cost**	**O&M**	**Revenue**
New Compost	35 Facilities	$600	$900	$1,800
Existing Wastewater Treatment	104 Facilities	$1,600	$2,800	$5,700
Total		**$2,200**	**$3,700**	**$7,500**
10-Year Net Present Value		**$1,400**		
Scenario 3: Compost	**Component**	**Capital Cost**	**O&M**	**Revenue**
New Compost	65 Facilities	$800	$800	$1,600
Total		**$800**	**$800**	**$1,600**
10-Year Net Present Value		**-$100**		

Table 19 suggests that under Scenario 1 and Scenario 2, organic waste diversion can generate a positive return. These scenarios may also contribute to regional air quality benefits, through reduced transportation emissions. However, revenue for these strategies, and the resulting net present value, is highly dependent on the value of LCFS and RIN credits. As shown in Table 20, for representative wastewater treatment and new AD facilities, the net present value of diverting organic materials – at the facility level – is negative without revenue from LCFS credits and RINs.

Table 20: Net Present Value of Representative Wastewater Treatment and New AD Facility under Varying LCFS Credit Prices and RIN Credit Prices (Million Dollars)

		Wastewater Treatment Facility					New AD Facility				
		LCFS credit price					LCFS credit price				
		$0	**$50**	**$100**	**$150**	**$200**	**$0**	**$50**	**$100**	**$150**	**$200**
Cellulosic RIN credit prices	**$0.00**	-$26.2	-$21.0	-$15.7	-$10.5	-$5.3	-$44.8	-$26.4	-$8.0	$10.3	$28.7
	$0.50	-$17.2	-$12.0	-$6.7	-$1.5	$3.7	-$24.9	-$6.5	$11.9	$30.2	$48.6
	$1.00	-$8.2	-$2.9	$2.3	$7.5	$12.7	-$5.0	$13.4	$31.8	$50.2	$68.6
	$1.85	$7.1	$12.4	$17.6	$22.9	$28.0	$28.9	$47.3	$65.7	$84.1	$102.5
	$2.50	$18.9	$24.1	$29.3	$34.6	$39.8	$54.8	$73.2	$91.6	$110.0	$128.4
	$3.00	$27.9	$33.1	$38.4	$43.6	$48.8	$74.7	$93.1	$111.5	$129.9	$148.3
	$3.50	$36.9	$42.1	$47.4	$52.6	$57.8	$94.7	$113.0	$131.5	$149.8	$168.2
	$4.00	$45.9	$51.2	$56.4	$61.6	$66.9	$114.6	$133.0	$151.4	$169.8	$188.2

State resources could be deployed to supplement financing of these types of biomethane projects through mechanisms such as upfront grants, loan assistance programs, and tax incentives. For example, the illustrative wastewater treatment facility in Table 19 would break even over a 10-year financing period with an upfront grant of $24 million. In the absence of revenue from the sale of LCFS or RIN credits, a representative new AD facility would require an upfront grant of $41 million to breakeven over a 10-year financing period. State agencies are collaborating to find solutions to these financial challenges.

Altogether, this analysis suggests that the diversion of organic waste can result in environmental and economic value to California. There are important uncertainties associated with facility costs and potential revenues, however, which may limit project development without additional support. In the absence of revenue from LCFS credits and RINs, significant financial support may be required to achieve the targets identified in this SLCP Strategy and deliver other environmental benefits. Through careful research, investments, and structured market-based incentives, the State can work with industry to significantly and permanently reduce methane emissions and divert organic waste.

4. Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities Regulation

This SLCP Strategy has a four-pronged approach to methane reductions in the oil and gas sector including regulation of production, processing, and storage facilities and implementation of SB 1371. The process to adopt rules and procedures to minimize natural gas leaks from natural gas pipelines under SB 1371 is just beginning and an analysis of the costs and potential benefits of SB 1371 will be conducted as measures are implemented.

ARB is developing a regulation to address methane from oil and gas production, processing, and storage facilities for final Board consideration in 2017. The regulation is anticipated to deliver environmental benefits that include an estimated reduction in GHG emissions through 2030 of about 13.3 $MMTCO_2e$ from oil and gas related emissions in California. In addition, the measure is expected to save about 620 million standard cubic foot (scf) per year of industrial natural gas through reductions of leaks and through vapor recovery systems, the monetized value of which is approximately $2.6 million per year.[172]

While air districts are currently combatting volatile organic compounds (VOC) leaks locally, these rules vary by district and are not addressing any methane only leaks. This measure is designed to expand upon existing local rules, promote statewide uniformity, minimize the administrative burden on local air districts, harmonize state requirements with current and near-future local and federal requirements, and achieve further methane reductions to achieve the goal outlined in this strategy of reducing fugitive methane emissions from all sources in the oil and natural gas sector by 45 percent by 2030.

The Oil and Gas measure proposes eight main control provisions that are designed to achieve emission reductions in crude oil and natural gas operations. These provisions build upon and in some ways increase existing local air district requirements to monitor, replace, and expand current capital at crude oil and natural gas facilities. The cost of this measure includes capital costs to: Install Vapor Recovery Units for tanks, well stimulations tanks, and centrifugal compressors; replace rod packing on reciprocating compressors; and change pneumatic devices. In addition, a leak detection and repair program (LDAR) as well as emission reductions and leak monitoring plans at underground gas storage facilities will have ongoing costs in each year beginning in 2018. The amortized[173] capital cost plus the ongoing costs yield an overall cost of the measure of just over $200 million through 2030. These costs are offset by natural gas collection from the reduction in leaks and vapor recovery; these savings amount to savings of almost $31 million through 2030 and persisting

[172] http://www.energy.ca.gov/2014publications/CEC-200-2014-001/CEC-200-2014-001-SF.pdf. Using a value of $4.10 per Mscf, which is the value of the natural gas prices are based upon wholesale prices that are forecasted by the California Energy Commission using their NAMGas general equilibrium model.
[173] Using a 5% discount rate.

thereafter. The costs, cost-savings, and emission reductions are outlined in Table 21 by each provision.

Table 21: Costs and Emissions for Oil and Gas Measure

Segment of Regulation	Total Reductions to 2030 (MTCO2e)	Annual Cost	Annual Savings	Total Cost to 2030	Total Savings to 2030
VRU for Tanks	6,456,000	$4,674,000	$653,000	$56,088,000	$7,836,000
Reciprocating Compressors	804,000	$203,000	$230,000	$2,436,000	$2,760,000
LDAR	2,112,000	$9,696,000	$596,000	$126,053,000	$7,744,000
Pneumatic Devices	3,828,000	$1,153,000	$1,043,000	$13,836,000	$12,516,000
Well Stimulations	60,000	$186,000	$17,000	$2,232,000	$204,000
Centrifugal Compressors	36,000	$4,000	$12,000	$48,000	$144,000
Monitoring Plan	TBD	TBD	TBD	TBD	TBD
Total	**13,296,000**	**$15,916,000**	**$2,551,000**	**$200,693,000**	**$31,204,000**

5. Hydrofluorocarbon (HFC) Emission Reductions

Note: The following HFC section was written before the global phasedown of HFCs was agreed to on October 15, 2016 (the "Kigali Amendment"). ARB is currently evaluating the Kigali Amendment's impact upon HFC emissions in California; this section will be further updated to reflect changes in BAU emissions, additional needed reductions, and the cost and benefit of HFC reductions measures.

Hydrofluorocarbons (HFCs) are used primarily as refrigerant substitutes to ozone-depleting refrigerants, and although not ozone-depleting, HFCs have high-global warming potentials (GWP) between 500 and 12,000 (20-year GWP values). HFCs currently account for four percent of California's GHG emissions, but are expected to double in emissions in the next few decades without additional reduction actions. Four

HFC measures are proposed in this strategy to reduce cumulative HFC emissions by 260 $MMTCO_2E$ (20-year GWP) by 2030 to meet the SLCP emission reduction target.

The proposed reduction measures include the following:

- Financial incentive program to install new low-GWP refrigeration and air-conditioning (AC) equipment
- Sales ban on refrigerants with very-high GWPs
- Phasedown in the supply of high-GWP HFCs (to be enacted through the international agreement of the Montreal Protocol Meeting of the Parties, October 15, 2016, in Kigali, Rwanda)
- Prohibitions on high-GWP refrigerants in new stationary refrigeration and AC equipment

The cost of strategies to reduce HFCs is highly dependent upon assumptions of the added initial cost of low-GWP equipment, which is estimated to be approximately 10 percent higher than baseline high-GWP equipment, as detailed in Appendix F. The additional initial cost ranges from $500,000 for a large cold storage facility, and $200,000 for a supermarket; to $400 for a residential AC system, and $140 for a residential refrigerator-freezer. In many cases, the added initial cost is offset or reversed through energy savings of low-GWP refrigeration and AC. Additionally, low-GWP refrigerants such as carbon dioxide refrigerant, ammonia, and hydrocarbons are less expensive than HFCs. The main barrier to adoption of low-GWP refrigeration equipment is the added initial cost. For low-GWP AC, the barriers include added initial cost and current building codes that do not allow very slightly flammable low-GWP refrigerants.

Measure costs were derived using the incremental per-unit equipment cost over the number of new units replacing retiring units each year. The total cost savings result from less energy use and less expensive refrigerant over the lifetime of the equipment. The cumulative costs and savings are outlined in Table 22.

The cost and savings from HFC reduction measures were estimated separately for each measure and then summed together to show total estimated cost and total estimated savings from all measures. This approach was used to avoid double-counting emission reductions, cost, and savings from measures that overlap significantly. For example, businesses installing low-GWP refrigeration because of the early adoption incentive program would not be subject to required prohibitions of high-GWP refrigerant in new equipment, and would not be affected by an HFC phasedown. An HFC phasedown could incentivize new equipment to use low-GWP refrigeration and AC, and a prohibition on high-GWP refrigeration and AC would largely overlap with HFC phasedown requirements. Detailed cost and savings for each individual measure are presented in Appendix F.

Table 22: HFC Measure Costs and Savings through 2030 (Million Dollars)

	Total Cost	Total Savings	Net Cost	Emission Reductions (MMTCO2e)
HFC Reduction Measures	$5,060	($4,850)	$210	260

GHG reductions from direct refrigerant emissions are estimated by modeling equipment sectors using a constant refrigerant charge size and annual leak rate, with the only variable that of the refrigerant's GWP. The reduction per unit per year is the difference between the emissions of the high-GWP equipment and the emissions expected from the new, low-GWP equipment. Indirect GHG emissions from less energy usage were also estimated using the default carbon intensity of California's electricity from the Cap-and-Trade Program. Note that the indirect emission reductions account for less than four percent of GHG reductions from refrigeration and AC (the carbon intensity of electricity generation used to power cooling equipment is overwhelmed by the very-high GWPs of HFC refrigerants).

B. Public Health Assessment

Short-lived climate pollutants are not only powerful climate forcers but are also harmful air pollutants with many direct and indirect impacts on health. The focused efforts identified in this SLCP Strategy will not only help to limit the impacts of climate change that are already underway, but also reduce local air pollution and produce other co-benefits. The World Health Organization (WHO) describes the direct and indirect impacts of SLCP emissions, on a global level, as follows:[174]

> Since SLCPs contribute to ambient levels of ozone and PM2.5, SCLP [sic] emissions are directly associated with cardiovascular and respiratory diseases, including heart disease, pulmonary disease, respiratory infections and lung cancer. SLCP emissions thus contribute significantly to the more than 7 million premature deaths annually linked to air pollution.
>
> Indirectly, the SLCPs, ozone, and black carbon reduce plant photosynthesis and growth, thus decreasing agricultural yields, which in turn threatens food security. They also affect weather patterns and the melting of snow and ice, which may harm and endanger health through extreme weather events such as floods.

[174] World Health Organization, "Reducing global health risks through mitigation of short-lived climate pollutants," accessed April 1, 2016. http://www.who.int/phe/health_topics/outdoorair/climate-reducing-health-risks-faq/en/

Furthermore, in its report on *Reducing global health risks through mitigation of short-lived climate pollutants,*[175] the WHO notes that certain efforts to cut emissions of SLCPs may provide other types of health benefits not associated with air pollution. These include improved diets or more opportunities for safe active travel and physical activity. As described in this SLCP Strategy, some strategies to cut emissions of SLCPs in California could have important benefits for water quality, and potentially for water supply in the State, as well.

The measures and goals identified in this SLCP Strategy could deliver many of these types of benefits in California, which might accrue especially in disadvantaged communities (see Section C). As they are further developed and implemented, it will be important to consider a broad array of potential impacts and benefits to ensure that prioritized strategies to cut SLCP emissions also maximize other health benefits. For example, as part of an integrated strategy that includes use of ultra-low-NOx vehicles and renewable natural gas in the transportation sector, converting manure management operations to scrape systems and injecting renewable natural gas into the pipeline can help to improve air quality and water quality near dairies and elsewhere in California. A discussion of the health impacts associated with the measures in this SLCP Strategy is provided below. A more detailed public health impacts analysis will be developed as part of any potential subsequent regulatory process.

Black carbon is a component of fine particulate matter (PM2.5). A large number of studies, particularly epidemiological (population-based) studies, have linked exposure to PM2.5 to a number of adverse health effects, including premature death, hospital admissions for the worsening of chronic cardiovascular and lung diseases, and emergency room visits for asthma.[176,177,178] Diesel particulate matter is a subset of PM2.5, and consists of black carbon particle cores that are coated with a variety of other chemical substances, including over 40 carcinogenic organic compounds, nitrates, sulfates, and heavy metals. To date, no studies have directly investigated potential health effects of black carbon. However, since black carbon particulate matter is a subset of PM2.5, which has been clearly shown to be related to adverse health effects, the scientific community has concluded that diesel and black carbon particulate matter likely have similar adverse effects as PM2.5. As part of its periodic

[175] WHO (2015) Reducing global health risks through mitigation of short-lived climate pollutants, Summary report for policymakers, World Health Organization, October. http://www.who.int/phe/publications/climate-reducing-health-risks/en/

[176] Krewski D., Jerrett M., Burnett R.T., Ma R., Hughes E., Shi Y., Turner M.C., Pope C.A. III, Thurston G., Calle E.E., Thun M.J.. 2009. Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. HEI Research Report 140. Health Effects Institute, Boston, MA. http://www.healtheffects.org/Pubs/RR140-Krewski.pdf

[177] Bell M.L., Ebisu K., Peng R.D., Walker J., Samet J.M., Zeger S.L., Dominici F. 2008. Seasonal and regional short-term effects of fine particles on hospital admissions in 202 U.S. counties, 1999–2005. Am J Epidemiol 168:1301–1310.

[178] Ito, K., G. D. Thurston and R. A. Silverman. 2007. Characterization of PM2.5, gaseous pollutants, and meteorological interactions in the context of time - series health effects models. J Expo Sci Environ Epidemiol. Vol. 17 Suppl 2: S45 - 60.

reviews of the national ambient air quality standards, the U.S. EPA draws conclusions as to the strength of the relationship between exposure to air pollution and broad categories of adverse health effects. In its most recent integrated science assessment for the PM standards, it concluded that PM2.5 plays a "causal" role in premature death and cardiovascular effects, and a "likely causal" role in respiratory effects.[179]

As a result of State and local efforts over the past decades to improve air quality, California has significantly cut particulate matter emissions from anthropogenic sources, especially from diesel engines. The result is that black carbon emissions are about 90 percent lower than they were in the 1960s and approximately 5,000 premature deaths are avoided in the State each year. Current NO_x and PM emission standards for on-road and off-road diesel engines that phase in between 2012 and 2020 will lead to significant additional reductions in primary PM2.5 emissions from diesel equipment.[180] (NO_X emissions are also projected to decrease, which could reduce ozone and secondary PM.) As a result, the health-related impacts associated with diesel PM2.5 are expected to continue to decrease through 2030.

Residential wood burning (fireplaces and woodstoves) is another important source of black carbon emissions and local air pollution, and its share of the State's black carbon inventory is increasing, as emissions from diesel engines fall. Fireplaces and woodstoves produce PM2.5, carbon monoxide, volatile organic compounds, and hazardous air pollutants. In ARB's black carbon inventory, emissions from these sources are assumed to increase between 2013 and 2030, due to increased residential construction. Actions outlined in this SLCP Strategy, such as restricting residential wood-burning fireplaces and promoting the conversion to cleaner wood-burning stoves, can help reduce these emissions and health-related impacts, which especially impact rural areas.

Methane contributes to global background levels of ozone in the lower atmosphere (troposphere). Global background ozone (tropospheric ozone) concentrations have roughly doubled since preindustrial times, and are projected to continue to increase. Ozone itself is a powerful SLCP as well as a regional ground level air pollutant. Ozone exposure has been linked to increases in emergency room visits for worsening of asthma, hospitalizations due to respiratory disease, and premature death. Additionally, ozone suppresses crop yields; harms ecosystems; and affects evaporation, cloud formation, and precipitation.[181] Thus, reducing methane emissions as part of a broader

[179] U.S. EPA. 2009. Integrated Science Assessment for PM. U.S. Environmental Protection Agency, Washington, DC Publication EPA/600/R-08/139F. http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_2007_isa.html

[180] Primary particles are directly released into the atmosphere by combustion processes (such as soot or black carbon and a large variety of organic carbons). "Secondary" particles also form in the atmosphere from other gaseous pollutants, particularly sulfur dioxide, nitrogen oxides (NO_X), ammonia, and volatile organic compounds (VOCs). The transportation sector is an important source of secondary particulate matter such as ammonium nitrate, especially in the winter.

[181] UNEP and WMO (2011) Integrated Assessment of Black Carbon and Tropospheric Ozone, United Nations Environment Programme and World Meteorological Association. http://www.unep.org/dewa/Portals/67/pdf/BlackCarbon_report.pdf.

effort to address climate change can complement local and regional efforts to reduce ground-level ozone.

Strategies to reduce methane emissions from dairy manure management can deliver important health benefits, especially if developed as part of a systematic approach to addressing air quality and water quality. For example, converting operations to pasture-based systems would likely reduce concentrations of and exposure to potentially harmful constituents, such as hydrogen sulfide, ammonia, and particulate matter. One study suggests that ammonia emissions could be 30 percent lower for pasture-based than for confinement systems.[182] It could also improve nutrient management on farms, helping to reduce soil and groundwater contamination. This strategy could be an important element of a sector-wide approach to reducing dairy methane emissions, but may have limited applicability. ARB estimates that about 25 dairies in the State could convert to pasture-based operations without reducing herd size or procuring new land.

Other strategies could also deliver environmental and health benefits. Converting dairies from flushwater manure management systems to dry manure management systems could also improve nutrient management, thereby potentially helping to improve groundwater quality. It is possible that farms may choose some management strategies which could increase or decrease emissions of pollutants of concern. If emissions increase, measures should be implemented to mitigate the impacts as part of the permitting process.

Strategies that capture or produce methane and utilize it for production of renewable energy and fuels could lead to additional sources of combustion, but as part of a regional approach to utilize low-NO_x vehicles and renewable fuels, can displace diesel combustion and help to improve air quality. If electricity is generated onsite using dairy derived biogas, using microturbines or fuel cells can minimize new emissions of NO_x and PM, minimizing potential local health impacts. To the extent that renewable natural gas is produced and injected into the natural gas pipeline network, or used in low-NO_x engines to displace diesel combustion, air quality impacts can be avoided. Prioritizing pipeline injection and onsite usage in low-NOx vehicles, in addition to a coordinated effort to increase use of low-NO_x vehicles with renewable fuels in areas surrounding dairies and elsewhere can reduce air pollution regionally and statewide. These emission reductions translate directly into health benefits, especially in disadvantaged communities near dairies and along transportation corridors, and in areas of non-attainment for ambient air quality standards.

Diverting organics from landfills to compost facilities and anaerobic digestion facilities, along with implementing food rescue and recovery programs, will significantly reduce the need for further landfill development in California, and may help increase the efficacy of landfill gas management systems at existing landfills, many of which are located in or near environmental justice communities. Phasing out the landfilling of

[182] Perry, A. (2011) Putting dairy cows out to pasture: An environmental plus, USDA-ARS Agricultural Research Magazine, May-June. http://www.ars.usda.gov/is/AR/2011/may11/cows0511.htm

organic materials will also help reduce future levels of fugitive methane emissions from landfills during their operational and post-closure stages. The number and frequency of heavy vehicle or truck trips to existing landfills, through neighboring communities, could potentially be reduced as organic materials are directed to anaerobic digestion facilities and regional compost facilities. To the extent that truck trips are reduced to and from landfills, they could increase in areas where facilities handling diverted organic waste are located. The net effect on overall truck trips in the State and associated emissions is uncertain, and could potentially increase as a result of changes in organic waste management, depending on how strategies are implemented. Many of the same issues associated with landfilling organic waste—potential criteria pollutant emissions, water quality impacts, and odors—could be issues at anaerobic digestion or compost facilities. In many cases, these can be effectively limited with available technologies and management strategies, including limiting trucking emissions by utilizing zero emission vehicles or renewable natural gas in low-NO_x engines associated with these operations.

Food rescue and recovery could deliver additional potential health benefits by utilizing useable food to relieve food insecurity and provide better access to healthy foods. Increasing edible food recovery—especially from large-scale food producers, processors, and users—and safely redirecting food to those in need could increase access to healthy fruits and vegetables and benefit millions of Californians who suffer from food insecurity.

Reducing leaks from the oil and gas sector will also reduce VOC emissions, which contributes to ground level ozone formation and related health impacts. For example, ARB's oil and gas regulation is expected to reduce VOC emissions and toxic air contaminants that are emitted from uncontrolled oil and water storage tanks and released from well stimulation recirculation tanks. The estimated reduction in VOCs from this measure is approximately 3,600 tons per year, or about 10 tons per day, statewide.

The measures identified in this SLCP Strategy for HFCs are unlikely to have noticeable health impacts. HFCs have negligible impacts on smog formation and are exempt from U.S. EPA’s definition of volatile organic compounds. At higher concentrations that could result from an accidental release in occupational settings, they might be toxic, and emissions of vapors containing HFCs in the workplace environment should be prevented. But at ambient concentrations, HFCs pose no significant health risk, and efforts described in this SLCP Strategy to phase down their use are not expected to deliver noticeable health benefits. Some potential replacements for HFCs could result in emissions of VOCs and particulate matter, but they would be negligible.

C. Environmental Justice and Disadvantaged Communities

The State of California defines environmental justice (EJ) in statute as "the fair treatment of people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations and policies" (Government Code section 65040.12). ARB is firmly committed to seeking fair treatment of all races, cultures, and incomes in the measures it develops and implements.[183] ARB works extensively with local air districts, EJ communities and other stakeholders during the development and implementation of its programs to respond to concerns about environmental justice.

AB 32 (Statutes of 2006, Chapter 488), directs ARB to convene an Environmental Justice Advisory Committee (EJAC) to advise the Board in developing the Scoping Plan, and any other pertinent matter associated with the implementation of AB 32. In January 2007, the Board appointed the first EJAC to advise it on the Initial Scoping Plan before that plan was approved by the Board in December 2008. The EJAC was reconstituted in March 2013 to advise the Board on the First Update to the Scoping Plan. The EJAC is now advising ARB on the development of the 2030 Target Scoping Plan Update. As part of that process, staff worked with the EJAC to hold eleven community meetings around the state. The recommendations that emerged from that process are being incorporated into or otherwise addressed in the 2030 Target Scoping Plan Update.

As part of its ongoing effort to fully integrate environmental justice considerations into its programs, ARB has created the position of Assistant Executive Officer (AEO) for Environmental Justice. The AEO will serve as the primary internal and external contact for ARB on EJ issues and concerns. The AEO will be responsible for providing policy consultation and recommendations to ARB staff, and will participate in decision making during the development and implementation of all major ARB programs to ensure that EJ concerns are fully considered. The AEO will develop and implement a program to ensure that EJ concepts, values and objectives are understood and considered throughout the development and implementation of the ARB's policies and programs. Further, the AEO will develop and maintain relationships with EJ stakeholders, and enhance communication between external stakeholders and ARB program staff.

ARB briefed the current EJAC on the development of the SLCP Strategy on several occasions. The EJAC has met ten times since December 2015, and that process culminated with Initial Recommendations from the EJAC, finalized on August 26, 2016. The Initial Recommendations consist of about 140 recommendations, sorted by six broad categories:

1) Overarching Issues;
2) Industry;
3) Energy, Green Buildings, and Water;
4) Transportation;
5) Natural and Working Lands, Agriculture, and Waste; and
6) California Climate Investments.

[183] See https://www.arb.ca.gov/ch/programs/ej/ejpolicies.pdf.

Recommendations falling under these broad categories were then further grouped into five subcategories:

(A) Partnership with Environmental Justice Communities;
(B) Equity;
(C) Coordination;
(D) Economic Opportunity; and
(E) Long-Term Vision.

The EJAC provided direction that their Initial Recommendations are intended "to be read and implemented holistically and not independently of each other." ARB will provide responses to each Initial Recommendation as the 2030 Target Scoping Plan is developed. The complete set of Initial Recommendations is available at: www.arb.ca.gov/cc/ejac/ejac_recommendations082616revised.pdf. The EJAC recommendations that are relevant to this SLCP Strategy, and ARB's responses to those recommendations, follow:

(1) Address localized impacts of short-lived climate pollutant emissions, such as black carbon from all sources.

This SLCP strategy describes a comprehensive array of measures to reduce methane, black carbon, and HFC emissions in California. SB 1383 directs ARB to develop measures to reduce black carbon from anthropogenic sources. As such, the strategy supports measures in place and under development that reduce black carbon from mobile sources, proposes new measures to reduce black carbon emissions from wood-burning stoves, and proposes next steps to foster emission reduction from other sources such as agricultural burning. These black carbon emission reductions will benefit climate, local air quality, and health.

(2) Divert dairy waste as fertilizer and for carbon sequestration before it can be converted to methane.

The dairy and livestock section of this SLPC Strategy describes a range of potential methane reduction measures that will be considered under future incentive and regulatory programs. Among them are measures in which manure would be used as a soil conditioner and fertilizer without first being digested. Because the measures developed under the SLCP program must be technically and economically feasible, and must not lead to emissions leakage, no measures can be ruled out at this point in the process. All measures eventually adopted under the SLCP program, however, must also avoid adverse impacts to disadvantaged communities.

(3) Perform a complete lifecycle analysis of dairy and other bio-digester technology and related infrastructure investment. If biogas from dairies is converted to bio-methane, ARB must mandate that vehicles servicing digesters and converters utilize that gas as a primary fuel source. This is a better use of the fuel than

building new pipelines and related infrastructure to transport the gas to other locations.

Before biomethane can generate credits under the LCFS, it must obtain a carbon intensity (CI) value. A CI is a full lifecycle GHG emissions value. Depending on credit values, much of the vehicle fuel produced from dairy manure biogas will have LCFS CI values. In general, however, ARB is obligated to account for all emissions in the measures it develops. SB 1383 is clear that we are not to develop methane measures that produce adverse air quality impacts. It will therefore be important to avoid significant increases in vehicular and equipment emissions. Measures that result in the use of dairy digester biomethane in vehicles and equipment servicing dairy digester projects is one way to achieve this goal. Digester biomethane in excess of what can feasibly be used locally, however, must be transported to markets.

(4) Identify and establish effective methods for implementing food rescue programs, with quality controls to avoid dumping inedible food on communities. Identify strategies for getting edible food to those who need it. Incentivize these programs and promote communication plans for projects, so all communities have access to successful plans.

SB 1383 requires CalRecycle, in consultation with ARB, to develop regulations to reduce disposal of organic waste by 50 percent of 2014 levels by 2020 and 75 percent by 2025. Of the edible food in the organic waste stream, not less than 20 percent is to be recovered to feed people in need by 2025.

(5) Develop more local agricultural processing centers so food is not being trucked long distances. Introduce a scoring system for food that indicates food-miles traveled. Encourage local food processing of food and meat, and educate people on the greenhouse gas reduction benefits of not eating meat. Establish public financing for healthy, environmentally sound food sources.

These are potentially viable measures. Staff will consider them in the development of measures to reduce methane emissions under this SLCP Strategy.

ARB staff has been working with staff from other state agencies to develop a holistic and synergistic approach to reducing methane emissions, and will continue to work with them to develop and implement these measures. ARB staff will continue to consult with EJ communities as we develop and implement the measures to ensure minimum impact and maximum benefit to environmental justice communities. Furthermore, the EJAC recommendations will be taken into consideration as specific actions and policies discussed in this SLCP Strategy are developed into regulatory and non-regulatory measures and policies.

The California Environmental Protection Agency, pursuant to Senate Bill 535 (De León, Chapter 830, Statutes of 2012), has identified the communities in California that are most disproportionately burdened by pollution for the purposes of expenditure of

California Climate Change Investment Funds. Of the 12 indicators of pollution included in its methodology, three are directly related to SLCP emissions (fine particle emissions, diesel particulate emissions, and solid waste sites and facilities), and at least six others (mostly related to water quality and air quality) are at least related to sources of SLCP emissions.[184]

The distribution of these communities often aligns with locations of SLCP emission sources, including sources of organic waste streams and dairies in the Central Valley; ports and freight corridors in the East Bay, Los Angeles area and Inland Empire; and oil production, landfills and other sources of SLCP emissions throughout the State. Many communities in these areas have some of the worst pollution burdens in the State and high rates of poverty and unemployment. Rural communities in the northern part of the State and the Sierra also are stricken with high rates of poverty and unemployment. Many billions of dollars in public and private investment will flow to communities in all of these regions in the coming years to reduce SLCP and CO_2 emissions, strengthen our agricultural sector, and build sustainable freight systems.

The integrated strategy to reduce SLCP emissions from agriculture and waste, developed in this SLCP Strategy, can be part of an integrated strategy to improve air and water quality in agriculture regions, such as in the Central Valley. Additionally, the Healthy Soils Initiative will improve California's agriculture economy and support further economic development in these communities.

The measures identified in this SCLP Strategy will be further developed in a formal public process that specifically considers environmental justice concerns. Opportunities for public participation will be provided during the development of each measure, and regulatory language will be made available in easily understood and useful formats, such as program-specific webpages and slide presentations.

D. Environmental Analysis

ARB, as the lead agency for the SLCP Strategy, has revised the Draft Environmental Analysis (EA) that was initially released for review on April 11, 2016, to address changes that were made to the SLCP Strategy in response to the requirements of SB 1383. The Revised Draft EA is being recirculated for public comment with the revised SLCP Strategy as Appendix E. Since the entire Draft EA has been substantially revised and is being recirculated for a new 45-day public comment period, new comments must be submitted on the Revised Draft EA, and ARB will respond only to those comments received on the recirculated Revised Draft EA.

The Revised Draft EA was prepared in accordance with the requirements of the California Environmental Quality Act (CEQA) and ARB's regulatory program certified by the Secretary of Natural Resources (California Code of Regulation, title 17, sections 60006-60008; California Code of Regulation, title 14, section 15251, subdivision

[184] http://oehha.ca.gov/calenviroscreen/indicators

(d)). The resource areas from the CEQA Guidelines Environmental Checklist were used as a framework for a programmatic environmental analysis of the reasonably foreseeable compliance responses resulting from implementation of the proposed measures discussed in this SLCP Strategy. The Revised Draft EA provides an analysis of both the beneficial and adverse impacts and feasible mitigation measures for the reasonably foreseeable compliance responses associated with the proposed measures under each of 17 environmental resource areas. Collectively, the Revised Draft EA finds implementation of these actions could result in the following short-term and long-term beneficial and adverse impacts: beneficial long-term impacts to air quality and greenhouse gas emissions; less than significant impacts to aesthetics, agriculture and forest resources, air quality, biological resources, cultural resources, energy demand, geology and soils, greenhouse gases (short-term), hazards and hazardous materials, hydrology and water quality, resources related to land use planning, mineral resources, noise, population and housing, public services, recreational services, transportation/traffic and utilities and service systems; and potentially significant and unavoidable adverse impacts to aesthetics, agriculture and forest resources, air quality, biological resources, cultural resources, geology and soils, hazards and hazardous materials, hydrology and water quality, resources related to land use planning, noise, transportation/traffic, and utilities and service systems. The potentially significant and unavoidable adverse impacts are primarily related to short-term construction-related activities, which explains why some resource areas are identified above as having both less-than-significant impacts and potentially significant impacts. Please refer to the Revised Draft EA in Appendix E for further details.

ARB will prepare written responses to all comments received on the Revised Draft EA, which will be presented to the Board for consideration along with the Final EA.

IX. Next Steps

The final SLCP Strategy, the final Environmental Analysis (EA), and written responses to comments received on the Revised Draft EA will be presented to the Board for consideration for approval in early 2017.

SB 1383 requires ARB to begin implementing the SLCP Strategy by January 1, 2018, as well as specifies timeframes for other requirements (see Table 23).

Table 23: Timeline for SB 1383 Mandates

Action	Deadline
ARB approves SLCP Strategy and begins Implementation Expected approval date Statutory deadline	 First Quarter 2017 By January 1, 2018
ARB, CDFA, State Water Resources Control Board and Regional Water Quality Control Boards in coordination with the energy agencies, will work with the dairy industry to establish a dairy workgroup to identify and address barriers to the collection and utilization of biomethane.	First Quarter 2017
ARB, in consultation with CPUC and CEC, develops policies to encourage development of infrastructure and biomethane projects at dairy and livestock operations	By January 1, 2018
ARB develops a pilot financial mechanism to reduce LCFS credit value uncertainty from dairy-related projects and makes recommendations to the Legislature to expand the mechanism to other biogas sources	By January 1, 2018
ARB provides guidance on the impact of regulations on LCFS credits and compliance offsets	By January 1, 2018
CPUC, in consultation with ARB and CDFA, directs utilities to develop at least 5 dairy biomethane pipeline injection projects	By January 1, 2018
CEC develops recommendations for the development and use of renewable gas as part of its 2017 Integrated Energy Policy Report	By early 2018
PUC renewable gas policies based on CEC IEPR	Ongoing
ARB, in consultation with CDFA, evaluates the feasibility of enteric fermentation methane reduction incentives and regulations and develops regulations as appropriate	Ongoing
ARB, in consultation with CDFA, analyzes and reports on the methane reduction progress of the dairy and livestock sector	By July 1, 2020
CalRecycle, in consultation with ARB, evaluates progress towards meeting the 2020 and 2025 organics waste reduction goals, the status of organics markets and barriers, and recommendations for additional incentives	By July 1, 2020

Action	Deadline
CalRecycle adopts an organics disposal reduction regulation	2018
CalRecycle implements an organics disposal reduction regulation	On or after January 1, 2022
ARB begins developing and considers for adoption a manure management methane reduction regulation	Before January 1, 2024
ARB implements a manure management methane reduction regulation	On or after January 1, 2024

All regulatory measures developed pursuant to this SLCP Strategy will be subject to its own public process with workshops, opportunities for stakeholder discussion, consideration of environmental justice, and legally required analyses of the economic and environmental impacts. While this SLCP Strategy is intended to be comprehensive, it is not exhaustive. We will continue to pursue new cost-effective programs and measures as technology and research on SLCP emission sources and potential mitigation measures advances. Staff will track the progress of implementation of the SLCP measures and provide periodic updates to the Board. This information, as well as updates to the SLCP emission inventory, will be posted to ARB's SLCP website. Effectively implementing this SLCP Strategy will require working with local, regional, federal and international partners, and diligently investing time and money to overcome market barriers that hinder progress. The extent to which we do so will drive results, which can include a wide range of significant economic and environmental benefits for California broadly, and many of the State's most disadvantaged communities, specifically.

Appendix A: Senate Bill 605

Senate Bill No. 605

CHAPTER 523

An act to add Chapter 4.2 (commencing with Section 39730) to Part 2 of Division 26 of the Health and Safety Code, relating to greenhouse gases.

[Approved by Governor September 21, 2014. Filed with Secretary of State September 21, 2014.]

LEGISLATIVE COUNSEL'S DIGEST

SB 605, Lara. Short-lived climate pollutants.

The California Global Warming Solutions Act of 2006 designates the State Air Resources Board as the state agency charged with monitoring and regulating sources of emissions of greenhouse gases. The state board is required to adopt a statewide greenhouse gas emissions limit equivalent to the statewide greenhouse gas emissions level in 1990 to be achieved by 2020 and to adopt rules and regulations in an open public process to achieve the maximum, technologically feasible, and cost-effective greenhouse gas emissions reductions.

This bill would require the state board to complete a comprehensive strategy to reduce emissions of short-lived climate pollutants, as defined, in the state.

The people of the State of California do enact as follows:

SECTION 1. Chapter 4.2 (commencing with Section 39730) is added to Part 2 of Division 26 of the Health and Safety Code, to read:

CHAPTER 4.2. GLOBAL WARMING

39730. (a) Notwithstanding Sections 38550 and 38551, no later than January 1, 2016, the state board shall complete a comprehensive strategy to reduce emissions of short-lived climate pollutants in the state. In developing the strategy, the state board shall do all of the following:

(1) Complete an inventory of sources and emissions of short-lived climate pollutants in the state based on available data.

(2) Identify research needs to address any data gaps.

(3) Identify existing and potential new control measures to reduce emissions.

(4) Prioritize the development of new measures for short-lived climate pollutants that offer cobenefits by improving water quality or reducing other air pollutants that impact community health and benefit disadvantaged communities, as identified pursuant to Section 39711.

(5) Coordinate with other state agencies and districts to develop measures identified as part of the comprehensive strategy.

(b) As part of the strategy developed pursuant to subdivision (a), the state board shall consult with experts in academia, industry, and the community on short-lived climate pollutants. The topics shall include, but not be limited to, all of the following:

(1) Assessment of the current status of controls that directly or indirectly reduce emissions of short-lived climate pollutants in the state.

(2) Identification of opportunities and challenges for controlling emissions.

(3) Recommendations to further reduce emissions.

(c) To provide a forum for public engagement, the state board shall hold at least one public workshop during the development of the strategy required pursuant to subdivision (a).

(d) For purposes of this section, "short-lived climate pollutant" means an agent that has a relatively short lifetime in the atmosphere, from a few days to a few decades, and a warming influence on the climate that is more potent than that of carbon dioxide.

(e) This section does not affect the existing authority of a state agency to adopt and implement rules and regulations that result in the reduction of greenhouse gas emissions or short-lived climate pollutants to the extent authorized or required by existing law.

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Appendix B: Senate Bill 1383

Senate Bill No. 1383

CHAPTER 395

An act to add Sections 39730.5, 39730.6, 39730.7, and 39730.8 to the Health and Safety Code, and to add Chapter 13.1 (commencing with Section 42652) to Part 3 of Division 30 of the Public Resources Code, relating to methane emissions.

[Approved by Governor September 19, 2016. Filed with Secretary of State September 19, 2016.]

LEGISLATIVE COUNSEL'S DIGEST

SB 1383, Lara. Short-lived climate pollutants: methane emissions: dairy and livestock: organic waste: landfills.

(1) The California Global Warming Solutions Act of 2006 designates the State Air Resources Board as the state agency charged with monitoring and regulating sources of emissions of greenhouse gases. The state board is required to approve a statewide greenhouse gas emissions limit equivalent to the statewide greenhouse gas emissions level in 1990 to be achieved by 2020. The state board is also required to complete a comprehensive strategy to reduce emissions of short-lived climate pollutants, as defined, in the state.

This bill would require the state board, no later than January 1, 2018, to approve and begin implementing that comprehensive strategy to reduce emissions of short-lived climate pollutants to achieve a reduction in methane by 40%, hydrofluorocarbon gases by 40%, and anthropogenic black carbon by 50% below 2013 levels by 2030, as specified. The bill also would establish specified targets for reducing organic waste in landfills.

This bill would require the state board, in consultation with the Department of Food and Agriculture, to adopt regulations to reduce methane emissions from livestock manure management operations and dairy manure management operations, as specified. The bill would require the state board to take certain actions prior to adopting those regulations. This bill would require the regulations to take effect on or after January 1, 2024, if the state board, in consultation with the department, makes certain determinations.

This bill would require the state board, the Public Utilities Commission, and the State Energy Resources Conservation and Development Commission to undertake various actions related to reducing short-lived climate pollutants in the state. The bill would require state agencies to consider and, as appropriate, adopt policies and incentives to significantly increase the sustainable production and use of renewable gas.

(2) The California Integrated Waste Management Act of 1989, which is administered by the Department of Resources Recycling and Recovery, establishes an integrated waste management program that requires each

county and city and county to prepare and submit to the department a countywide integrated waste management plan.

The bill would require the department, in consultation with the state board, to adopt regulations that achieve the specified targets for reducing organic waste in landfills. The bill would authorize local jurisdictions to charge and collect fees to recover the local jurisdiction's costs incurred in complying with the regulations. The bill would require, no later than July 1, 2020, the department, in consultation with the state board, to analyze the progress that the waste sector, state government, and local governments have made in achieving the specified targets for reducing organic waste in landfills. The bill would authorize the department, depending on the outcome of that analysis, to amend the regulations to include incentives or additional requirements, as specified. By adding to the duties of local governments related to organic waste in landfills, this bill would impose a state-mandated local program.

(3) The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement.

This bill would provide that no reimbursement is required by this act for a specified reason.

The people of the State of California do enact as follows:

SECTION 1. (a) The Legislature finds and declares all of the following:

(1) Short-lived climate pollutants, such as black carbon, fluorinated gases, and methane, are powerful climate forcers that have a dramatic and detrimental effect on air quality, public health, and climate change.

(2) These pollutants create a warming influence on the climate that is many times more potent than that of carbon dioxide.

(3) Short-lived climate pollutants that are toxic air contaminants also are a significant environmental risk factor for premature death.

(4) Reducing emissions of these pollutants can have an immediate beneficial impact on climate change and on public health.

(5) To the extent possible, efforts to reduce emissions of short-lived climate pollutants should focus on areas of the state that are disproportionately affected by poor air quality.

(b) It is the intent of the Legislature to support the adoption of policies that improve organics recycling and innovative, cost effective, and environmentally beneficial uses of biomethane derived from solid waste facilities.

(c) It is intent of the Legislature that the disposal reduction targets established pursuant to Section 39730.6 of the Health and Safety Code shall serve as a statewide average target and not as a minimum requirement for each jurisdiction.

SEC. 2. Section 39730.5 is added to the Health and Safety Code, to read:

39730.5. (a) No later than January 1, 2018, the state board shall approve and begin implementing the comprehensive short-lived climate pollutant strategy developed pursuant to Section 39730 to achieve a reduction in the statewide emissions of methane by 40 percent, hydrofluorocarbon gases by 40 percent, and anthropogenic black carbon by 50 percent below 2013 levels by 2030.

(b) Prior to approving the short-lived climate pollutant strategy pursuant to subdivision (a), the state board shall do all of the following:

(1) Coordinate with other state and local agencies and districts to develop measures identified as part of the strategy.

(2) Provide a forum for public engagement by holding at least three public hearings in geographically diverse locations throughout the state.

(3) Evaluate the best-available scientific, technological, and economic information to ensure that the strategy is cost effective and technologically feasible.

(4) Incorporate and prioritize, as appropriate, measures and actions that provide the following cobenefits:

(A) Job growth and local economic benefits in the state.

(B) Public health benefits.

(C) Potential for new innovation in technology, energy, and resource management practices.

(c) The state board shall publicly notice the strategy described in subdivision (a) and post a copy of that strategy on the state board's Internet Web site at least one month prior to the state board approving the strategy pursuant to subdivision (a).

SEC. 3. Section 39730.6 is added to the Health and Safety Code, to read:

39730.6. (a) Consistent with Section 39730.5, methane emissions reduction goals shall include the following targets to reduce the landfill disposal of organics:

(1) A 50-percent reduction in the level of the statewide disposal of organic waste from the 2014 level by 2020.

(2) A 75-percent reduction in the level of the statewide disposal of organic waste from the 2014 level by 2025.

(b) Except as provided in this section and Section 42652.5 of the Public Resources Code, the state board shall not adopt, prior to January 1, 2025, requirements to control methane emissions associated with the disposal of organic waste in landfills other than through landfill methane emissions control regulations.

SEC. 4. Section 39730.7 is added to the Health and Safety Code, to read:

39730.7. (a) For purposes of this section, the following terms have the following meanings:

(1) "Department" means the Department of Food and Agriculture.

(2) "Commission" means the Public Utilities Commission.

(3) "Energy commission" means the State Energy Resources Conservation and Development Commission.

(4) "Strategy" means the strategy to reduce short-lived climate pollutants developed pursuant to Section 39730.

(b) (1) The state board, in consultation with the department, shall adopt regulations to reduce methane emissions from livestock manure management operations and dairy manure management operations, consistent with this section and the strategy, by up to 40 percent below the dairy sector's and livestock sector's 2013 levels by 2030.

(2) Prior to adopting regulations pursuant to paragraph (1), the state board shall do all of the following:

(A) Work with stakeholders to identify and address technical, market, regulatory, and other challenges and barriers to the development of dairy methane emissions reduction projects. The group of stakeholders shall include a broad range of stakeholders involved in the development of dairy methane reduction projects, including, but not limited to, project developers, dairy and livestock industry representatives, state and local permitting agencies, energy agency representatives, compost producers with experience composting dairy manure, environmental and conservation stakeholders, public health experts, and others with demonstrated expertise relevant to the success of dairy methane emissions reduction efforts.

(B) Provide a forum for public engagement by holding at least three public meetings in geographically diverse locations throughout the state where dairy operations and livestock operations are present.

(C) In consultation with the department, do both of the following:

(i) Conduct or consider livestock and dairy operation research on dairy methane emissions reduction projects, including, but not limited to, scrape manure management systems, solids separation systems, and enteric fermentation.

(ii) Consider developing and adopting methane emissions reduction protocols.

(3) The state board shall make available to the public by posting on its Internet Web site a report on the progress made in implementing paragraph (2). Pursuant to Section 9795 of the Government Code, the state board shall notify the Legislature of the report.

(4) Notwithstanding the Administrative Procedure Act (Chapter 3.5 (commencing with Section 11340) of Part 1 of Division 3 of Title 2 of the Government Code), the regulations adopted pursuant to paragraph (1) shall be implemented on or after January 1, 2024, if the state board, in consultation with the department, determines all of the following:

(A) The regulations are technologically feasible.

(B) The regulations are economically feasible considering milk and live cattle prices and the commitment of state, federal, and private funding, among other things, and that markets exist for the products generated by dairy manure management and livestock manure management methane emissions reduction projects, including composting, biomethane, and other products. The analysis shall include consideration of both of the following:

(i) Electrical interconnection of onsite electrical generation facilities using biomethane.

(ii) Access to common carrier pipelines available for the injection of digester biomethane.

(C) The regulations are cost effective.

(D) The regulations include provisions to minimize and mitigate potential leakage to other states or countries, as appropriate.

(E) The regulations include an evaluation of the achievements made by incentive-based programs.

(c) No later than July 1, 2020, the state board, in consultation with the department, shall analyze the progress the dairy and livestock sector has made in achieving the goals identified in the strategy and specified in paragraph (1) of subdivision (b). The analysis shall determine if sufficient progress has been made to overcome technical and market barriers, as identified in the strategy. If the analysis determines that progress has not been made in meeting the targets due to insufficient funding or technical or market barriers, the state board, in consultation with the department and upon consultation with stakeholders, may reduce the goal in the strategy for the dairy and livestock sectors, as identified pursuant to paragraph (1).

(d) (1) (A) No later than January 1, 2018, the state board, in consultation with the commission and the energy commission, shall establish energy infrastructure development and procurement policies needed to encourage dairy biomethane projects to meet the goal identified pursuant to paragraph (1) of subdivision (b).

(B) The state board shall develop a pilot financial mechanism to reduce the economic uncertainty associated with the value of environmental credits, including credits pursuant to the Low-Carbon Fuel Standard regulations (Subarticle 7 (commencing with Section 95480) of Title 17 of the California Code of Regulations) from dairy-related projects producing low-carbon transportation fuels. The state board shall make recommendations to the Legislature for expanding this mechanism to other sources of biogas.

(2) No later than January 1, 2018, the commission, in consultation with the state board and the department, shall direct gas corporations to implement not less than five dairy biomethane pilot projects to demonstrate interconnection to the common carrier pipeline system. For the purposes of these pilot projects, gas corporations may recover in rates the reasonable cost of pipeline infrastructure developed pursuant to the pilot projects.

(e) No later than January 1, 2018, the state board shall provide guidance on credits generated pursuant to the Low-Carbon Fuel Standard regulations (Subarticle 7 (commencing with Section 95480) of Title 17 of the California Code of Regulations) and the market-based compliance mechanism developed pursuant to Part 5 (commencing with Section 38570) of Division 25.5 from the methane reduction protocols described in the strategy and shall ensure that projects developed before the implementation of regulations adopted pursuant to subdivision (b) receive credit for at least 10 years. Projects shall be eligible for an extension of credits after the first 10 years to the extent allowed by regulations adopted pursuant to the California Global Warming Solutions Act of 2006 (Division 25.5 (commencing with Section 38500)).

(f) Enteric emissions reductions shall be achieved only through incentive-based mechanisms until the state board, in consultation with the department, determines that a cost-effective, considering the impact on animal productivity, and scientifically proven method of reducing enteric emissions is available and that adoption of the enteric emissions reduction method would not damage animal health, public health, or consumer acceptance. Voluntary enteric emissions reductions may be used toward satisfying the goals of this chapter.

(g) Except as provided in this section, the state board shall not adopt methane emissions reduction regulations controlling the emissions of methane from dairy operations or livestock operations to achieve the 2020 and 2030 greenhouse gas emissions reduction goals established pursuant to the California Global Warming Solutions Act of 2006 (Division 25.5 (commencing with Section 38500)).

(h) Nothing in this section shall limit the authority of the state board to acquire planning and baseline information, including requiring the monitoring and reporting of emissions.

(i) This section does not in any way affect the state board's or districts' authority to regulate emissions of criteria pollutants, toxic air contaminants, or other pollutants pursuant to other provisions of this division.

SEC. 5. Section 39730.8 is added to the Health and Safety Code, to read:

39730.8. (a) For purposes of this section, the following terms have the following meanings:

(1) "Commission" means the Public Utilities Commission.

(2) "Energy commission" means the State Energy Resources Conservation and Development Commission.

(3) "Strategy" means the strategy to reduce short-lived climate pollutants developed pursuant to Section 39730.

(b) The energy commission, in consultation with the state board and the commission, shall develop recommendations for the development and use of renewable gas, including biomethane and biogas, as a part of its 2017 Integrated Energy Policy Report prepared pursuant to Section 25302 of the Public Resources Code. In developing the recommendations, the energy commission shall identify cost-effective strategies that are consistent with existing state policies and climate change goals by considering priority end uses of renewable gas, including biomethane and biogas, and their interactions with state policies, including biomethane and all of the following:

(1) The Renewables Portfolio Standard program (Article 16 (commencing with Section 399.11) of Chapter 2.3 of Part 1 of Division 1 of the Public Utilities Code).

(2) The Low-Carbon Fuel Standard regulations (Subarticle 7 (commencing with Section 95480) of Title 17 of the California Code of Regulations).

(3) Waste diversion goals established pursuant to Division 30 (commencing with Section 40000) of the Public Resources Code.

(4) The market-based compliance mechanism developed pursuant to Part 5 (commencing with Section 38570) of Division 25.5.

(5) The strategy.

(c) Based on the recommendations developed pursuant to subdivision (b), and to meet the state's climate change, renewable energy, low-carbon fuel, and short-lived climate pollutants goals, including black carbon, landfill diversion, and dairy methane targets identified in the strategy, state agencies shall consider and, as appropriate, adopt policies and incentives to significantly increase the sustainable production and use of renewable gas, including biomethane and biogas.

(d) Based on the recommendations developed pursuant to subdivision (b), the commission, in consultation with the energy commission and the state board, shall consider additional policies to support the development and use in the state of renewable gas, including biomethane and biogas, that reduce short-lived climate pollutants in the state.

(e) In implementing this section, priority shall be given to fuels with the greatest greenhouse gas emissions benefits, including the consideration of carbon intensity and reduction in short-lived climate pollutants, as appropriate.

SEC. 6. Chapter 13.1 (commencing with Section 42652) is added to Part 3 of Division 30 of the Public Resources Code, to read:

Chapter 13.1. Short-Lived Climate Pollutants

42652. The Legislature finds and declares all of the following:

(a) The organic disposal reduction targets are essential to achieving the statewide recycling goal identified in Section 41780.01.

(b) Achieving organic waste disposal reduction targets requires significant investment to develop organics recycling capacity.

(c) More robust state and local funding mechanisms are needed to support the expansion of organics recycling capacity.

42652.5. (a) The department, in consultation with the State Air Resources Board, shall adopt regulations to achieve the organic waste reduction goals for 2020 and 2025 established in Section 39730.6 of the Health and Safety Code. The regulations shall comply with all of the following:

(1) May require local jurisdictions to impose requirements on generators or other relevant entities within their jurisdiction and may authorize local jurisdictions to impose penalties on generators for noncompliance.

(2) Shall include requirements intended to meet the goal that not less than 20 percent of edible food that is currently disposed of is recovered for human consumption by 2025.

(3) Shall not establish a numeric organic waste disposal limit for individual landfills.

(4) May include different levels of requirements for local jurisdictions and phased timelines based upon their progress in meeting the organic waste reduction goals for 2020 and 2025 established in Section 39730.6 of the Health and Safety Code. The department shall base its determination of progress on relevant factors, including, but not limited to, reviews conducted

pursuant to Section 41825, the amount of organic waste disposed compared to the 2014 level, per capita disposal rates, the review required by Section 42653, and other relevant information provided by a jurisdiction.

(5) May include penalties to be imposed by the department for noncompliance. If penalties are included, they shall not exceed the amount authorized pursuant to Section 41850.

(6) Shall take effect on or after January 1, 2022, except the imposition of penalties pursuant to paragraph (1) shall not take effect until two years after the effective date of the regulations.

(b) A local jurisdiction may charge and collect fees to recover the local jurisdiction’s costs incurred in complying with the regulations adopted pursuant to this section.

42653. (a) No later than July 1, 2020, the department, in consultation with the State Air Resources Board, shall analyze the progress that the waste sector, state government, and local governments have made in achieving the organic waste reduction goals for 2020 and 2025 established in Section 39730.6 of the Health and Safety Code. The analysis shall include all of the following:

(1) The status of new organics recycling infrastructure development, including the commitment of state funding and appropriate rate increases for solid waste and recycling services to support infrastructure expansion.

(2) The progress in reducing regulatory barriers to the siting of organics recycling facilities and the timing and effectiveness of policies that will facilitate the permitting of organics recycling infrastructure.

(3) The status of markets for the products generated by organics recycling facilities, including cost-effective electrical interconnection and common carrier pipeline injection of digester biomethane and the status of markets for compost, biomethane, and other products from the recycling of organic waste.

(b) If the department determines that significant progress has not been made on the items analyzed pursuant to subdivision (a), the department may include incentives or additional requirements in the regulations described in Section 42652 to facilitate progress towards achieving the organic waste reduction goals for 2020 and 2025 established in Section 39730.6 of the Health and Safety Code. The department may, upon consultation with stakeholders, recommend to the Legislature revisions to those organic waste reduction goals.

42654. This chapter shall not limit the authority of a local jurisdiction to adopt, implement, or enforce requirements in addition to those set forth in the regulations adopted pursuant to this chapter.

SEC. 7. No reimbursement is required by this act pursuant to Section 6 of Article XIII B of the California Constitution because a local agency or school district has the authority to levy service charges, fees, or assessments sufficient to pay for the program or level of service mandated by this act, within the meaning of Section 17556 of the Government Code.

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Appendix C: California SLCP Emissions

California SLCP Emissions

ARB develops an annual statewide GHG emission inventory to track GHG emission trends and progress towards California's GHG emission reduction goals. The 2015 GHG emission inventory includes emissions from 2000 to 2013 for carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride.[1]

California's GHG inventory includes two short-lived climate pollutants: methane and F-gases. Because not all F-gases in the GHG emission inventory are short-lived, the SLCP inventory used for this SLCP Strategy includes only those hydrofluorocarbons (HFC) with lifetimes of a few decades[2] which represent about 97 percent of total F-gas emissions in California. Methane and short-lived F-gas emissions in this Appendix are presented using 20-year global warming potential (GWP) values from the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report (AR4).

Unlike methane and F-gases, black carbon is not routinely inventoried by ARB. Per SB 605 and to support this SLCP Strategy, ARB has developed a black carbon emission inventory for key years. Black carbon emission data in this discussion are presented using the 20-year GWP value from the IPCC Fifth Assessment Report (AR5), the first report to define a GWP for black carbon. The black carbon inventory does not include emissions of brown carbon, or account for potential warming effects of brown carbon.

This Appendix provides a brief overview of current and projected SLCP emissions and inventory methods. Additional data tables and detailed methodology are available on the SLCP inventory webpage.[3]

A. Black Carbon

1. Emission Sources

Black carbon is emitted from combustion processes, primarily from diesel engines and biomass burning.

The major anthropogenic sources of black carbon in 2013 include diesel-fueled mobile sources, fuel combustion and industrial processes, and residential fireplaces and woodstoves. Off-road mobile emissions account for over a third of statewide black carbon emissions. On-road mobile sources account for nearly a quarter of emissions, primarily from on-road diesel combustion. Fuel combustion and industrial processes

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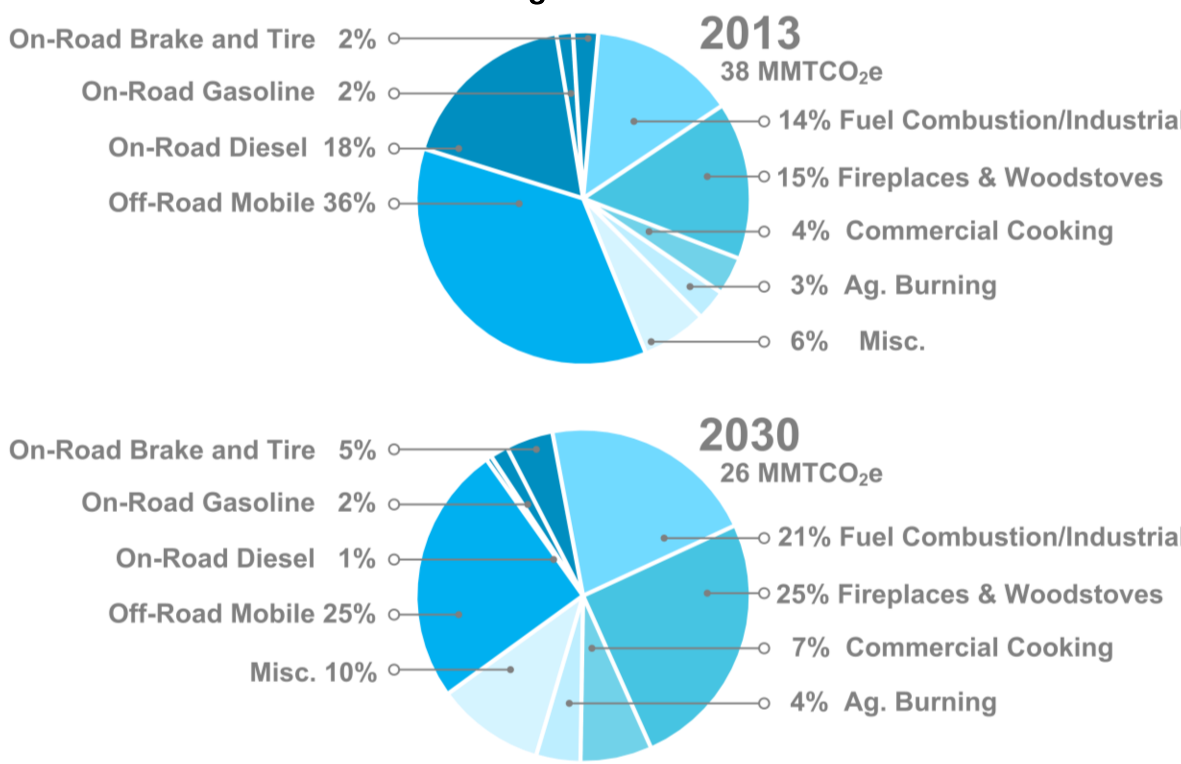
[1] ARB (2015). California's Greenhouse Gas Emission Inventory – 2015 Edition. http://www.arb.ca.gov/cc/inventory/data/data.htm

[2] Short-lived F-gases include the nine short-lived hydrofluorocarbons: HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-245fa, HFC-32, HFC-365mfc, and HFC-43-10mee.

[3] Inventory methodology and detailed inventory tables available at: http://www.arb.ca.gov/cc/inventory/slcp/slcp.htm

are also an important source of black carbon. This emission category consists of a large number of engines and industrial processes, with a wide variety of applications including electricity production, manufacturing, concrete, asphalt, pulp and paper, and service and commercial sectors. Residential fireplaces and woodstoves account for approximately 15 percent of black carbon emissions in 2013. On-road gasoline and brake and tire wear emissions are small. Miscellaneous sources include dust, waste disposal, residential natural gas combustion, and unplanned structure and car fires. Figure 1 presents 2013 and projected 2030 anthropogenic black carbon emissions and sources.

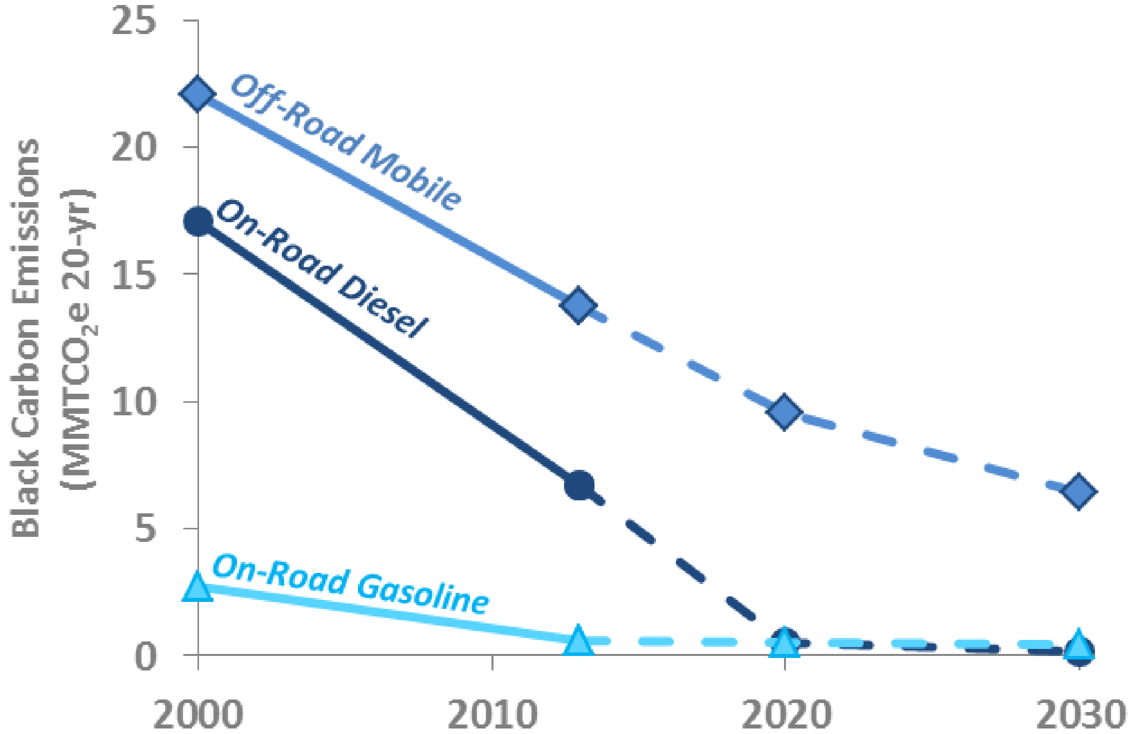
Figure 1. 2013 Anthropogenic Black Carbon Emissions and Projected 2030 Emissions* with Existing Measures



***Using 20-yr GWPs**

As illustrated in Figure 2, on-road mobile source emissions are projected to decline significantly by 2030 due to ARB's regulatory actions to reduce diesel emissions. On-road black carbon emissions have decreased by 62 percent since 2000 and are projected to decrease another 92 percent by 2030. Emissions from off-road vehicles are projected to decline by over 70 percent between 2000 and 2030 but remain an important source of black carbon, accounting for approximately one quarter of emissions in 2030. Non-mobile source categories will become a larger share of statewide emissions as mobile sources decline in the future. In 2030, fuel combustion and industrial processes will account for one quarter of emissions as will residential wood combustion.

Figure 2. Black Carbon Emissions from On-Road and Off-Road Mobile Sources with Existing Measures



Wildfire is the largest source of black carbon in California. Prescribed fires also emit black carbon, but are an important tool for forest managers However, since the legislative direction and intent of SB 1383 is to include only non-forest sources of black carbon in the target, a target for forest-derived black carbon emission reductions is not included in this SLCP Strategy. For reference, estimates for 10-year annual average black carbon emissions from fires that occurred in forests and other lands are provided in Table 1. Emissions from fires in forests and other lands vary dramatically from year-to-year, and these inventories contain higher uncertainty[4] than the anthropogenic sources in Figure 1.

Table 1. 10-Year Average California Black Carbon Emissions: Wild and Prescribed Fire

Source	10-Year Average Emissions (MMTCO2e)*
Prescribed Burning	3.6
Wildfire	86.7

*Using 20-year GWP

[4] California Air Resources Board 2015 Edition of California's Black Carbon Emission Inventory. https://www.arb.ca.gov/cc/inventory/slcp/doc/bc_inventory_tsd_20160411.pdf

2. Inventory Methods

California's black carbon emission inventory was developed using existing particulate matter (PM2.5) emission estimates, combined with speciation profiles that define the fraction of PM2.5 that is elemental carbon. Elemental carbon is the "best available indicator"[5] of black carbon, but is not a perfect proxy for warming effects, which depend on the physical and chemical properties of the particles. Elemental Carbon is not a proxy for brown carbon, thus brown carbon is not included in the inventory. The PM2.5 inventory was assembled using a wide variety of techniques including models, data reported by local air districts, and ARB inventory calculation methodologies.

Speciation profiles were developed by ARB as part of photochemical modeling efforts. Black carbon emissions depend on a variety of factors including fuel, engine operating conditions, age, maintenance, emission control technology, load, and drive cycle. Variability in these factors and their impact on speciation profiles remains a large source of uncertainty in black carbon inventory development.

The PM2.5 inventory, excluding wildfire, was projected using a 2012 base year, and includes both growth assumptions and existing control measures. Growth and control assumptions are defined for each source and air basin, in collaboration with applicable air districts.

Wildfire PM2.5 emissions are large, and can vary significantly from year to year. California's black carbon inventory in Table 1 above uses the ten-year average wildfire PM2.5 emissions from 2001 to 2011 to avoid large year-to-year variations in the inventory. Annual PM2.5 emissions are calculated using geospatial fire activity and vegetation fuels data in the First Order Fire Effects Model (FOFEM).[6] FOFEM accounts for vegetation fuel size class distributions, configuration, moisture content, fuel consumption and emissions associated with flaming and smoldering phases. The geodatabase classifies wildfires according to management objective: suppression or non-suppression (wildfire use for resource benefit).

As with other sources, speciation profiles are applied to the ten year average wildfire PM2.5 emissions to estimate black carbon. Black carbon emissions from biomass burning vary depending on fire conditions, such as the fuel type, moisture content, oxygen availability, and local meteorology. This variation leads to high uncertainty in speciation assumptions, and adequate speciation profiles to account for various fire conditions are not available. For these reasons, the wildfire emission estimate contains very high uncertainty, and should be understood to be an order-of-magnitude estimate of emissions for a typical year.

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[5] USEPA (2012). United States Environmental Protection Agency, Department of the Interior, Environment and Related Agencies. "Report to Congress on Black Carbon". http://www.epa.gov/blackcarbon/

[6] Lutes, D. (2013) FOFEM User Guide. Missoula Fire Laboratory, Rocky Mountain Research Station, USDA Forest Service. Missoula, MT. Available at https://www.frames.gov/rcs/15000/15530.html

3. Inventory Improvement

California's black carbon inventory relies on particulate matter inventories coupled with speciation profiles that define the fraction of particulate matter that is black carbon. The sources that emit black carbon are well understood from a control prospective, and major sources are regulated in California. However, it is a challenge to estimate statewide black carbon emissions, and to define speciation profiles for all sources because of: 1) the diversity and large number of sources, 2) the wide variety of engines, after treatment, operating conditions, and fuels, and 3) the difficulty in measuring black carbon and its co-pollutants.

Additional representative source measurements are needed to better characterize black carbon speciation profiles by emissions source, fuel type, and combustion conditions. Better characterization of emissions from wildfire, open biomass burning, commercial charbroiling, and residential wood combustion can help improve inventory estimates. The scientific literature reports large variability in black carbon speciation profiles from biomass burning due to the many variables that affect emissions. Future research is needed to provide a scientific consensus on speciation profile choice and best practices to produce biomass burning emission inventories. In general, California's mobile source emissions are among the best characterized, but improved information is still needed for some sectors, such as off-road mobile sources.

Quantifying emissions from wildfires is an active area of research in the earth science and air quality community, but is technically challenging due to the inherent variability in vegetation fuel loads, fire behavior, and consumption. Ongoing efforts to improve the scientific understanding of the ecological role and air quality effects of wildland fire are occurring as part of the federal Joint Fire Science Program[7] and special projects such as the NOAA Fire Influence on Regional and Global Environments Experiment (FIREX)[8]. Research areas include development and evaluation of emission models and underlying model parameters, smoke in context of health and air quality standards, fire in a changing climate, and ecosystem health in relation to fire.

ARB is also in the process of comparing the black carbon emission inventory to field observations at the Mount Wilson monitoring station located above the Los Angeles basin. Air masses from Los Angeles exhibit consistent agreement between black carbon and carbon monoxide, indicating a well-mixed air mass and similar sources. This monitoring data will be used to derive a 'top down' observation for comparison to the 'bottom up' black carbon inventory.

[7] http://www.firescience.gov/
[8] http://www.esrl.noaa.gov/csd/projects/firex/

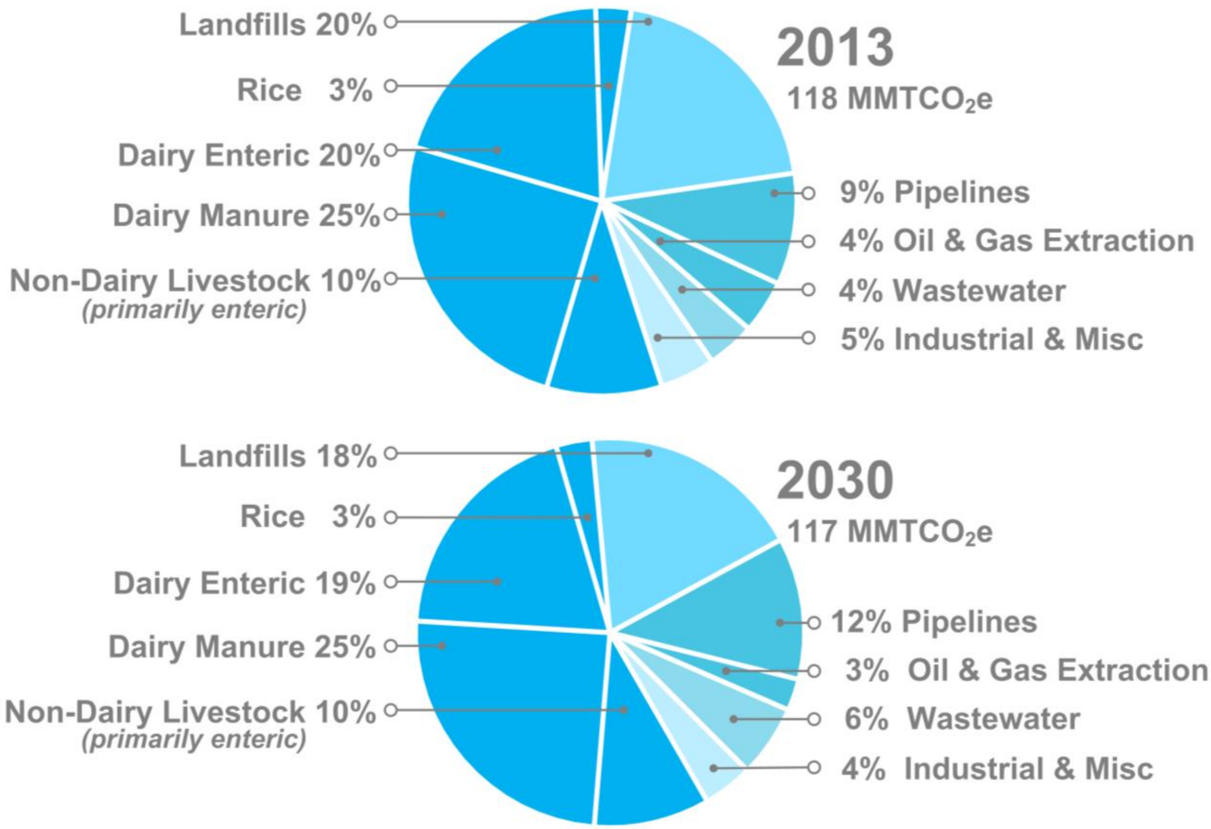
B. Methane

1. Emission Sources

Methane is emitted from a wide range of fugitive sources and biological processes. In 2013, agriculture represented the largest methane source, accounting for nearly 60 percent of emissions. Enteric fermentation and manure management from dairy operations produced almost 80 percent of these agricultural emissions. Enteric fermentation and manure management from non-dairy livestock and rice emissions are smaller agricultural sources. Ninety percent of non-dairy livestock emissions are from enteric fermentation, and the remaining emissions are from manure management. Landfills are the next largest source of methane, accounting for one fifth of statewide methane emissions. Natural gas pipeline leaks, oil and gas extraction, wastewater, and other industrial and miscellaneous sources make up the remainder of emissions. Miscellaneous sources include industrial fugitive emissions, methane produced as a byproduct of fuel combustion, composting, and petroleum seeps. Figure 3 presents 2013 and projected 2030 business-as-usual (BAU) methane emissions and sources.

Compared to current emissions, projected 2030 BAU methane emission sources and levels are not expected to change significantly without additional reduction measures. In a BAU scenario, natural gas pipeline leaks are projected to increase slightly due to aging infrastructure and expansion of the pipeline system without additional actions to reduce emissions.

Figure 3. 2013 Methane Emissions and Projected 2030 Emissions with Existing Measures*



*** Using 20-yr GWPs**

2. Inventory Methods

Statewide methane emission estimates rely on state, regional, or federal data sources using calculation methodologies consistent with the 2006 Intergovernmental Panel on Climate Change guidelines.[9] Landfill emissions are calculated using a First-Order Decay Model with California-specific waste characterization. This model is supplemented with emission data for individual landfills provided by ARB surveys, CalRecycle, and U.S. EPA mandatory reporting. California's livestock methane inventory is based on U.S. EPA modeling of enteric fermentation and manure management. The model estimates methane emissions using detailed parameters by animal type such as age, size, volatile solids excretion, feed, and manure management pathways. Emissions from oil and gas extraction and pipeline leaks are estimated based on survey data conducted by ARB and other federal data sources. A complete description of the methodologies is available online.[10]

[9] IPCC (2006). IPCC Guidelines for National Greenhouse Gas Inventories. http://www.ipcc-nggip.iges.or.jp/public/2006gl/

[10] ARB 2015 Edition GHG Inventory. http://www.arb.ca.gov/cc/inventory/data/data.htm

Methane emissions are projected for 2030 by applying sector-specific growth factors to base-year emissions. Base-year emissions use the average emissions from 2009 to 2011 to dampen the effects of year-to-year variability in factors that influence emissions. The sector-specific growth factors come from projection analysis prepared by other state and federal agencies. A complete description of forecast methodology is available online.[11]

3. Inventory Improvement

While improving inventory quality is not a prerequisite for many actions to reduce SLCP emissions, it is nonetheless important to inform ongoing efforts. ARB staff continually assesses ways to improve the methane inventory using the latest scientific understanding of methane sources and the best available activity data. The improvements made to the 2015 edition of the statewide methane inventory include incorporation of ARB oil and gas survey data for fugitive methane emission estimates, use of the new EMFAC 2014 on-road mobile emissions model, and updates to the emissions of non-citrus fruit wastewater methane emissions.

ARB is further improving the methane emission inventory with ongoing coordinated research with other agencies. ARB and the California Energy Commission (CEC) have several ongoing partnerships for measurement and evaluation of methane emission sources in the energy sector. ARB operates a statewide methane monitoring network that provides a record of real time methane concentrations in California, supported by CEC and other sister agencies. Data from this network were used in several research contracts, and formed the basis of a comprehensive statewide inverse receptor-oriented modeling and various trends assessment analyses to verify and inform the statewide GHG inventory.

ARB is also actively participating in the Megacities Carbon Project in the South Coast Air Basin which is developing and testing methods for monitoring various GHG emissions to link measured concentrations to emission activity. In addition, AB 1496 (Thurmond, Chapter 604, Statutes of 2015) requires ARB, in consultation with the local air districts, to monitor and measure high-emission methane “hot spots” in the State. Researchers at ARB, CEC, and NASA's Jet Propulsion Laboratory are collaborating to identify large "hot spot" methane sources through a systematic survey of high methane emitters using aerial and ground measurement to survey various sources in the agriculture, waste, and oil and gas sectors. Collectively, these efforts are expected to improve our understanding of the various methane emission sectors and aid in developing effective mitigation programs to reduce GHG emissions in California.

In addition, CalRecycle is currently working with ARB to better quantify fugitive methane emissions from landfills by measuring methane fluxes at a representative sample of landfills across California. This study will provide information on landfill gas collection

[11] http://www.arb.ca.gov/cc/inventory/slcp/slcp.htm

system efficiencies, and improve the State's ability to estimate the benefits associated with the diversion of organics from landfills.

ARB funded a study to gather updated emission factors for natural gas distribution pipeline leaks and is funding a contract to study emissions from natural gas customer meters. The CEC is sponsoring several research contracts to identify the main sources of emissions from the natural gas distribution system. Research activities also include methane surveys of residential housing, which may be an important and unrecognized source of methane.

Future research will be necessary to continue refining the methane inventory, and provide California-specific activity data. Emissions from enteric fermentation and manure management are currently modeled using international or national default parameters due to a lack of California-specific data. The ARB is funding research on California-specific feed data, and its effect on enteric emissions. A second research project is characterizing the diverse dairy manure management system in California, to better understand the effect of management practices on methane emissions. This research will better reflect on-farm realities and inform the enteric and manure management methane inventories.

Research to better quantify fugitive methane emissions from the natural gas and oil systems are necessary to inform the emission inventory. Methane emissions from anaerobic digesters in domestic wastewater treatment facilities, and pulp and paper mill wastewater are currently estimated using activity data from U.S. EPA. Future research is needed to update these estimates with California-specific data to improve inventory estimates. Research into fugitive emissions from new infrastructure and technologies is also necessary to understand the impact of these new technologies on methane emissions.

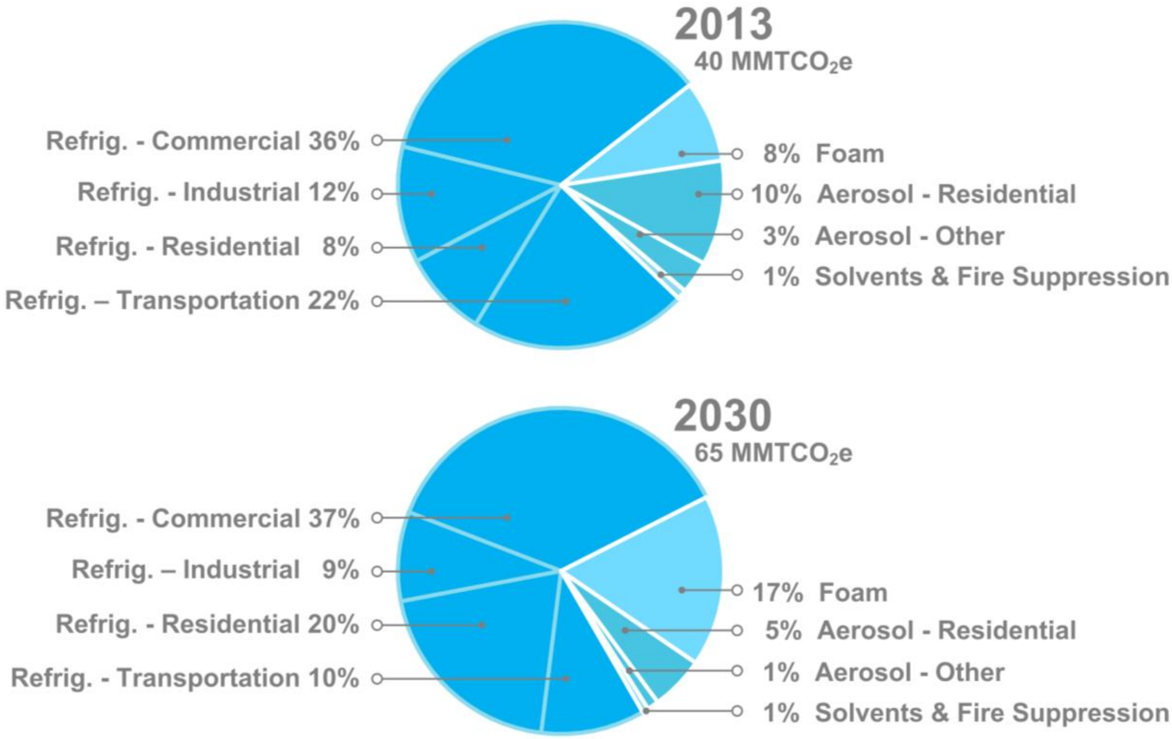
C. F-Gases

1. Emission Sources

Due to the global HFC phasedown agreed to on October 15, 2016 (the "Kigali Amendment"), ARB will sponsor a third-party assessment in early 2017 on the impact of the Kigali Amendment on HFC emissions and reductions in California. ARB plans to utilize the results from this assessment to inform future update to BAU projections for HFC emissions.

F-gases are used in refrigeration and air conditioning, insulating foams, solvents, aerosol products, and fire protection. Nearly 80 percent of F-gas emissions in California are from refrigeration and air conditioning equipment. Commercial refrigeration is the single largest source of short-lived F-gases, followed by commercial and residential air conditioning. Figure 4 presents the 2013 and projected 2030 F-gas emissions and sources. The F-gas inventory includes nine short-lived HFCs: (HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-245fa, HFC-32, HFC-365mfc, and HFC-43-10mee), but excludes two long-lived HFCs with negligible emissions.

Figure 4. 2013 F-Gas Emissions and Projected 2030 Emissions* with Existing Measures[12]

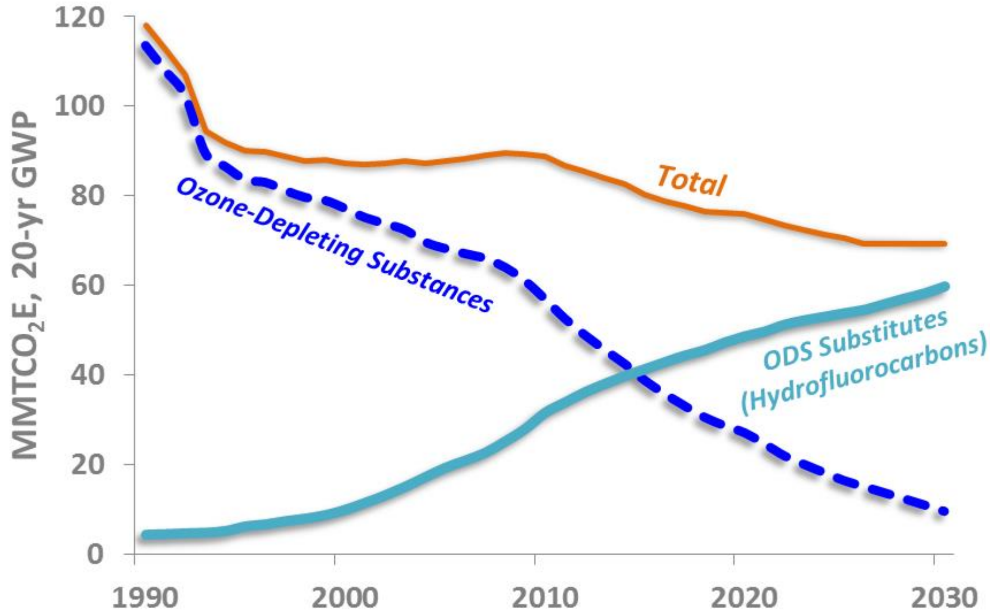


***Using 20-yr GWPs**

Annual F-gas emissions are expected to increase 60 percent by 2030, even with current ARB and U.S. EPA regulations in place. This is primarily because HFCs continue to replace ODS that have been phased-down or phased-out of new production by the 1987 Montreal Protocol. ODS are not included in the California GHG emission inventory since they are not listed in AB 32. However, ODS emissions are declining rapidly as HFC emissions increase (Figure 5). The net warming impact is declining overall, but emissions of high GWP compounds must be reduced to meet California's climate goals.

[12] "Refrig." includes both refrigeration and air conditioning.

Figure 5. Emissions of ODS and ODS substitutes (hydrofluorocarbons) using 20-year GWPs.



Mobile air conditioning refrigerant emissions are one of the few HFC sources projected to decline by 2030 in response to State and federal programs to incentivize low-leak air conditioning systems and low GWP refrigerants for light-duty vehicles, and federal regulations prohibiting high GWP F-gases in new light-duty vehicles starting in model year 2021. The availability of low GWP refrigeration and air conditioning alternatives are increasing yearly, as industries anticipate a global HFC phase down, recently adopted in Kigali, Rwanda. Additionally, foam expansion agents, aerosol propellants, solvents, and fire suppressants are increasingly trending towards low GWP alternatives that are often less expensive.

2. Inventory Methods

ARB developed the F-gas emission inventory using California-specific data based on several research contracts funded by ARB. The inventory also leverages data from local and state regulations to inform emission estimates, including the South Coast Air Quality Management District Rule 1415 and ARB's Refrigeration Management Program.

Using these data, a California-specific F-gas emission model was developed by ARB, forming the basis for California's GHG emission inventory for F-gases. Equipment production, retirement, and F-gas usage and emissions are calculated annually for 37 F-gases. Historical F-gas emissions are backcast to 1990 from a 2008 base year using equipment inventories estimated by ARB research contracts. Future F-gas emissions are projected based on population growth, as F-gas emissions and population are shown to be highly correlated in California. The emission estimates account for the rapid replacement of ODS with hydrofluorocarbons as well as reductions from existing regulations. Additional methodology details can be found in the GHG documentation[13] and in Gallagher, et al., 2014.[14]

3. Inventory Improvement

The F-gas inventory is updated annually as new regulations change the projected emissions, and new reported data become available. The assumptions for the aerosol propellant F-gas emission baseline (last updated 2006) will be updated using the final 2014-2015 ARB consumer products survey data. ARB also funds research and measurements contracts to collect F-gas measurements at a monitoring site at the Mt. Wilson Observatory. These data are being analyzed to verify and track the emissions of various F-gases from the Southern California basin. Emissions from medical dose inhaler propellants are the only remaining F-gas subsector that relies on scaled-down national estimates. This inventory could be improved if California-specific usage was available, but confidentiality becomes a factor for medical devices.

4. Sulfuryl Fluoride

Sulfuryl fluoride (SO_2F_2) is a fluorinated gas with a lifetime of several decades and a 20-year GWP of 6840. Sulfuryl fluoride is used as a pesticide fumigant and is one of the most common replacements for methyl bromide, an ozone-depleting substance whose use is being phased out. According to the California Department of Pesticide Regulation (DPR), 3 million pounds of sulfuryl fluoride were used in 2013 (most recent data available).[15] Its main use is as a structural pest control fumigant to kill drywood termites in homes and buildings, accounting for 82 percent of all usage in 2013. According to the University of California, Riverside, more than 100,000 structural fumigations with sulfuryl fluoride are conducted each year in California.[16] Sulfuryl fluoride is also a common fumigant for dried fruits, nuts, and other agricultural commodities that must be kept pest-free during storage prior to shipping (15 percent of all usage in 2013). The remaining three percent of sulfuryl fluoride application was for other fumigation uses. Sulfuryl fluoride is not registered for use as a field soil fumigant and is not used on agricultural fields.

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[13] ARB 2015 Edition GHG Inventory. http://www.arb.ca.gov/cc/inventory/data/data.htm

[14] Gallagher, G.; Zhan, T.; Hsu, Y-K.; Gupta, P.; Pederson, J.; Croes, B.; Blake, D. R.; Barletta, B.; Meinardi, S.; Ashford, P.; Vetter, A.; Saba, S.; Slim, R.; Palandre, L.; Clodic, D.; Mathis, P.; Wagner, M.; Forgie, J.; Dwyer, H.; Wolf, K. 2014. "High-global Warming Potential F-gas Emissions in California: Comparison of Ambient-based versus Inventory-based Emission Estimates, and Implications of Refined Estimates". Environ Sci. Technol., 2014, 48, 1084−1093. dx.doi.org/10.1021/es403447v

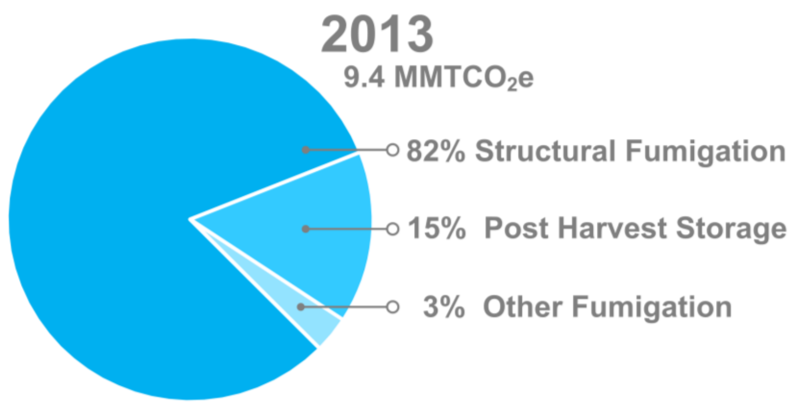
[15] Summary of Pesticide Use Report Data 2013 - Indexed by Commodity, California. California Department of Pesticide Regulation, May 2015. Available at: http://www.cdpr.ca.gov/docs/pur/pur13rep/13_pur.htm.

[16] Sulfuryl Fluoride Structural Fumigation, Personal Chemical Exposure Program, Department of Entomology, University of California, Riverside. Available at: http://faculty.ucr.edu/~krieger/SF%20Web%20Presentation%20Krieger%207%2019.pdf.

Sulfuryl fluoride was not recognized as a high-GWP GHG until 2009. Because sulfuryl fluoride was not identified as a high-GWP gas by the time AB 32 was enacted, it was not initially included as a part of ARB's statewide GHG inventory. However, the annual usage of sulfuryl fluoride is inventoried by DPR as a highly-regulated pesticide and ARB uses this data to track emissions. In 2013, the 3 million pounds of SO_2F_2 usage was equivalent to 9.4 $MMTCO_2E$ emissions (using 20-year GWP values), or approximately 20 percent of all F-gas emissions.

Sulfuryl fluoride emissions and sources in California are presented in Figure 6.

Figure 6. 2013 Sulfuryl Fluoride Emissions*

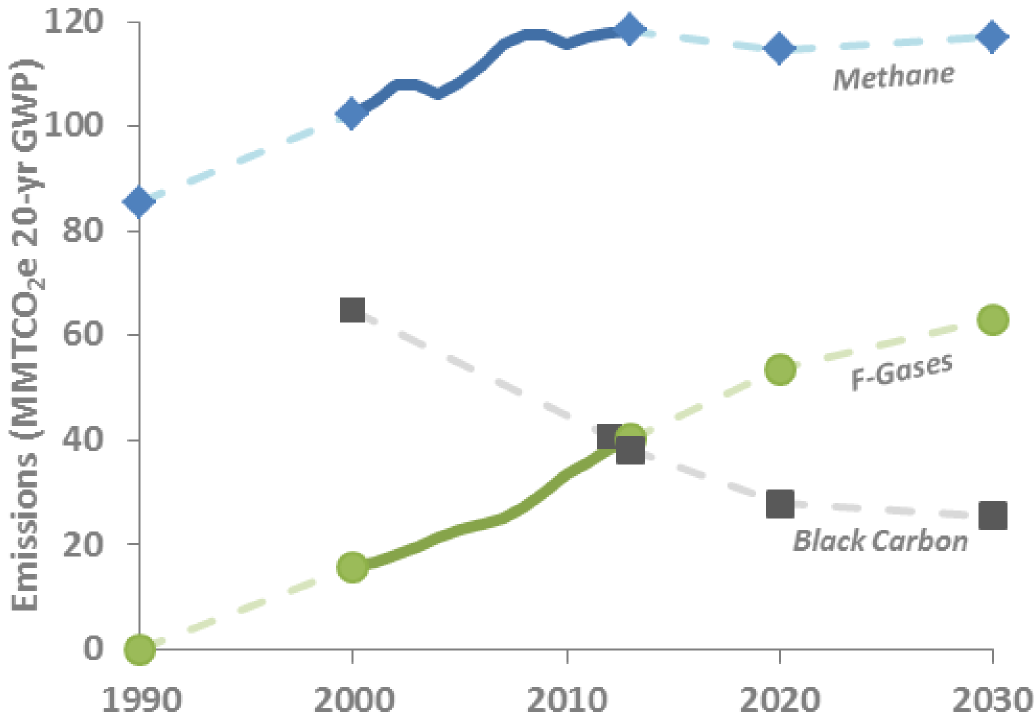


Using 20-yr GWPs

D. Emission Trends for SLCPs

Figure 7 shows the trends in emissions for methane, F-gases, and anthropogenic black carbon. Solid lines represent annual GHG emission inventory data available for 2000 to 2013. Symbols represent individual data years for 1990, 2013, 2020, and 2030. Dashed lines are meant to guide the eye, and do not represent emissions for intermediate years. 2020 and 2030 projections represent expected future emissions based on the current state of knowledge. The projections in the figure include existing control measures at the time of inventory development, but do not include measures under development or planned programs.

Figure 7. Trends in Methane, F-gases (HFCs), and Anthropogenic Black Carbon Emissions with Existing Measures Using 20-year GWPs.[17]



Methane emissions have increased since 1990 but are expected to remain relatively constant going forward, as dairy cow populations are expected to stay flat. F-gas emissions increase between 1990 and 2030 as HFCs replace ozone depleting chlorofluorocarbons, which are also potent warming compounds. Anthropogenic black carbon emissions decline significantly from 2000 to 2020, primarily due to mobile source diesel regulations, but are projected to decrease only slightly between 2020 and 2030 as reductions from existing regulations are already realized.

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[17] - F-gases include the nine short-lived F-gases: HFC-125, HFC-134a, HFC-143a, HFC-152a, HFC-227ea, HFC-245fa, HFC-32, HFC-365mfc, and HFC-43-10mee.
- Black carbon excludes prescribed fire and wildfire.
- Dashed lines are linearly interpolated between points to guide the eye but are not mean to represent emissions for intermediate years.

Appendix D: Research Related to Mitigation Measures

Research Related to Mitigation Measures

A. Black Carbon

Successful programs to reduce emissions of anthropogenic black carbon rely on scientific research to develop and deploy new technologies, quantify emission benefits and cost-effectiveness, understand lifecycle emissions, and ensure continued emission reductions from programs in place. There are many active areas of research to reduce black carbon spanning the varied source categories and areas where additional research is needed.

1. Current Research

California has a long and successful history of adopting technology-advancing vehicle emission standards to protect public health, built on a strong research foundation. This research supports strategies to meet federal air quality standards, reduce health risk from toxic air contaminants, and meet GHG emission reduction goals. ARB-funded research on vehicles and associated emissions also monitors the effectiveness of emission reduction strategies to ensure that the expected air quality and public health benefits are achieved. Much of ARB's recent research on heavy-duty vehicles, and their emissions, has focused on tracking the results of regulatory efforts to meet the goal of the Diesel Risk Reduction Plan. Research included evaluating the emission reductions from in-use rules on heavy-duty diesel vehicles, and investigations into the durability, degradation, and failure rates of exhaust after treatment devices.

Additional research is underway to adapt diesel filter use to a wider variety of engines, develop and deploy zero-emission technology and infrastructure, and identify the emission benefits from alternative fuels. To support and inform the Sustainable Freight Action Plan, the 2016 SIPs, and other ARB emission reduction planning efforts, ARB and the South Coast Air Quality Management District have been conducted technology and fuel assessments for a variety of source categories. The assessments will provide essential information on the technologies and fuels that will provide the most benefit for California to meet its air quality and climate goals, including black carbon reductions.

In coordination with U.S. EPA and the National Highway Traffic Safety Administration, ARB passenger vehicle research has turned to understanding market forces and consumer acceptance of new vehicle technologies, such as plug-in hybrid electric vehicles and ZEVs. Sustainable community research is another active area that aims to investigate strategies to reduce emissions and improve health by reducing vehicle miles traveled through alternative land use planning practices. The results will inform local governments, planners, and other practitioners on the best strategies to reduce emissions from passenger vehicles.

Air districts are also researching and developing cost-effective air pollution controls for under-fired char broilers. Demonstration of air pollution control devices in restaurants are in progress. Successful demonstration and installation of these control devices will further black carbon reductions from this source category.

An international research collaborative is also underway to help mitigate PM and black carbon emissions. The India-California Air Mitigation Pollution Program (ICAMP), launched in October 2013, devises ways to tackle the joint air pollution-and-climate change problem. ICAMP draws on California's decades of experience developing the scientific basis for understanding air pollution impacts, engine and fuel technologies that are proven to reduce pollution levels, and governance for effective implementation of mitigation polices. The Program has now established working groups on science, technology, and governance to design measures to reduce India's air pollution and propose an Action Plan to policy makers. The Program will also explore options for pilot projects to reduce diesel emissions in major Indian cities and states.

2. Future Research

Future research will ensure continued emission reductions using the most cost-effective strategies, verify emission reductions from existing regulations, and support development of new strategies.

New technologies offer significant promise for continued emission reductions. It is important to evaluate emissions under real-world conditions and as the technologies age. For example, heavy duty trucks and some off-road engines are transitioning to Diesel Particulate Filters (DPFs), mitigating emissions in most cases. As with any new technology, real-world implementation reveals component deterioration or failure that needs to be addressed. There is a growing transition to gasoline direct injection for on-road light-duty vehicles, which emit more PM and a higher fraction of black carbon than conventional passenger vehicles. Similarly, it was expected that DPFs would be used to meet the stringent Tier 4 standards for off-road engines. However, many engine manufacturers are developing systems that meet certification standards without diesel particle filters. It will be important to characterize the particulate and black carbon emissions from these engines to understand the implication of new technologies. Research to monitor fleet performance and to support new regulations related to inspection and maintenance, repairs, and warranty requirements will help ensure continued black carbon emission reductions.

In the freight sector, continued black carbon emission reductions are expected through efficiency improvement, and electrification. The development of system-wide technology and economic models will help identify emission reductions at the least cost. While there is already a significant amount of data available for the development of these models, additional data on costs, duty cycles, and power use profiles is needed.

A better understanding of the costs and benefits of mitigation by sector and development of new or improved technologies will ensure continued black carbon emission reduction across the diverse black carbon emission sectors. This research also allows for a comparison of emission reduction potential, cost, and benefit for climate and human health of various strategies.

California has made extraordinary progress to reduce PM and black carbon emissions, especially from on-road mobile sources. This record of success makes California an international leader in reducing harmful PM and black carbon emissions to protect health, the environment, and climate. Technology transfer is a fast-growing activity in the U.S. research and development system, and one which has received substantial attention from governments, industry, and universities. The strategies and technologies developed in California can also be applied to other regions to produce additional emission reductions.

B. Methane

Methane mitigation research relative to oil and gas processing and distribution, dairies, and waste management are tightly linked and involve coordinated research efforts among multiple State agencies. In essence, these research efforts investigate the use of diverted waste and agricultural byproducts for beneficial purposes, such as to produce renewable fuels that can replace fossil-derived fuels through the most economically feasible and environmentally beneficial pathways.

1. Current Research

The CEC's sponsored research focuses on developing technologies for the production of renewable natural gas (RNG), and investigates the potential health and environmental impacts of biomethane production and use. This includes an RNG technology research roadmap, demonstration projects of technology to capture biogas from wastewater treatment plants and landfills, scrubbing and preconditioning technology to upgrade biogas to RNG, and feasibility studies for pipeline injection.

Research at the CEC is also evaluating and demonstrating technology to produce commercially-valuable products for use in conjunction with RNG production as a way to make this process more commercially competitive. Examples of this include the production of fertilizer products from digester effluent, the production of biochar, LNG and CNG production from green waste, and potential technologies to convert CO_2 into a variety of commercially-valuable products.

ARB sponsored research aims to assess the feasibility of RNG as a low carbon alternative fuel to meet the Low Carbon Fuel Standard, to evaluate the volume of fuel that could be made commercially available, and to estimate the savings in emissions and fuel prices compared to traditional hydrocarbon-based transportation fuels. The research is also assessing whether the use of RNG as a transportation fuel would impact other bioenergy pathways in California for heating, power generation, and liquid fuels.

ARB and CEC have both funded research on the air quality impacts of biogas production. ARB recently finalized a project that assessed the associated emissions of GHGs and criteria pollutants associated with the production of biogas. CEC is currently funding a project to look at toxic air emissions as a potential health threat from the combustion of biogas produced from different sources, and different levels of treatment. The results of these projects will improve our understanding of the air quality implications associated with different biogas adoption strategies.

ARB and CEC are also currently collaborating with scientists at NASA's Jet Propulsion Laboratory to identify large "hot spot" methane sources through a systematic survey of high-methane emitters in the agriculture, waste, and oil and gas sectors. This research will aid in future control and regulatory plans to reduce GHG emissions in California.

2. Future Research

Dairies and Livestock

Methane that is produced by the microorganisms involved in the digestive processes in the stomachs of ruminants, such as sheep, goats, buffalo and cattle, is referred to as enteric fermentation. Since these emissions account for about one third of California's methane inventory, it is essential to develop strategies to reduce emissions from these sources to meet State GHG emission reduction targets.

Strategies that have been investigated to reduce enteric fermentation include increasing rumen efficiency and reducing the amount of methane produced for a given amount of feed intake, breeding animals for lower methane production, gut microbial interventions, and changes to nutrition and animal management. Further research is needed to fully evaluate the viability of these strategies in California, and to assess their associated costs and co-benefits, potential impacts on animal and human health, other environmental impacts, and lifecycle GHG and air toxic emission impacts.

Additional research is needed to help identify financing options to reduce costs and improve the economic feasibility of dairy digester projects. The costs of owning and operating a digester are not well understood. Assessments are needed to determine how much time, effort, and money dairy operators spend acquiring permits and contracting with energy service providers. Other research gaps include understanding potential markets for agricultural and dairy organic waste including compost and digester residues, and costs, long term performance, and co-pollutant emission impacts of alternative management practices. Alternative management practices include solids separation, dairy digesters, conversion to pasture-based operation, scrape management systems, or other dry manure management systems.

Oil and Gas

In a recently concluded ARB-sponsored contract, emission measurements from well stimulation operations were collected from a limited number of samples. In this study, well recirculation tanks were identified as a source of uncontrolled emissions. Well recirculation is a process whereby recirculated water is used to clear a well of excess sand using a temporary, open-top, portable tank. Accordingly, additional testing is necessary to obtain verifiable data and provide a quantification of recirculation tank GHG, VOC, and toxic air contaminant emissions. The Western States Petroleum Association undertook a study to collect more emissions data from well recirculation tanks.

In addition, ARB staff will be releasing an RFP to collect GHG, VOC, and toxic air contaminant emissions data from oil production wastewater ponds. As part of the recent ARB well stimulation contract, limited measurements were taken at an oil production wastewater evaporation pond system. Again, because of the limited sampling, an additional contract is being pursued.

Wastewater Treatment

Research is also needed to determine if emerging technologies for wastewater treatment processes for managing municipal solid waste can more effectively reduce methane emissions. New treatment technologies are currently being piloted at Stanford University, UC Berkeley, and by some wastewater agencies, which may fundamentally change treatment processes. Moreover, future wastewater treatment could involve a shift away from large end-of-pipe facilities to smaller distributed systems. Understanding how these technology and infrastructure transitions may affect methane emissions is an important research topic.

Waste Management

Policy and economic analyses should explore potential mechanisms that could increase the diversion of organic waste from landfills, and use compost in innovative ways to support the development of healthy soils. Ideally, this research should be regionally focused to address the logistical challenges and potential co-digestion opportunities that exist in different areas of the State.

C. F-Gases

Low-GWP refrigeration and air-conditioning is currently the subject of major research and development globally, due to heightened concerns over the impact of F-gases on global warming. Incentivized by the adoption of the European F-gas regulation, which went into effect January 1, 2015, and ultimately requires a 79 percent reduction in new F-gas usage by 2029, chemical and equipment manufacturers have cumulatively spent billions of dollars to achieve low-GWP solutions. Although not all cooling applications currently have low-GWP options, research and development is proceeding rapidly to find low-GWP applications for all refrigeration and air-conditioning end-uses.

Current research overseen by ARB includes a study to determine the reductions, technical feasibility, and cost-effectiveness of low-GWP commercial refrigeration, with particular attention paid to the feasibility of low-GWP in high-ambient temperature climates. Results are expected in 2016.

Alternatives to sulfuryl fluoride as a drywood termite fumigant have been the subject of several research projects.[1,2,3] Additionally, thousands of structures in the past twenty years have been treated for termites without using sulfuryl fluoride (or methyl bromide). Each treated structure could be considered its own real-world case study, although not necessarily subject to rigorous research controls. The peer-reviewed research studies indicate that sulfuryl fluoride fumigation is more effective than alternative means of termite eradication. However, many termite control companies refute these findings and report that orange oil or non-chemical treatments can be as effective as the use of sulfuryl fluoride.

The state of Florida Department of Agriculture and Consumer Services issued a guide for residential homeowners on termite treatment, which in part states:

> Alternative methods [to sulfuryl fluoride] now being performed by licensed pest control companies include: the electric gun, freezing with liquid nitrogen, heating, and chemical drill and injection control with termiticides and wood preservatives. All alternative methods have advantages and limitations which each pest control company should be willing to discuss with consumers.
>
> Consumers should be aware that these alternative treatments are considered spot treatments since the entire structure is not treated regardless of the warranty terms offered.
>
> This is not to imply that these alternative methods may be ineffective, but only to alert the consumer that these treatments cannot assure a complete treatment of all wood-destroying organisms infesting the wood within the entire structure.[4]

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[1] Simulated Field Evaluation of Six Techniques for Controlling the Drywood Termite Incisitermes minor (Isoptera: Kalotermitidae) in Residences, Vernard R. Lewis (UC Berkeley), and Michael I. Haverty (Forest Service, U.S. Dept. of Agriculture). Study conducted for the Structural Pest Control Board of California, 1996. Available at www.pestboard.ca.gov/howdoi/research/1996.pdf.

[2] Field Evaluations of Localized Treatments for Control of Drywood Termite Infestations in California, Final Report 2009 for the Structural Pest Control Board, Structural Pest Control Research Contract No. 084-4261-7. Vernard Lewis, Sara Moore, Robin Tabuchi, and Gail Getty of University of California, Berkeley. Available at: pestboard.ca.gov/howdoi/research/2009_field_rpt.pdf.

[3] Laboratory Evaluation of Efficacy of Orange Oil (XT-2000) for Control of Drywood Termites in Naturally-Infested Boards, Technical Release 2009, by Vernard Lewis for Dow AgroSciences. Available at: http://www.dowagro.com/vikane/images/pdfs/010-71269.pdf.

[4] Florida Department of Agriculture and Consumer Services. "Alternative Methods of Treatment for Drywood Termites - A Guide for Residential Homeowners". Bureau of Inspection and Incident Response, Revised July 2014.

The University of California at Riverside Department of Entomology in July 2009 reviewed sulfuryl fluoride structural fumigation and concluded “No alternative treatments have been identified to date that have the same consistency, completeness, and degree of efficacy as sulfuryl fluoride fumigation for pest elimination.”[5]

At the present time, it appears that total fumigation of structures is necessary in many cases for termite control, with sulfuryl fluoride proven as an effective fumigant. Similarly, insect treatment of dried fruit and nuts is often accomplished using sulfuryl fluoride, with lower-GWP alternatives such as phosphine being used less than previously due to insect resistance.[6] It should be noted that sulfuryl fluoride is not registered for use as a field soil fumigant and is not used on agricultural fields.

ARB will continue to work with the Department of Pesticide Regulation to assess alternatives to sulfuryl fluoride.

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[5] Drywood Termites - Integrated Pest Management In and Around the Home, Pest Notes Publication 7740, August 2014. University of California, Agriculture and Natural Resources, Statewide Integrated Waste Management Program. Available at: http://www.ipm.ucdavis.edu/PMG/PESTNOTES/pn7440.html

[6] Phosphine Fumigation of Stored Agricultural Commodity - Programmatic Environmental Assessment. November 2013. United States Agency for International Development (USAID), prepared under USAID’s Global Environmental Management Support (GEMS) project. Available at: http://www.usaidgems.org/documents/fumigationpea/fumigationpeafeb24_2014.pdf.

APPENDIX E

REVISED DRAFT ENVIRONMENTAL ANALYSIS

Prepared for the

PROPOSED SHORT-LIVED CLIMATE POLLUTANT REDUCTION STRATEGY

Air Resources Board 1001 I Street
Sacramento, California, 95814

Date of Release: November 28, 2016

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ACRONYMS AND ABBREVIATIONS

AB	Assembly Bill
APA	Administrative Procedure Act
APE	Area of Potential Effects
ARB or Board	California Air Resources Board
CAL FIRE	California Department of Forestry and Fire Protection
CalRecycle	California Department of Resources Recycling and Recovery
Cal/OSHA	California Division of Occupational Safety and Health Administration
CDFA	California Department of Food and Agriculture
CEC	California Energy Commission
CEQA	California Environmental Quality Act
CFC	chlorofluorocarbon
CO	carbon monoxide
CO_2	carbon dioxide
CPUC	California Public Utilities Commission
dBA	A-weighted decibels
DOGGR	California Department of Conservation’s Division of Oil, Gas, and Geothermal Resources
DPR	California Department of Pesticide Regulation
EA	Environmental Analysis
EIR	Environmental Impact Report
EO	Executive Office
FED	Functional Equivalent Document
F-gases	fluorinated gases
FTA	Federal Transit Administration
GHG	greenhouse gas
GWP	global warming potential
HCFC	hydrochlorofluorocarbon
HFC	hydrofluorocarbon
HFO	hydrofluoro-olefin
in/sec	inches per second
ISOR	Initial Statement of Reasons
LCFS	Low Carbon Fuel Standard

LDAR	Leak Detection and Repair
Leq	Equivalent level measurement
Lmax	Maximum sound level
$MTCO_2e$	metric tons of carbon dioxide equivalent
$MMTCO_2e$	million metric tons of carbon dioxide equivalent
NEPA	National Environmental Policy Act
N_2O	nitrous oxide
NOAEL	no observed adverse effect level
NOx	oxides of nitrogen
NPDES	National Pollutant Discharge Elimination System
OH	Hydrocyl radical
OIMP	Odor Impact Minimization Plan
OMP	Odor Management Plan
PM	particulate matter
PM_{10}	respirable particulate matter
$PM_{2.5}$	fine particulate matter (particles with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers)
PPV	Peak particle velocity
PRC	Public Resources Code
PRS	Project Specific Requirements
RNG	Renewable Natural Gas
RWQCB	Regional Water Quality Control Board
SB	Senate Bill
SLCP	short-lived climate pollutant
SLCP Strategy	Proposed Short-Lived Climate Pollutant Reduction Strategy
SNAP	Significant New Alternatives Policy
SOx	oxides of sulfur
SPR	Standard Project Requirements
SWPPP	Stormwater Pollution Prevention Plan
TAC	toxic air contaminant
TCR	Tribal Cultural Resources
TFA	trifluoroacetic acid
U.S. EPA	U.S. Environmental Protection Agency

µg/L	microgram per liter
USFS	U.S. Forest Service
VdB	vibration decibels
VMT	vehicle miles traveled
VOC	volatile organic compounds
WDR	Waste Discharge Requirements

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1.0 INTRODUCTION AND BACKGROUND

A. Introduction

This Draft Environmental Analysis (Draft EA) is a revised and recirculated environmental analysis developed for the Proposed Short-Lived Climate Pollutant Reduction Strategy (SLCP Strategy). A Draft EA was first released with the SLCP Strategy on April 11, 2016, for public comment. After the close of public comment on the April documents, the Legislature passed and Governor Brown signed Senate Bill (SB) 1383 (Lara, Chapter 395, Statutes of 2016) mandating the California Air Resources Board (ARB or Board) to take certain actions with regard to the short-lived climate pollutant strategy. Specifically, it mandated that ARB, no later than January 1, 2018, approve and begin to implement the short-lived climate pollutant strategy developed under Health and Safety Code section 39730 to achieve specified targets identified for each of the pollutants and after carrying out certain procedures and analyses. In response to this new mandate, ARB revised both the SLCP Strategy and the Draft EA to reflect the requirements of the bill.

This Revised Draft EA is included as Appendix E to the revised SLCP Strategy that will be presented to the California Air Resources Board (ARB or the Board) for consideration in early 2017. The Project Description section of this Revised Draft EA presents a summary of the proposed project under the California Environmental Quality Act (CEQA). A detailed description of each proposed action is included in the revised SLCP Strategy released November 23, 2016, which is hereby incorporated by reference. The full text of the SLCP Strategy is available at http://www.arb.ca.gov/cc/shortlived/shortlived.htm.

This Revised Draft EA is intended to disclose potentially significant adverse environmental impacts and potential mitigation for impacts resulting from implementation of the SLCP Strategy. The SLCP Strategy is designed to create environmental benefits related to greenhouse gas (GHG) reduction and related air quality conditions. In some cases, as described elsewhere in the Revised Draft EA, potentially significant indirect environmental impacts to other environmental resources may occur as a result of implementing measures in the strategy through compliance actions taken in response to the measures. In general, mitigation described in this Revised Draft EA would be expected to reduce potentially significant impacts identified to less-than-significant levels at the project level when compliance actions are carried out, if agencies with mitigation implementation authority enforce the mitigation. Nonetheless, this Revised Draft EA takes a conservative approach in its post-mitigation significance conclusions (i.e., tending to overstate the risk that feasible mitigation may not be sufficient or may not be implemented by other parties) and discloses, for CEQA compliance purposes, that potentially significant environmental impacts may be unavoidable. It is expected that many of these potentially significant impacts can be feasibly avoided or mitigated to a less-than-significant level as described in each resource area as a result of the project-specific environmental review processes associated with compliance actions and as a result of compliance with local and state laws and regulations.

B. Background and Purpose of the SLCP Strategy

Assembly Bill (AB) 32, the California Global Warming Solutions Act of 2006 (AB 32, Chapter 488, Statutes of 2006), declares that global warming poses a serious threat to the economic well-being, public health, natural resources, and environment of California and charges the ARB with “monitoring and regulating sources of emissions of greenhouse gases that cause global warming in order to reduce emissions of greenhouse gases.” (Health & Saf. Code, § 38510.) AB 32 provided initial direction on creating a comprehensive multi-year program to limit California’s GHG emissions to 1990 levels by 2020 and initiate the transformations required to achieve the State’s long-range climate objectives. One specific requirement of AB 32 is to prepare a “scoping plan” for achieving the maximum technologically feasible and cost-effective GHG emission reductions by 2020. (Health & Saf. Code, § 38561, subs. (a).) Developing a short lived climate pollutant (SLCP) strategy is identified in the First Update to the Climate Change Scoping Plan as one of the recommended actions to achieve additional GHG emission reductions. SLCPs include black carbon, methane, and hydrofluorocarbons (HFCs), which are powerful climate forcers and harmful air pollutants with an abbreviated atmospheric lifespan compared to other known climate pollutants (e.g., carbon dioxide [CO_2]) and comprise 40 percent of current net climate forcers. More recently, the Legislature passed, and the Governor signed SB 32 (Pavley, Chapter 249, Statutes of 2016), which requires ARB to ensure that statewide greenhouse gas emissions are reduced to 40 percent below the 1990 level by 2030. SLCP reductions are important to continuing and maintaining the greenhouse gas reductions called for by AB 32 and to ensuring emissions meet the statewide greenhouse gas emission limit established in SB 32. The SLCP Strategy also supports the goals of Executive Order (EO) B-30-15 issued by Governor Brown extending the administration’s GHG reduction target from achieving 1990 levels of statewide GHG emissions by the year 2020 to 40 percent below 1990 levels by 2030, which is now codified in SB 32.

SB 605 (Lara, Chapter 523, Statutes of 2014) directed ARB to develop a comprehensive strategy to reduce emissions of SLCPs. Subsequently, SB 1383 (Lara, Chapter 395, Statutes 2016) directed ARB to approve and begin implementing the strategy initiated under SB 605 (Lara, Chapter 523, Statutes of 2014) by January 1, 2018 that would achieve targets of a 40 percent reduction in methane, a 40 percent reduction in hydrofluorocarbon gases, and a 50 percent reduction in anthropogenic black carbon emissions from 2013 levels by 2030. SB 1383 essentially codified the direction of the draft strategy ARB proposed under SB 605 in April 2016, including the reduction targets ARB identified in that draft strategy. SB 1383 also provides specific direction to ARB on its process to develop regulations to implement the strategy.

The purpose of the SLCP Strategy is to broadly analyze and identify a comprehensive approach to reduce emissions of SLCPs, through mandatory and voluntary measures, incentives, and other policies and plans, as part of a broad effort to reduce emissions of all GHGs in the State. The SLCP Strategy identifies major sources of anthropogenic black carbon, methane, and HFCs, and recommends measures to substantially reduce emissions across the State to achieve the targets in SB 1383. The design of the recommended measures and the precise degree of emission reductions they can achieve will depend on the subsequent public processes required to develop specific measures (ie. rulemaking action). Accordingly, though the SLCP Strategy charts a course for further actions, it does not, itself, impose any mandates on those emission sources. Instead, it describes the course ARB intends to pursue, recognizing that the course may be altered (within appropriate legal boundaries) during the specific measure development, analyses, and public engagement.

Under SB 605, and subsequently, SB 1383, the development of the SLCP Strategy included coordination with local and State agencies, academic experts, businesses, organizations, and other stakeholders.

C. Environmental Review Process

1. Requirements under the California Air Resources Board Certified Regulatory Program

ARB is the lead agency for the SLCP Strategy and has prepared this Revised Draft EA under its CEQA certified regulatory program. Public Resources Code (PRC) section 21080.5 allows public agencies with regulatory programs to prepare a “functionally equivalent” or substitute document in lieu of an environmental impact report or negative declaration, once the program has been certified by the Secretary for Resources Agency as meeting the requirements of CEQA. ARB’s regulatory program was certified by the Secretary of the Resources Agency in 1978. (Cal. Code Regs., tit.14, § 15251, subs. (d).) As required by ARB’s certified regulatory program, and the policy and substantive requirements of CEQA, ARB prepared this Revised Draft EA to assess the potential for significant adverse and beneficial environmental impacts associated with the proposed measures and to provide a succinct analysis of those impacts. (Cal. Code Regs., tit.17, § 60005, subds. (a),(b)). The resource areas from the CEQA Guidelines Environmental Checklist (Appendix G) were used as a framework for programmatically assessing potentially significant impacts.

ARB has determined that approval of the SLCP Strategy is a “project” as defined by CEQA. CEQA defines a project as “the whole of an action, which has a potential for resulting in either a direct physical change in the environment, or a reasonably foreseeable indirect physical change in the environment, and that is … an activity directly undertaken by any public agency.” (Cal. Code Regs., tit.14, § 15378, subd. (a).) Although the recommended policy aspects of the SLCP Strategy do not directly alter the physical environment, physical changes to the environment could result from reasonably foreseeable compliance responses taken as a result of implementation of the subsequently developed measures identified in the SLCP Strategy.

2. Scope of Analysis and Assumptions

The degree of specificity required in a CEQA document corresponds to the degree of specificity inherent in the underlying activity it evaluates. The environmental analysis for broad programs cannot be as detailed as for specific projects. (Cal. Code Regs., tit.14, § 15146.) For example, the assessment of a construction project would naturally be more detailed than for the adoption of a plan because the construction effects can be predicted with a greater degree of accuracy. (Cal. Code Regs., tit.14, § 15146, subd. (a).) The level of detail in this Revised Draft EA reflects that the project is a broad strategy.

Consequently, the analysis does not provide the level of detail that will be provided in subsequent environmental documents prepared for specific regulatory actions that ARB or other agencies pursue to reduce SLCPs. (Cal. Code Regs., tit. 14, § 15152.) If ARB, or other state agencies, pursue regulations to implement any of the SLCP measures discussed in the SLCP Strategy, each regulation would go through the Administrative Procedure Act (APA) process. The APA is a rigorous process that includes technical, environmental, and economic analyses, and public review and input. The Initial Statement of Reasons (ISOR) prepared by ARB for each proposed regulation, also known as the Staff Report, would include an environmental analysis specific to that proposal. This Revised Draft EA provides a good-faith effort to evaluate programmatically the potential for significant adverse impacts associated with implementation of the broad policy aspects of the entire broad strategy based on what is known at this time.

In addition to APA requirements, AB 32,SB 32, SB 605, and SB 1383 also require ARB to carefully consider the potential effects on criteria pollutants, potential interactions with other environmental challenges, the risk of "leakage" (displacing industry out of state, rather than controlling its emissions), and impacts on disadvantaged communities. SB 1383 identifies specific considerations and analyses that ARB must complete before moving forward with certain sectors and regulatory options. Accordingly, the SLCP Strategy identifies a path that can ensure these considerations are addressed, beginning with incentive programs and research, moving through reporting and recordkeeping regulations to build expertise, and finally to direct emission control requirements (developed according to information gathered from this collaborative process). Any regulatory measures developed would need to be proposed and considered for adoption by the Board at a future date through a rulemaking proceeding specific to that measure.

The SLCP Strategy recommends measures that are consistent with all of ARB's obligations under CEQA, the APA, SB 605, SB 1383, AB 32, SB 32, and all other binding law. Mandates include (but are not limited to) commitments to:

- Ensure that AB 32 regulations complement, and do not interfere with, efforts to achieve and maintain federal and state ambient air quality standards and to reduce toxic air contaminant emissions;

- Consider cost-effectiveness and overall societal benefits of regulations, including benefits to the economy, environment, and public health;
- Avoid disproportionate impacts on disadvantaged communities;
- Minimize leakage in response to AB 32, SB 605, and SB 1383;
- Conduct the analyses required by SB 32 and calibrate any regulatory choices (including the stringency of potential regulations) on the basis of those analyses;
- Prioritize SLCP reduction measures that achieve co-benefits of improving water quality or reducing other air pollutants that impact community health and benefit disadvantaged communities; and
- Develop regulations consistent with the careful processes required by the APA and CEQA and address environmental impacts identified by the CEQA process.

The SLCP Strategy recommits ARB to following these principles, among its other mandates, as it develops measures, including for dairy methane reduction. These commitments, and the underlying statutory requirements, will shape how and when ARB ultimately seeks to achieve the legislatively mandated targets and will condition ARB's decision as to whether to pursue any particular measure. SB 1383, and other governing law, as well as the SLCP Strategy itself, commit ARB to implementing agricultural methane controls in environmentally and economically effective ways. The SLCP Strategy sets ARB on a course towards further research, evaluation, and public discussion as it moves towards developing regulations mandated in 2024. The shape and nature of those regulations will be shaped by progress made before that date, while taking careful account of the statutory factors set out in SB 1383. The impacts likely from methane controls must ultimately be consistent with the substantive requirements of SB 1383 (require minimizing leakage of emissions), along with those of SB 605 and AB 32, which require ARB to account for emissions impacts and other environmental considerations. ARB will propose regulations that foreseeably violate these statutory commitments. Nonetheless, in the interest of full disclosure, at this early programmatic stage, ARB is describing the range of impacts that could occur from potential compliance responses, in the absence of a fully designed program. This disclosure at the programmatic level is intended to provide a conservative overview of possible responses, including those which regulations must be designed to avoid or minimize.

The scope of analysis is intended to help focus public review and comments and ultimately to inform the Board of the environmental benefits and potential for adverse environmental impacts before Board action on the proposal. The analysis of potentially significant adverse environmental impacts from the SLCP Strategy is based on the following assumptions:

- This analysis addresses the potentially significant adverse environmental impacts resulting from implementing the SLCP Strategy compared to existing conditions.

- The analysis of environmental impacts and determinations of significance are based on the range of reasonably foreseeable compliance responses that could occur in response to implementing the measures in the SLCP Strategy.
- The analysis in this Revised Draft EA addresses environmental impacts both within California and outside the State to the extent they are reasonably foreseeable and do not require speculation.

The level of detail of the impact analysis is necessarily and appropriately general and programmatic because the SLCP Strategy itself is programmatic. Furthermore, the measures are recommendations at this planning stage and decisions that would be undertaken in response to the specific measures once they are more fully designed and adopted that could affect the physical environment cannot be fully known at this planning stage. This includes actions that may involve the design of new or modified facilities, which are largely unknown, and are therefore speculative, if not impossible, to predict with precision given the lack of specificity of implementation of the specific measures, the influence of other business and market considerations in those decisions, and the numerous locations where such facilities might be built. Specific development projects pursued in response to specific measures undertaken to implement the SLCP Strategy would undergo required project level environmental review and compliance processes at the time they are proposed.

This Revised Draft EA generally does not analyze site-specific impacts when the location of future facilities or other infrastructure is speculative. However, it does examine regional (e.g., air basin) and local issues to the degree feasible where appropriate. As a result, the impact conclusions in the resource- oriented sections of Chapter 4, Impact Analysis and Mitigation Measures, cover broad types of impacts, considering the potential effects of the full range of reasonably foreseeable actions undertaken in response to the SLCP Strategy.

D. Organization of the Environmental Analysis

The Revised Draft EA is organized into the following chapters to assist the reader in obtaining information about the SLCP Strategy and the specific environmental issues.

Chapter 1, Introduction and Background – provides a project overview, background information, and other introductory material.

Chapter 2, Project Description – summarizes the SLCP Strategy, implementation assumptions, and range of reasonably foreseeable compliance responses expected in response to implementation of the measures in the SLCP Strategy.

Chapter 3, Environmental and Regulatory Setting, in combination with Attachment A – contains the environmental setting and regulatory framework relevant to the environmental analysis of the SLCP Strategy.

Chapter 4, Impact Analysis and Mitigation – identifies the potentially significant environmental impacts associated with the SLCP Strategy and mitigation measures for each resource area with potentially significant impacts identified.

Chapter 5, Cumulative and Growth-Inducing Impacts – identifies the cumulative impacts of implementing the SLCP Strategy against a backdrop of past, present, and reasonably foreseeable future projects.

Chapter 6, Mandatory Findings of Significance – discusses whether the SLCP Strategy has the potential to degrade the quality of the environment, cause substantial adverse impacts on human beings, and cause cumulatively considerable environmental impacts.

Chapter 7, Alternatives Analysis – discusses a reasonable range of potentially feasible alternatives that could reduce or eliminate significant adverse environmental impacts identified for the SLCP Strategy.

Chapter 8, References – identifies sources of information used in this Revised Draft EA.

E. Public Review Process for the Environmental Analysis

At a public workshop held on May 27, 2015, ARB staff invited public feedback on a Concept Paper on SLCP reductions. After consideration of comments, ARB released the Draft Strategy for public comment on September 30, 2015. A notice of Preparation (NOP) was sent out on October 6, 2015 with the review period ending on November 5, 2015. No comments on the development of the Draft EA were received during this review period. At three regional public workshops held on October 13, 14, and 19, 2015, ARB described plans to prepare a Draft EA for the SLCP Strategy, and invited public feedback on the scope of the analysis.

The first SLCP Strategy and Draft EA were released for a 45-day public comment period on April 11, 2016, which ended on May 26, 2016. During that public comment period, ARB held public workshops on April 26 and May 3, 2016, and a Board hearing on May 19, 2016. In response to the Governor signing SB 1383, in September 2016, ARB revised the SLCP Strategy to reflect the requirements of SB 1383. In response to these changes to the SLCP Strategy, ARB revised the Draft EA, which is being recirculated for a new 45-Day public review period. (Cal. Code Regs., tit.14, § 15088.5.)

In accordance with ARB's certified regulatory program, and consistent with ARB's commitment to public review and input on its proposed actions, this Revised Draft EA is subject to a public review process through the posting of the SLCP Strategy and this Revised Draft EA for a public review period that begins on November 28, 2016 and ends on January 17, 2016. ARB is also holding public workshops in December 2016.

At the conclusion of the public review period, ARB will prepare written responses to comments received on the Revised Draft EA and make revisions, as necessary, for the

Final EA. As outlined in the CEQA recirculation requirements, ARB will not respond to comments submitted on the Draft EA released April 11, 2016 and will respond in writing only to comments submitted on the recirculated Revised Draft EA. (Cal. Code Regs., tit.14, § 15088.5, subd. (f).) Comments submitted on the Draft EA released in April 2016 will remain part of the record. The Final EA and the written responses to comments of the Revised Draft EA will be presented to the Board at a public hearing to be scheduled for early 2017. If the SLCP Strategy is approved by the Board, a Notice of Decision will be posted on ARB's website and filed with the Secretary for Natural Resources. (Cal. Code Regs., tit. 17, § 60007, subd. (b).) The Notice of Decision will also be filed with the State Clearinghouse.

2.0 PROJECT DESCRIPTION

This section provides a summary of the Proposed Short-Lived Climate Pollutant Reduction Strategy (SLCP Strategy) and the proposed measures for purposes of the impacts analysis. Please refer to Chapters IV, V and VI of the SLCP Strategy for full descriptions.

A. Overview of the Proposed Short-Lived Climate Pollution Reduction Strategy and Scope of the "Project" under CEQA

Short-lived climate pollutants (SLCPs) include methane, black carbon, and hydrofluorocarbons (HFCs). They are powerful greenhouse gases (GHGs) that remain in the atmosphere for a much shorter period of time than longer-lived climate pollutants, such as carbon dioxide (CO_2) and nitrous oxide (N_2O). Despite their relatively shorter atmospheric lifespan, their relative potency in terms of how they heat the atmosphere (i.e., global warming potential [GWP]) can be tens, hundreds, or even thousands of times greater than that of CO_2.

California has some of the nation's highest levels of particulate matter (PM) and ozone pollution, and much of the State will need to virtually eliminate black carbon emissions and other pollutants to meet health-based federal air quality standards over the next 20 years. California has already taken steps to reduce methane emissions from the agricultural, oil and gas, and waste treatment sectors. HFCs are the fastest growing source of GHG emissions in California and globally, and must be further controlled to keep the State on track to meet its 2020 and 2050 GHG limits. California previously developed an inventory of HFCs, and has rules in place to cut their emissions by 25 percent below business-as-usual emissions levels by 2020. Black carbon emissions have already declined substantially in California in response to existing health-based regulations, but additional steps are needed to meet federal air quality standards and protect public health.

B. Project Objectives

The primary objectives of the SLCP Strategy are listed below. These objectives are derived from the SLCP concepts in the 2014 Scoping Plan Update, developed under Assembly Bill (AB) 32 (Health & Saf. Code, § 38561), and from the requirements of Senate Bill (SB) 605 and SB 1383 which require the California Air Resources Board (ARB or Board) to adopt and implement the SLCP Strategy.

The scope of the SLCP Strategy includes actions to reduce emissions from major sources of methane, black carbon, and HFCs. The major administrative and program implementation objectives of the SLCP Strategy include the following:

1. Complete an inventory of sources and emissions of SLCPs in the State based on available data;
2. Identify research needs to address any data gaps;

3. Identify and implement existing and potential new control measures to reduce emissions of methane and hydrofluorocarbon gases by 40 percent and anthropogenic black carbon by 50 percent below 2013 levels by 2030 and;
4. Coordinate with other state agencies and districts to develop measures identified as part of the SLCP Strategy.
5. Provide consultation to California's Department of Resources Recycling and Recovery (CalRecycle) during the development of regulations to reduce the level of the statewide disposal of organic waste by 50 percent by 2020 and 75 percent by 2025. These regulations:
   - May require local jurisdictions to impose requirements on generators and authorize jurisdictions to impose penalties on generators for noncompliance;
   - Shall include requirements intended to meet the goal that not less than 20 percent of edible food that is currently disposed of is recovered for human consumption by 2025;
   - Shall not establish numerical organic waste limits on individual landfills;
   - May include different levels of requirements for local jurisdictions and phased timelines based upon their progress in meeting the organic waste reduction goals for 2020 and 2025; and
   - May include penalties imposed by CalRecycle for noncompliance;
   - Shall take effect on or after January 1, 2022;
6. Provide consultation to CalRecycle to evaluate progress towards meeting the 2020 and 2025 organics waste reduction goals by July 1, 2020. This analysis will evaluate:
   - The status of new organics infrastructure development;
   - The status of efforts to reduce regulatory barriers to the siting of organics recycling facilities;
   - The effectiveness of policies aimed at facilitating the permitting of organics recycling infrastructure; and
   - The status of markets for products generated by organics recycling facilities.
7. ARB, in consultation with California Department of Food and Agriculture (CDFA), develop and adopt regulations to reduce methane emissions from livestock manure management operations and dairy manure management operations consistent with an up to 40 percent reduction in the dairy sector's and livestock sector's 2013 sector-wide levels by 2030 on or after January 1, 2024. In considering adoption of these regulations, ARB must determine:
   - The regulations are technologically feasible.
   - The regulations are economically feasible considering milk and live cattle prices and the commitment of state, federal, and private funding, among other things, and that markets exist for the products generated by dairy manure management and

livestock manure management methane emissions reduction projects, including composting, biomethane, and other products. The analysis shall include consideration of both of the following:

- o Electrical interconnection of onsite electrical generation facilities using biomethane;
- o Access to common carrier pipelines available for the injection of digester biomethane;
- o The regulations are cost effective;
- o The regulations include provisions to minimize and mitigate potential leakage to other states or countries, as appropriate;
- o And the regulations include an evaluation of the achievements made by incentive-based programs.

8. Prior to implementing a regulation to reduce methane emissions from livestock and dairy manure management operations, ARB publish a report on the ARB website evaluating progress toward eliminating barriers, engaging stakeholders, considering and conducting research, and considering development and adoption of additional methane reduction protocols;
9. ARB, in consultation with California Public Utilities Commission (CPUC) and California Energy Commission (CEC), develop policies to encourage development of infrastructure and biomethane projects at dairy and livestock operations;
10. ARB develop a pilot financial mechanism to reduce Low Carbon Fuel Standard (LCFS) credit value uncertainty from dairy-related projects and make recommendation to the Legislature to expand the mechanism to other biogas sources;
11. ARB provide guidance on the impact of regulations on LCFS credits and compliance offsets;
12. CPUC, in consultation with ARB and CDFA, direct utilities to develop at least 5 dairy biomethane pipeline injection projects;
13. ARB, in consultation with CDFA, analyze and report on the methane reduction progress of the dairy and livestock sector;
14. ARB, in consultation with CDFA, evaluate the feasibility of achieving enteric methane reduction through incentive-based mechanisms and develop regulation if it determines is cost-effective, considers impact to animal productivity, is scientifically proven, and would not damage animal health, public health, or consumer acceptance.
15. Incorporate and prioritize, as appropriate, measures for SLCPs that offer the following co-benefits: improving water quality or reducing other air pollutants to reduce effects on community health and provide benefits to disadvantaged communities, as identified in Health and Safety Code Section 39711, job growth and local economic benefits in the state; public health benefits; potential for new innovation in technology, energy, and resource management practices; and

16. Evaluate the best-available scientific, technological, and economic information to ensure the strategy is cost effective and technologically feasible.

C. Description of Recommended Actions

The following section summarizes the recommended actions and the reasonably foreseeable compliance responses resulting from implementation of the recommended actions for each of the major SLCPs discussed in the SLCP Strategy: methane, non-forest sources of black carbon, and HFCs. The anticipated compliance responses to various measures discussed in this section focus on those activities with the potential to result in either a direct or indirect physical change in the environment. These include construction activities, infrastructure and equipment installations, and substantial operational changes to facilities. Some potential compliance responses are activities that would not result in environmental effects (e.g., convening a research panel). Such activities are noted in the discussion.

1. Black Carbon

Airborne PM varies in its composition, substantially affects human health, and is a major influence on the climate system. PM is emitted from a variety of natural processes and human activities, and tends to remain in the air for only a few days to about a week, resulting in extreme spatial and temporal variability. Among different types of particles, carbonaceous particles (those that contain organic and black carbon) are particularly important because of their abundance in the atmosphere. With respect to climate impact, black carbon is the principal absorber of visible solar radiation in the atmosphere while organic carbo is often described as a light-reflecting compound.

Black carbon is emitted from burning fuels such as coal, diesel, and biomass, as well as from various forms of non-fuel biomass combustion (destruction of excess woody wastes, wildfires, etc.). Black carbon contributes to climate change both directly by absorbing sunlight and indirectly by depositing on snow and by interacting with clouds and affecting cloud formation. In addition to its climate and health impacts, black carbon disrupts cloud formation, precipitation patterns, water storage in snowpack and glaciers, and agricultural productivity.

California's program to reduce emissions from transportation sources of black carbon can serve as a blueprint for other jurisdictions seeking to address both the climate change and public health impacts of mobile sources, particularly diesel engines. Over the last few decades, ARB has employed a variety of strategies that has drastically reduced black carbon emissions from mobile sources, including lower emission standards, clean fuel requirements, in-use rules, incentives, and investments in research and new technology. Diesel particulate filters have been instrumental in reducing black carbon in on-road and major portions of the off-road sector. Today's diesel particulate filter-equipped trucks are more than 99 percent cleaner than those manufactured in 1990. Measures have also been implemented on the State and local level to reduce PM, and thus black carbon, emissions from non-mobile sources, including residential burning, commercial cooking, and agricultural burning. Existing measures are projected to cut mobile source emissions by 75 percent and total anthropogenic emissions by nearly 60 percent between 2000 and 2020.

Additional measures under ARB's State Implementation Plan Strategy, Mobile Source Strategy, and the 2030 Target Scoping Plan Update that target GHG and PM reductions will also indirectly reduce black carbon emissions from these sources. In addition, the Sustainable Freight Action Plan, a multi-agency effort to deploy a sustainable and efficient system for goods movements, provides guidance to improve system efficiencies with the co-benefit of reducing black carbon emissions.

Wildfire is the largest source of black carbon in California. Prescribed fires also emit black carbon, but are an important tool for forest managers. However, since the legislative direction and intent of SB 1383 is to include only non-forest sources of black carbon in the target, a target for forest-derived black carbon emission reductions is not included in the SLCP Strategy. Therefore, the Revised Draft EA analyzes only anthropogenic non-forest sources of black carbon emissions (residential fireplaces and woodstoves).

a) Residential Fireplaces and Woodstoves

If no new programs are implemented, residential wood combustion is forecasted to be the largest individual anthropogenic source of black carbon in 2030, accounting for a quarter of anthropogenic black carbon emissions. Reducing 2030 residential wood combustion black carbon emissions by half (3 million metric tons of carbon dioxide equivalent [$MMTCO_2e$]) would set California on a path toward meeting the 2030 target in the SLCP Strategy.

Removal of old fireplaces and woodstoves and replacement with EPA-Certified wood-burning devices, electric heaters, or gas fireplaces can provide long lasting reductions in emissions of black carbon, criteria pollutants, and air toxics in residential neighborhoods. Conversion to electric heating or gas fireplaces provides more certain emission reductions than conversion to certified wood-burning devices. While certified wood-burning devices reduce fine particulate emissions, certification values may not correlate well with in-home performance of wood heaters,[1] and emission reductions are not as large as for non-wood technologies. Electric heating or gas devices (including central HVAC) ensure local reductions of particulate matter, black carbon and air toxics. To protect public health and use incentive dollars efficiently, non-wood burning devices should be prioritized where possible. If wood burning devices are used, they should be the cleanest available technologies, currently those adhering to the 2020 EPA emission standard. Some areas may require the use of wood burning equipment for safety, especially areas that experience heavy snow which traps residents in homes, and

[1] U.S. EPA (2016). Process for developing improved cordwood test methods for wood heaters. https://www.epa.gov/burnwise/process-developing-improved-cordwood-test-methods-wood-heaters

where distributed natural gas is not available or electricity loss is frequent. Additionally, natural gas, propane, or electricity may cost more than wood in some regions, placing an additional financial burden on homeowners.

a. Measure Summary

ARB is proposing to work with local air districts to determine the most effective approach to reduce residential wood combustion emissions in California. This could include incentives to replace old polluting devices with the cleanest available technology and encourage the installation of non-wood burning centralized heating in new construction. In areas where this is not an option, the cleanest available burning technology could be required.

Education and outreach are important tools to reduce emissions from residential wood combustion. Education on proper burn practices may reduce emissions when wood is used, and is essential to achieve full emission reductions from U.S. EPA-certified wood burning devices. Some districts have already implemented education programs, which should be expanded to all parts of the State as part of this measure.

b. Potential Compliance Responses

Implementation of this measure would likely increase the replacement of fireplaces and woodstoves with U.S. EPA-certified devices, gas fireplaces, electric heaters, or gas heaters. This measure could also include encouraging the installation of non-wood burning centralized heating in new construction. It is anticipated that the increased demand for U.S. EPA-certified woodstoves would be met by existing manufacturing facilities that already have increased production of this equipment due to U.S. EPA's new amendments to the New Source Performance Standard for new residential woodstoves. The increase in demand for gas fireplaces, electric heaters, and gas heaters is expected to be met by existing global production of this equipment as the increased demand caused by the measure would not be significant enough on a global scale to lead to the construction or operation of new manufacturing facilities for this equipment.

Implementation of this measure also has the potential to increase the rate at which old stoves are recycled or destroyed, which is expected to occur at existing facilities and not lead to any new facilities. Because this measure encourages the use of gas fireplaces and electric heaters, there may also be a decrease in the demand for wood-based fuel for residential uses and a reduction in the amount of wood collected in forests for personal and commercial uses. However, this decrease would not be substantial and would not be expected to change forest residue management strategies.

2. Methane

Methane is emitted from a wide range of fugitive sources and biological processes, and is the second largest component of global GHG emissions. Methane emissions are growing globally as a result of human activities related to agriculture, waste handling and treatment, and oil and gas production. Agriculture represents the largest methane source in California, accounting for nearly 60 percent of methane emissions. Landfills are the next largest source of methane, accounting for a fifth of statewide methane emissions. Pipeline leaks, oil and gas extraction, wastewater, and other industrial and miscellaneous sources comprise the remainder of emissions. As California relies on natural gas for a large fraction of its energy supply, it is critical to increase supplies of renewable natural gas and minimize fugitive emissions of methane from natural gas infrastructure.

To reduce methane emissions, the SLCP Strategy contains methane reduction measures and identifies research needs and information gaps to be addressed. Among these areas to be addressed are: landfills; wastewater treatment plants; and oil and gas production, processing, storage and distribution. Additionally, SB 1383 requires ARB to "conduct or consider livestock and dairy operation research on dairy methane emissions reduction projects, including, but not limited to, scrape manure management systems, solids separation systems, and enteric fermentation."

a) Dairy Manure and Livestock Enteric Fermentation

California's dairy and livestock industries account for more than half of the State's total methane emissions and for about five percent of the State's overall GHG inventory based on 100-year GWPs. Twenty-five percent of the State's methane emissions come from manure management practices at dairies, primarily from lagoon storage of flushed manure from the State's milking cows. Nearly 20 percent of the State's methane emissions come from enteric fermentation (mostly belching) of dairy cows, and another ten percent comes from enteric fermentation of non-dairy livestock (primarily other cattle).

California is legislatively mandated to reduce methane emissions from the dairy and livestock sector by up to 40 percent of 2013 sector-wide levels by 2030 through manure methane controls. California must also explore additional pathways to achieve feasible reductions in enteric fermentation. Through the SLCP Strategy and related efforts, the State can effectively reduce methane emissions from the State's largest source. These targets can be achieved by capturing or avoiding methane currently emitted from lagoons or other anaerobically stored manure at less than half of the State's approximately 1,400 dairies.

Methane is also produced by the microorganisms involved in the digestive processes in the stomachs of dairy cows and other ruminants, such as sheep, goats, buffalo and cattle. This process is referred to as enteric fermentation. These emissions account for approximately 30 percent of California's methane inventory, making it important to explore strategies to reduce emissions from these sources to meet the State's 40 percent economy-wide methane emission reduction target.

Strategies that have been investigated to reduce enteric fermentation include increasing production efficiencies to reduce the amount of methane produced for a given amount of product, breeding animals for lower methane production, gut microbial interventions, and changes to nutrition and animal management.

The Legislature recognized the important role of enteric fermentation emission reductions in meeting the goals in SB 1383 by requiring consideration of enteric fermentation research, allowing voluntary reductions to be considered in the design of dairy and livestock emission reduction measures, and by providing that these reductions count towards economy wide methane emission reductions targets. It also recognized the limited available information and potential impacts associated with achieving enteric fermentation emission reductions, allowing only incentive-based approaches to these reductions until ARB, in consultation with CDFA, determines that cost-effective and scientifically validated methods for reducing enteric emissions are available. In addition, adoption of an enteric emission reduction method must not compromise animal health, public health, or consumer acceptance of dairy products.

a. Measure Summary

The State will encourage and support research and near-term actions by dairies to reduce emissions through market support and financial incentives. Initially, as the recently appropriated $50 million in Cap-and-Trade funds become available, the State will incorporate lessons learned from previous incentive programs to improve the effectiveness and efficiency of new incentives, while overcoming persistent barriers and challenges. At the same time, ARB will initiate a rulemaking process, pursuant to SB 1383, to develop regulations for reducing dairy and livestock manure emissions in California. The process will begin by considering research on manure management practices and by developing reporting and recordkeeping regulations to improve California-specific data and ARB's GHG emission inventory. This information will shape the emission control regulations developed pursuant to the SLCP Strategy, along with information obtained through other collaborative efforts. This coordinated approach will aim to develop a competitive, low-carbon dairy industry in California and avoid emissions leakage.

Specifically, California will take the following steps to significantly cut methane emissions from manure management at dairies:

(a) Accelerate Early Project Development Through Incentives and Market Development

As provided under SB 1383, the State will support efforts to accelerate project development and help the industry reduce emissions before regulatory requirements take effect. In particular, the State will work to support improved manure management practices through financial incentives, collaboration to overcome barriers, and other market support.

ARB, CDFA, State Water Resources Control Board, and Regional Water Quality Boards' staff will establish a working group with other relevant agencies and stakeholders to focus specifically on developing measures to overcome the barriers that have constrained dairy manure projects in the past. The group will aim to monitor, ensure, and accelerate market and institutional progress and report its findings to the Legislature. It may cover several topics, including: project finance, permit coordination, California Environmental Quality Act (CEQA), feed-in tariffs, simplified interconnection procedures and contracts, credits under the Low Carbon Fuel Standard (LCFS), increasing the market value of manure products, and uniform biomethane pipeline standards. This group will be coordinated with similar working group efforts related to anaerobic digestion, composting, energy, healthy soils, and water. Additionally, State agencies will coordinate activities with federal agencies, including the U.S. Department of Agriculture and U.S. Department of Energy, to align common efforts and attract federal investment to California. Further, ARB will work with State and regional water quality agencies to capitalize on opportunities for joint development of measures that conserve water and improve water quality. Similarly, ARB will work with the air districts to ensure opportunities for air quality efforts are developed jointly.

CalRecycle, CDFA, and other agencies are working together to support healthy soils through composting and building markets for soil amendment products in the State. Enabling pipeline injection of biomethane and minimizing associated costs would contribute to use of dairy biogas in the transportation sector and allow for the generation of LCFS and Renewable Identification Number (RIN) credits, which could provide a valuable revenue stream. The state will continue to support these efforts.

(b) Research the Reduction Potential of Manure Management Practices

While the need and potential to reduce methane emissions from dairy manure is clear, some potentially effective strategies are still in the development stage. SB 1383 directs the agencies to consider research about the emissions-reduction potential of solids separation, enteric fermentation, and conversion of flush systems to solid manure management systems. ARB and CDFA will continue to support research to eliminate information gaps and improve understanding of potential manure management practices and their associated methane reduction benefits, as well as potential air quality or water quality impacts.

(c) Develop Regulations to Ensure Emission Reductions

In coordination with CDFA and local air quality and water quality agencies, ARB will initiate a rulemaking process to reduce manure methane emissions from the dairy sector consistent with the objectives in this SLCP Strategy. As noted earlier, the rulemaking process will involve extensive stakeholder engagement and consideration of multiple factors. The regulations are to be implemented on or after January 1, 2024. Pursuant to SB 1383, ARB, in consultation with CDFA, will analyze the progress dairies are making in achieving the goals in the Strategy by July 1, 2020, and may make adjustments to those goals if sufficient progress has not been made.

The rulemaking process will first focus on developing measures to require regulated parties to both report and maintain records covering the parameters that affect GHG emissions at California dairies and other livestock operations. Reported information will be used to refine inventory quantification, evaluate policy effectiveness, assess methane reduction progress, and aid in future policy planning and regulatory development. ARB will work with other State agencies and industry groups to improve outreach on new reporting requirements, as well as merge reporting activities with current forms and requirements to avoid duplicative reporting wherever feasible.

During this period, ARB will continue to encourage emission reductions, and work to remove barriers to the development of emissions control projects, as the statute directs. As ARB reviews the information it gathers, and the progress which the industry makes in response to these activities, it would begin the regulatory process required by SB 1383. The regulatory process will include consideration of available financial incentives, market support, progress made to date, and the potential for emissions leakage, as well as other considerations outlined in section 39730.7 (b) of SB 1383, in identifying appropriate timelines and requirements for the sector. ARB will calibrate the reductions that must be required by regulation to meet SB 1383's target in part on the basis of progress made on voluntary reductions.

(d) Research Mitigation Strategies for Enteric Fermentation

Federal and State agencies, industry, and academia will collaborate on research and demonstration projects through available funding mechanisms (e.g. ARB's annual research solicitation program and CDFA's Dairy Digester Research and Development Program). Progress will continue to be monitored to develop strategies that can help to reduce enteric fermentation emissions from dairy cows and livestock in the California context.

b. Potential Compliance Responses

Below is a summary of the construction, equipment and infrastructure installations, and operational activities that could affect some of California's 1,400 existing dairies, and the development and operational characteristics of any new dairies developed in California as a result of implementation of the measures described above. Chapter VIII and Appendix D of the SLCP Strategy provides a more detailed discussion of the types of actions that could occur at dairies in the State.

It is important to emphasize that SB 1383 includes an extensive set of regulatory considerations for ARB in developing regulations for this sector, which are intended to support cost-effective regulations, minimize leakage to other states, ensure technological feasibility, and support related goals. These requirements will, along with other regulatory considerations, shape ARB's program design in ways that favor economically and environmentally beneficial projects since ARB is required to design its program in ways that are consistent with SB 1383 and other laws, which mandate careful consideration of economic and environmental impacts. Nonetheless, the potential compliance responses described here are conservative in that they consider the range of potential actions that could occur.

Some of the State's existing dairies may convert flush-water lagoon manure management systems, which are currently used at most dairies, to solid manure management systems. This conversion to solid manure management systems would potentially involve construction activities related to installing scrape systems or using equipment such as manure vacuums, storage silos and tanks, manure drying pads, and related manure handling equipment and storage facilities. Solid scrape or vacuum manure management could use on-site, above ground tank or plug-flow, anaerobic digestion systems to produce renewable natural gas (RNG) that would meet utility pipeline injection or vehicle fueling standards. The installation of anaerobic digesters would result in the installation and operation of a variety of industrial-type equipment and infrastructure at dairies. This may include electricity generation equipment, biogas storage tanks, compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations.

Alternatively, dairy operators may install anaerobic digestion systems to capture and utilize manure methane on site. Collected manure could also be transported to centralized digesters, transported via a dedicated pipelines to a centralized cleanup and pipeline injection facility and potentially co-digested with other feedstocks (such as food waste) for increased fuel production. This would be feasible at large dairies in close proximity to one another that collectively could connect to a natural gas pipeline at lower cost than could occur individually. Implementation of digesters and associated equipment could provide small- scale electricity production, distributing biogas via pipeline, and providing fuel for on- or off-site vehicle fleets

In some instances, converting dairies to pasture-based systems, in which manure is left in the field to decompose aerobically (as opposed to anaerobically in a lagoon), may be a viable option to avoid methane production. Conversion of diary operations to pasture-based management may require new irrigation facilities, fencing, and structures to support animal husbandry (e.g., to provide shelter). Additionally hybrid models that employ aspects of both pasture and conventional systems should also be investigated for their potential benefits and impacts for dairy and livestock operations.

The proposed dairy regulatory measure may also affect ARB's approved compliance offset protocol for livestock methane control. Under that protocol, certain agricultural methane capture and destruction projects may generate offsets for compliance with ARB's Cap-and-Trade Regulation (ARB 2014). The protocol is designed to secure additional reductions beyond those that would occur under business-as-usual activities (ARB 2014; Cal. Code Regs., tit.17 § 95802, subd. (a)(4), § 95973, subd. (a)(2)). ARB anticipates that if the emission control regulation proposed in the Strategy was adopted, ARB would likely no longer accept new projects for offset credits after the effective date of the regulation regardless of whether the projects are in California. If this occurred, existing projects would be able to continue generating offsets for ten years from the date they began reporting to ARB for offset purposes (ARB 2014; Cal. Code Regs., tit.17, § 95802 (a)(87)). ARB anticipates that the ten-year crediting period available to offset projects would allow existing projects (as of the effective date of the regulation identified in the SLCP Strategy) to continue capturing the funding stream from the offset protocol for a long enough period to support operations, smoothing the transition into a regulatory regime. [2]

Similarly, the number of LCFS credits would decline after adoption of an emission control regulation. Credits for avoided methane emissions under the LCFS would not be available for new projects as the reductions would not be additional to the regulation or business-as-usual. However, projects in place before the regulation takes effect would still be able to generate credits for avoided methane emissions for their current crediting period, which is ten years of operation. For new projects after a regulation takes effect, credits under the LCFS would still be available, but would only consider the displacement of petroleum fuel. Sufficient lead time would be provided before regulatory requirements take effect to allow the market to react.

ARB will issue guidance on the impact of regulations on credits generated under the LCFS and Cap-and-Trade programs by January 1, 2018 as per the requirements of SB 1383 (Health & Saf. Code, § 39730.7, subd. (e)). In designing this guidance, ARB will ensure that projects developed before the implementation of emission control regulations will receive credit for at least 10 years.

The SLCP Strategy supports substantial incentives to support new and existing projects. Accordingly, ARB believes that few, if any, of the projects supported in part by the compliance offset protocol or LCFS credits would cease operating as of the effective date of the regulation. After the crediting period for a particular project passes (as much as ten years after 2024), operational changes may occur for some projects, while others may continue to operate. It is difficult to predict the regulatory and economic context for all projects with certainty. However, in jurisdictions (including California) that emphasize regulatory and incentive paths for the industry, the measures proposed here would likely support continued operation as regulatory requirements replace incentive financing and offset financing.

For these reasons, and the advent of foreseeable regulatory and incentive measures, ARB does not expect that the methane control measures would, at the end of the offset crediting periods generate reasonably foreseeable significant shifts in the compliance responses at projects now being driven by ARB's market programs and livestock methane compliance offset protocol.

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[2] Moving towards regulation where possible, rather than continued use of compliance offset protocols, is a long-standing ARB policy. As explained in the 2014 First Scoping Plan Update, "California has a history of identifying and regulating emissions when it is feasible and cost-effective," *id.* at 86, but will continue to explore other possible offset protocols and liquidity mechanisms to the extent regulations supplant existing protocols, thereby limiting any effects on the larger market. As explained in the 2010 Final Statement of Reasons for the Cap-and-Trade Regulation (*see, e.g.*, Response to Comment M- 127), ARB would "reevaluate and readjust project baseline and additionality requirements in the future if the regulatory environment changes, and if we determine that offset projects are no longer additional." *See also* ARB, California Air Resources Board's Process for the Review and Approval of Compliance Offset Protocols in Support of the Cap-and-Trade Regulation (2013) at 7-8 (discussing additionality).

b) Landfills

Landfilling of organic materials leads to the anaerobic breakdown of these materials into methane, at least some of which works its way into the atmosphere, becoming a fugitive emission. Organic waste constitutes more than 40 percent of California's waste stream, and as with dairy manure, a holistic approach is needed to effectively divert and manage it. This means not only keeping organics out of landfills, either through source reduction or recycling, but also improving the infrastructure for diverting and/or recycling organics, including minimizing and rescuing edible food wastes, composting, anaerobic digestion and other novel processes for energy recovery.

In particular, California must have enough in-state composting and in-vessel digestion, or other organics processing and recycling capacity, to maximize the benefits from the waste stream and effectively minimize the spreading of unprocessed organic waste on open lands. It also means having markets for this material that are robust and resilient, whether as food rescue/recovery, compost, soil amendments, mulch for erosion control, transportation fuels, energy, or other uses. The State can accelerate progress by providing more consistent financial and institutional support for these efforts, and taking steps to align tipping fees, financial incentives, and cross-media regulatory structures in the sector with its organics diversion goals.

a. Measure Summary

The State has already established its intent to phase out the disposal of organics from landfills. Existing law sets a goal to reduce, recycle, or compost 75 percent of solid waste by 2020 and provides other measures and requirements to support diverting organics from landfills. California will build on that intent and progress, with market and institutional support, and reduce disposal of organics by 50 percent of 2014 levels by 2020 and 75 percent by 2025.

Waste-in-place will continue to emit methane for decades to come. California has the Landfill Methane Control Regulation in place that requires owners and operators of certain uncontrolled municipal solid waste landfills to install gas collection and control systems (Cal. Code Regs, tit. 17, § 95460 to 95476). This effort has improved management of landfills in California and reduced methane emissions. There may be additional opportunities to employ best practices and further reduce methane emissions from landfills over time. Accordingly, the State will take the following actions to reduce methane emissions from landfills in California.

(a) Require Organics Diversion from Landfills

CalRecycle, in consultation with ARB, will develop regulations to reduce disposal of organic waste by 50 percent of 2014 levels by 2020 and 75 percent by 2025, as required by SB 1383. These regulations shall take effect on or after January 1, 2022. Of the edible food in the organic waste stream, not less than 20 percent is to be recovered to feed people in need by 2025. This goal could be met through waste prevention and local food rescue programs, which may be independent of or through partnership with haulers and jurisdictions.

Material that cannot be effectively recovered would be diverted to organics recycling facilities, including wastewater treatment plants, to make useful products, including compost, fuel, or energy. These facilities may be developed at existing landfills, other waste management sites, or at new stand-alone sites. Some organic wastes could also be diverted to regional waste water treatment plants or dairies that have excess capacity for co-digestion. Local governments must play an important role in diverting organics both as land use and permitting authorities for recycling facilities and as partners in implementing SB1383 and other statutory requirements. The State will work with its local partners to explore development of helpful tools such as programmatic Environmental Impact Reports (EIRs) or guidance documents. Community engagement, outreach and engagement in the planning and environmental review processes are critical, both for understanding and mitigating potential negative health and environmental impacts and for understanding the positive economic and health and environmental benefits afforded by such projects.

(b) Align Financial Incentives with Organics Diversion

Eliminating organics disposal in landfills will require additional infrastructure capacity to process and reuse diverted organic waste destined for landfills through composting (including chipping and grinding), anaerobic digestion, or other methods. Continued, increased State funding will be critical to building this necessary infrastructure. An increase in California’s Integrated Waste Management Fee is also needed to support the establishment of food rescue programs, discourage the landfilling of organic waste and other recyclables, and provide funding to support organics recycling infrastructure and markets.

CalRecycle estimates that State support of at least $100 million per year for five years, in the form of grants, loans, or incentive payments, will be needed to leverage private sector financing and local rate structure changes to support the development of necessary organic infrastructure and help to foster markets. However, as disposal in landfills decreases per the goals of this SLCP Strategy, so too would the funding from the Integrate Waste Management Fee. One option for stabilizing funding would be to establish a charge for waste generation, decoupling funding from landfill disposal.

(c) Collaborate to Overcome Barriers

State agencies, including the AB 1045 working group and the Interagency Waste Working Group are currently collaborating to evaluate and resolve existing constraints in the planning, siting, and permitting process to provide clear standards and compliance pathways for all public health and environmental goals and to quantify co-benefits. Also, appropriate standards should be developed to guide the direct application of organic materials on land and ensure this activity does not pose a threat to human or environmental health.

(d) Foster Recovery Programs and Markets

CalRecycle will work collaboratively with other agencies and departments to help establish food rescue programs and to identify, develop, and expand markets for the use of compost, mulch, and renewable fuels and energy. CalRecycle and CDFA will continue their efforts to incentivize the use of compost on agricultural lands in support of the Healthy Soils Initiative, including developing best management practices for agricultural use.

(e) Improve Understanding of Landfill Emissions

ARB and CalRecycle are currently pursuing research opportunities to improve understanding of emissions from California landfills and landfill gas collection efficiencies and will support research to identify opportunities to further reduce emissions from existing waste-in-place. ARB will consider the latest science and whether adjustments to emissions accounting in the inventory or other programs is warranted. Based on this information, ARB, in collaboration with CalRecycle, may consider additional actions to further reduce and capture methane emissions from landfills in the future.

(f) Evaluate Progress towards Organic Diversion Goals

To evaluate progress towards meeting the 2020 and 2025 organics waste reduction goals, CalRecycle, in consultation with ARB, will complete a detailed analysis by July 1, 2020. This analysis will evaluate:

- The status of new organics infrastructure development;
- The status of efforts to reduce regulatory barriers to the siting of organics recycling facilities;
- The effectiveness of policies aimed at facilitating the permitting of organics recycling infrastructure; and
- The status of markets for products generated by organics recycling facilities.

The analysis may result in making additional requirements and/or incentives in the regulations.

b. Potential Compliance Responses

It is anticipated that this measure would result in the development of up to 100 new or expanded organic material composting and/or digesting facilities throughout the State. It is anticipated that new facilities would be sited near or at existing waste disposal sites or landfills. Much of the material diverted to these facilities, typically by truck transport, would consist of yard or green wastes, but may also include other regional sources of organic wastes such as food or agricultural produce.

Not all California communities currently participate in source-separated green waste or organic waste collection programs. Therefore, achieving the goals of this measure would potentially expand waste collection services in certain communities and increase the number of operating waste collection trucks and trips.

Most of the organic material diverted to new or existing composting facilities would be expected to be converted to compost. The typical kinds of equipment that would be installed and operated at compost facilities include tractors, compost turners, and grinders. Composted material would potentially be transported from composting facilities and spread on open space lands, particularly agricultural land, as a soil amendment.

It’s anticipated that several of these compost facilities could also develop or install anaerobic digesters, which capture the methane from stored organic waste and convert it to biogas. The captured biogas could potentially be used for on or off-site electricity generation, or cleaned and compressed for use as a natural gas pipeline supplement or as a vehicle fuel. The installation of anaerobic digesters would result in the installation and operation of a variety of industrial-type equipment and infrastructure at composting facilities (which potentially may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations). The installation and operation of such equipment and infrastructure would create a multi-purpose operation and function for new or existing compost facilities.

This measure also includes continued research and regulatory efforts towards implementing “best management practices” to further control and capture methane emissions from landfills. These practices could include upgrading landfill gas collection systems, improved post-closure maintenance, improved monitoring, and phased closure. These types of actions would require some modifications to existing or future facilities and would occur within boundaries of the associated landfills.

This proposed operational support for “food rescue” programs, could potentially involve the development of new, or reuse of existing, buildings or warehouses to support the collection, storage and distribution of edible food stock, via truck transport.

c) Wastewater Treatment Plants

Wastewater treatment plants provide a promising complementary opportunity to help divert a portion of organic wastes from landfills and create useful byproducts such as electricity, biofuels, fertilizers, and soil amendments. Wastewater treatment plants are designed to remove contaminants from wastewater, primarily from household sewage, but with infrastructure improvements could increase acceptance of food waste and fats, oils, and grease (FOG) for co-digestion. Anaerobic digestion is a typical part of the wastewater treatment process employed at most of the larger plants, with many plants capturing the methane they currently generate for on-site heating or electricity needs.

Many of these plants may have spare capacity, and can potentially take in additional sources of organic waste for anaerobic digestion. Existing or new digesters at these facilities could be designed to co-digest materials such as food waste and FOG from residential, commercial, or industrial facilities. Many of the largest plants are ideally located close to population centers and could potentially obtain and process significant amounts of food and other suitable waste streams within the region. The State proposes to take the following actions to realize this opportunity.

a. Measure Summary

(a) Develop Regional Opportunities to Co-Digest Waste

ARB will work with CalRecycle, the State Water Resources Control Board, Regional Water Quality Control Boards (RWQCBs), and others to determine opportunities to support the co-digestion of food- related waste streams at existing and new digester facilities, including wastewater treatment plants.

(b) Align Financial Incentives with Methane Capture and Reuse at Wastewater Treatment Facilities

A program that relies on financial incentives and/or regulatory actions could be implemented to ensure that new and existing wastewater treatment plants in California fully implement methane capture systems (ideally to produce on-site renewable electricity, transportation fuel, or pipeline biogas), and maximize digestion of regional organic materials. The Water Boards could develop permit terms and other regulatory tools to support the program while achieving water supply, water quality, and related co- benefits.

(c) Collaborate to Overcome Barriers

Many wastewater treatment plants are permitted to burn digester biogas through flaring and are classified as industrial facilities. Capturing the biogas to produce electricity, such as through a combined heat and power (CHP) system may result in re-classifying the facility's purpose as "electricity generation" and subject the plant to more onerous emission compliance and abatement equipment rules. In addition, the beneficial use of methane generated at wastewater treatment facilities faces many of the same hurdles faced by dairy digesters and organic waste composting facilities. Support for technologies and strategies to capture biogas to generate electricity, supplement natural gas pipeline fuel, or for use as a transportation fuel, is needed to overcome some of these barriers and may open up more valuable fuel and credit markets. ARB will work with other relevant State and local agencies to identify and remove financial and regulatory barriers that hinder the productive use of waste streams processed at wastewater treatment plants.

b. Potential Compliance Responses

It's anticipated that some of California's existing, and potentially new, wastewater treatment plants that operate anaerobic digesters may install additional equipment to collect, store, and co-digest regionally-sourced organic wastes (such as food, cooking grease byproducts, and agricultural produce waste), and install other equipment and infrastructure to use captured biogas for beneficial purposes.

Captured biogas could potentially be used for on or off-site electricity generation, or cleaned and compressed for use as a natural gas pipeline supplement or as a vehicle fuel. The use of digester biogas for these purposes would potentially result in the installation and operation of a variety of equipment and infrastructure at wastewater treatment plants (which potentially may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations).

The operational nature of existing wastewater treatment plants would potentially expand from the single function of treating wastewater, to include multiple functions such as generating electricity for on-or off-site consumption, distributing pipeline gas, vehicle fueling, and organic waste diversion, handling, and disposal. These infrastructure additions to existing plants could be accommodated within the existing footprint of the facilities or may require facility expansion.

d) Oil and Gas Production, Processing, Storage and Distribution

California has a large oil and gas industry with more than 50,000 active oil wells, including off shore platforms, about 1,500 active natural gas wells and nearly 500 underground natural gas storage wells. The majority of the oil wells are located in Southern California with most of the gas fields located in Northern California. An extensive network of oil and gas pipelines within the State transport California's crude oil from import terminals and on- and off-shore oil fields to refineries, and distributes finished fuels to more than 70 product terminals throughout the State.

California also has about 215,000 miles of natural gas transmission and distribution pipelines; 22 compressor stations; and 25,000 metering and regulating stations. Natural gas is currently California's largest source of electrical generation fuel, and supplies most of the energy used for industrial operations. Natural gas is also a primary source of energy used for residential and commercial space heating and cooking, and represents the primary source of GHG emissions from the residential and commercial sectors.

a. Measure Summary

California has an emerging, comprehensive framework in place to reduce methane emissions from oil and gas infrastructure. Effectively implementing this framework could reduce methane emissions from oil and gas systems by 40-45 percent in 2025, matching federal commitments. The State's framework on oil and gas methane emissions includes the following elements:

(a) Adopt and Implement a Regulation for Greenhouse Gas Emission Standards for Crude Oil and Natural Gas Facilities

In July 2016, the Board directed staff to continue working with local air districts and other stakeholders to develop a regulation for final Board consideration by early 2017. The proposed regulation will likely require:

- Vapor collection on uncontrolled oil and water separators and storage tanks with emissions above a set methane standard;
- Vapor collection on all uncontrolled well stimulation circulation tanks;

- Leak Detection and Repair (LDAR) on components currently not covered by local air district rules, such as valves, flanges, and connectors;
- Vapor collection of large reciprocating compressors' vent gas, or require repair of the compressor when it is leaking above a set emission flow rate;
- Vapor collection of centrifugal compressor vent gas, or replacement of higher emitting "wet seals" with lower emitting "dry seals";
- "No bleed" pneumatic devices and pumps; and
- Ambient methane monitoring and more frequent well head methane monitoring at underground natural gas storage facilities.

This would build upon some existing air districts' volatile organic compound based rules and include additional areas and infrastructure components (such as valves, flanges, and seals) that are not currently covered by local district programs.

(b) Improve Monitoring and Standards to Detect and Minimize Emissions

ARB and the Division of Oil, Gas, and Geothermal Resources (DOGGR) are working together to ensure that both above and below ground monitoring of storage facilities is improved. As mentioned above, ARB is considering improved above-ground methane monitoring of underground storage facilities in its upcoming Greenhouse Gas Emissions Standards for Crude Oil and Natural Gas Facilities Regulation.

In February 2016, DOGGR adopted emergency regulations to implement protective standards specifically designed to ensure that operators of underground gas storage facilities are properly minimizing risks and taking all appropriate steps to prevent uncontrolled releases, blowouts, and other infrastructure-related accidents. The emergency regulations will ensure that operators of existing underground gas storage facilities monitor for and report leaks to DOGGR, function test all safety valve systems, perform inspections of wellheads and surrounding area and equipment, develop risk management plans that require verification of mechanical integrity and corrosion assessment and monitoring, and provide DOGGR with complete project data and risk assessment results.

In July 2016, DOGGR released a pre-rulemaking discussion draft that will replace its emergency rulemaking. Public comment for the discussion draft ended on August 22, 2016. The discussion draft contains much of the content included in the emergency rulemaking with the addition of, among other things, stricter well construction standards and mechanical integrity testing requirements to reduce the risk of wells leaking. DOGGR anticipates that the formal rulemaking process will conclude in the early part of 2017. Immediate implementation of these standards will ensure that underground gas storage facilities are properly operated, minimizing the potential that an incident such as the gas leak at the Aliso Canyon Natural Gas Storage Facility recurs.

ARB and DOGGR will coordinate on the monitoring provisions to ensure consistency and comprehensiveness while limiting duplication.

Additionally, AB 1496 requires ARB, in consultation with scientific experts and other state, local, and federal agencies, to undertake monitoring and measurements of high-emission methane "hot spots" and conduct lifecycle GHG emission analysis for natural gas produced in and imported into California. Pursuant to this bill, ARB will continue its efforts related to hot spots monitoring and lifecycle greenhouse gas accounting for fuels, and host a scientific workshop in June 2016 to collect the best available knowledge on these topics. ARB will update relevant policies and programs to incorporate any new information gathered as a result of these efforts.

(c) Effectively Implement SB 1371 to Reduce Emissions from Pipelines

SB 1371 (Leno, Chapter 525, Statutes of 2014) directs the CPUC, in consultation with ARB, to adopt rules and procedures to minimize natural gas leaks from CPUC-regulated intrastate transmission and distribution gas pipelines and facilities. Among other requirements, SB 1371 directs the CPUC to adopt rules and procedures that provide for the maximum technologically feasible and cost-effective avoidance, reduction, and repair of leaks and leaking components. In January 2015, the CPUC launched a rulemaking proceeding (R.15-01-008) to carry out the intent of SB 1371. Under this proceeding, CPUC published a report that identifies new gas leak detection technologies that can be used to optimize methane reductions from transmission, distribution and storage processes. CPUC also required utility companies and gas suppliers to report natural gas emission data annually and best leak management practices. To date, the industry has submitted two consecutive emission inventories in 2015 and 2016, respectively. In June 2015, CPUC conducted a prehearing conference to discuss the draft scoping memo of relevant topics to be deliberated during the 24 month timeframe of the proceeding. In addition, several public workshops and workgroup meetings have been held in San Francisco and Sacramento.

ARB continues to actively participate in the proceeding and will lead efforts to analyze collected utility emission data, develop quantification protocols, and identify potential mitigation strategies. In particular, ARB will focus on the emission reduction potential of the proceeding in keeping with the objectives of AB 32 as they pertain to:

- Comparing the data collected under SB 1371 with the Mandatory Reporting Regulation;
- Analyzing emission data to determine potential mitigation strategies. For example, the proceeding may require the replacement of older pipelines or pipelines constructed of a certain material;
- Identifying any remaining data gaps;
- Establishing procedures for the development and use of metrics to quantify emissions;

- Reviewing and evaluating the effectiveness of existing practices for the operation, maintenance, repair, and replacement of natural gas pipeline facilities to determine the potential to reduce methane leaks and where alternative practices may be required;

- Provide input on cost-effectiveness; and

- Funding studies to update emission factors from important leak sources, such as pipelines and customer meters.

The final decision on potential rules and procedures by the CPUC, including ratemaking and financial incentives to minimize gas leaks, is anticipated in the fall of 2017. Upon evaluation of the industry's compliance with the decision, ARB will determine whether additional regulatory actions or incentives are required to further reduce methane emissions from this source.

b. Potential Compliance Responses

Implementation of ARB's regulation for oil and gas facilities could result in construction modifications to existing facilities, such as the installation of vapor recovery systems, the installation of low-bleed or zero-bleed pneumatic devices, and the replacement of leaking equipment. This could include construction activities related to the installation or replacement of pipelines, flanges, valves and similar features already associated with oil and gas facilities. Collected vapors would be routed to sales gas lines, microturbines, fuel gas system, low-NO_X flares, or underground injection wells. These equipment construction and installation activities would typically occur within the footprint of existing oil and gas facilities. A draft environmental analysis was prepared for this proposed regulation and released for public review with the Initial Statement of Reasons on May 31, 2016. It is expected the Board will consider approving this regulation in early 2017.

Implementation of actions under the SB 1371 proceeding may result in an increase in the rate at which pipelines and related equipment and facilities are replaced or repaired/reconstructed. In addition, additional leak surveys may result. Any pipeline replacement or reconstruction activities as well as leak surveys would likely be limited to work on existing infrastructure.

3. Hydrofluorocarbons (HFCs)

HFCs are fluorinated gases (F-gases) used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants. HFCs are replacements for ozone-depleting substances, and although HFCs do not harm the stratospheric ozone layer, they are potent GHGs with high GWPs ranging from several hundred to several thousand times that of CO_2.

The following is a list of the short-lived HFCs comprising more than 95 percent of all HFC emissions, with lifetimes and GWP values from the Intergovernmental Panel on Climate Change Fourth Assessment Report, 2007:

Common Name	Chemical Name	Lifetime (years)	20-year GWP	100-year GWP
HFC-32	Difluoromethane (CH_2F_2)	5.0	2,330	675
HFC-125	Pentafluoroethane (C_2HF_5)	29.0	6,350	3,500
HFC-134a	1,1,1,2-Tetrafluoroethane (CH_2FCF_3)	13.8	3,830	1,430
HFC-143a	1,1,1-Trifluoroethane ($C_2H_3F_3$)	52.0	5,890	4,470
HFC-152a HFC-227ea	1,1-Difluoroethane ($C_2H_4F_2$) 1,1,1,2,3,3,3-Heptafluoropropane (C_3HF_7)	1.4 33.0	437 5,310	124 3,220
HFC-245fa	1,1,1,3,3-pentafluoropropane ($C_3H_3F_5$)	7.2	3,380	1,030
HFC-365mfc HFC-4310mee	1,1,1,3,3-pentafluorobutane ($C_4H_5F_5$) 1,1,1,2,2,3,4,5,5,5-decafluoropentane ($C_5H_2F_{10}$)	9.9 15.0	2,520 4,140	794 1,640

a) HFC Emissions Reductions Measures

The annual Montreal Protocol Meeting of Parties from October 10-15, 2016 in Kigali, Rwanda, resulted in an historic international agreement, known as the “Kigali Amendment,” to phase down the production of HFCs globally. The agreement requires a reduction in the production and supply of HFCs for developed countries, including the U.S., as follows: 10 percent reduction in 2019; 40 percent in 2024, 70 percent in 2029, 80 percent in 2034, and 85 percent in 2036. Developing countries will not have to begin the phasedown until 2029, and will be allowed until 2045 to reach the 85 percent reductions in HFC consumption. Although the HFC phasedown will result in significant reductions, it must be noted that a long lag time of 10-20 years exists between a production phase-out and an equivalent emissions reduction.

The global phasedown by itself is not likely to reduce HFC emissions 40 percent by the year 2030 as required by SB 1383. Therefore, additional specific HFC emissions reductions proposals are included in the SLCP Plan.

For the purposes of the SLCP Strategy, there are four concepts recommended to reduce the emissions of high-GWP HFCs: 1) Incentive programs to use low or lower-GWP refrigeration systems; 2) The global phase-down on new HFC production and import, which will be administered by the U.S. EPA on behalf of all states, including California; 3) Sales ban on very-high GWP refrigerants in California; and 4) High-GWP refrigerant prohibitions in new stationary systems (refrigeration and air-conditioning). All of the proposed measures would result in the replacement of high-GWP HFCs with various lower-GWP alternatives.

a. Measure summary

All of the measures require that the current high-GWP HFC refrigerants used would eventually be replaced by lower-GWP refrigerants. The most likely substitutes to high-

GWP HFCs are CO_2, ammonia, hydrocarbons, and hydrofluoro-olefins (HFOs). HFOs are a new generation of synthetic refrigerants that are unsaturated HFC compounds with very short atmospheric lifetimes of several weeks, and very low 100-year GWP values of less than 5 (compared to 124 to 14,800 for HFCs). All of the above compounds, with the exception of HFOs, are already commercially produced in large quantities in the U.S. and internationally.

(a) Incentive Programs

A voluntary early action measure recommended is an incentive program to defray the potential added cost of installing new low-GWP refrigeration equipment or converting existing high-GWP systems to lower-GWP options. This program could provide immediate and ongoing emission reductions. A loan or grant program would support qualifying facilities that take action to reduce emissions prior to any national or state requirements to do so.

(b) Phasedown in Supply of HFCs

Due to the global HFC phasedown agreement, a California-specific HFC phasedown will not be necessary. However, as previously noted, there is a long time lag between reductions in HFC production and actual emissions reductions, due to the slow turnover of existing equipment that continue to emit high-GWP HFCs throughout their useful life. For example, a 40 percent reduction in HFC production may take 10-20 years to be realized in reduced emissions.

ARB will continue to assess the impact of the Kigali Amendment on HFC emission reductions in California. Additional reduction measures are likely to be needed to reach the 2030 HFC emission reduction goals set forth in SB 1383.

(c) Prohibition on the Sale of New Refrigerant with Very high GWPs

Very-high GWP refrigerants, such as those with a 100-year GWP greater than 2500, would not be allowed for sale or distribution. All very-high GWP refrigerants have current drop-in replacements at about the same cost. The ban would not apply to recycled or reclaimed refrigerants.

(d) High-GWP Refrigerant Prohibitions in New Stationary Systems

This measure would prohibit the use of high-GWP refrigerants in new commercial, industrial, and residential stationary refrigeration and air-conditioning equipment, as follows:

Stationary Refrigeration or Stationary Air-Conditioning Sector	**Refrigerants Prohibited in New Equipment with a 100-year GWP Value:**
Non-residential refrigeration	150 or greater

Air-conditioning (non-residential and residential)	750 or greater
Residential refrigerator-freezers	150 or greater

GWP limits for specific air conditioning equipment types could be made more stringent if low-GWP technologies develop more quickly than anticipated, such as the continued development of low and medium-pressure air-conditioning chillers that use refrigerants with a GWP less than 150.

Certain exceptions could be made to any maximum GWP limit if no low-GWP refrigerants are technically feasible in a specific application. Additionally, high-GWP prohibition dates could be extended for specific end-use sectors where codes and standards do not allow the use of feasible low-GWP refrigerants.

b. Potential Compliance Responses

Replacement of high-GWP compounds with low-GWP compounds would result in increased demand for low-GWP compounds (e.g. increased demand for HFOs) and modification to existing facilities. The increased demand for low-GWP compounds would occur as a result of the global HFC phase-down and the possible incremental increased demand from the SLCP Strategy alone would not lead to an increase of facilities to manufacture these compounds. In many cases, using drop-in blends and/or low- or lower-GWP HFCs would require minor modifications to existing facilities, such as changes in the types of lubricants and compressor calibrations for foam production and refrigeration units. However, if CO_2-, hydrocarbon, or ammonia-based systems are used, a complete retrofit of equipment would likely be necessary. Local permitting agencies may apply additional oversight on the planning and operations of refrigeration equipment using flammable refrigerants such as hydrocarbons, and toxic refrigerants such as ammonia.

b) Sulfuryl Fluoride

Sulfuryl fluoride (SO_2F_2) is a pesticide fumigant and one of the most common replacements for methyl bromide, an ozone-depleting substance whose use is being phased out. Because sulfuryl fluoride is also a short-lived climate pollutant, ARB has identified further research needs for control measures for this gas in the SLCP Strategy. No control measures are proposed at this time, so no further CEQA analysis is necessary. Accordingly, this information is included for public information purposes.

Sulfuryl fluoride is regulated by the California Department of Pesticide Regulation (DPR), and was listed as a toxic air contaminant (TAC) in 2006. As a pesticide and TAC, sulfuryl fluoride's use is strictly controlled. In December 2015, DPR submitted a report to the Legislature, which provided an update on adopted control measures for sulfuryl fluoride (DPR, 2015a), as required by AB 304 (Williams, 2013). DPR plans to develop additional mitigation measures by September 2016 to address unacceptable exposures of sulfuryl fluoride to bystanders and residents. Sulfuryl fluoride is not registered for use as a field soil fumigant and is not used on agricultural fields.

Until 2009, sulfuryl fluoride was believed to have a negligible GWP. Further research concluded that SO_2F_2 has a 20-year GWP of 6840, with a lifetime of several decades. According to the DPR, 3 million pounds of sulfuryl fluoride were used in California in 2013 (most recent data available) (DPR, 2015b). Its main use is as a structural pest control fumigant to kill drywood termites in homes and buildings, accounting for 82 percent of all usage in 2013. Sulfuryl fluoride is also a common fumigant for dried fruits, nuts, and other agricultural commodities that must be kept pest-free during storage prior to shipping (15 percent of all usage in 2013). The remaining three percent of sulfuryl fluoride application was for other fumigation uses.

Because sulfuryl fluoride was not identified as a high-GWP gas by the time AB 32 was enacted, it was not included as a part of ARB's statewide GHG inventory. However, the annual usage of sulfuryl fluoride is inventoried by DPR as a highly-regulated pesticide and ARB uses this data to track emissions. In 2013, the 3 million pounds of SO_2F_2 usage was equivalent to 9.4 $MMTCO_2E$ emissions (using 20-year GWP values), or approximately 20 percent of all F-gas emissions.

Identifying less toxic or lower-GWP alternatives to sulfuryl fluoride remains problematic. Methyl bromide (CH_3Br), with a 20-year GWP of 17, was the pesticide fumigant of choice for many applications until its use was almost completely phased-out by the Montreal Protocol because of its ozone- depleting potential, and because it is an identified toxic air contaminant (TAC) in California. Currently, sulfuryl fluoride is the only fumigant registered for treating structural pests in California. Termites or other wood-destroying pests are detected in over 250,000 California homes each year, with the cost of control and repair of damage from dry-wood termites in California exceeding $300 million annually (with 80 percent of fumigations occurring in Southern California).

For agricultural commodity fumigation storage (primarily dried fruits and nuts), methyl bromide is still used on a limited basis through critical use exemptions, granted by the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer. Methyl bromide use continues to decrease annually. An alternative fumigant, phosphine (PH_3), with a GWP of 0, is also used as an alternative to methyl bromide and sulfuryl fluoride. However, reported insect tolerance to phosphine has limited its widespread usage (USAID, 2014). Non-chemical commodity treatment has been studied since 1995, including irradiation, and controlling the atmosphere to "suffocate" insects in either low-oxygen or high carbon dioxide environments (DPR, 1995). Chemical treatment remains dominant due to cost and feasibility issues of non-chemical alternatives.

The effectiveness of less toxic (and lower-GWP) alternatives to sulfuryl fluoride in structural fumigation for drywood termites is the subject of much research, opinion, and disagreement. Structural fumigation generally includes tenting the entire structure and treating it to kill termites, or more rarely, wood-boring beetles and other pests living in the structure. While many termite control companies only use sulfuryl fluoride, many others have begun using alternative termite control methods, including orange oil, structure heating or extreme cooling, microwaves, and electricity. Additional research is required before sulfuryl fluoride mitigation measures can be proposed. ARB will continue working with the DPR to assess mitigation measures to sulfuryl fluoride emissions.

Because additional research is required, there are no measures proposed at this time and no reasonably foreseeable compliance responses associated with sulfuryl fluoride.

3.0 ENVIRONMENTAL AND REGULATORY SETTING

The California Environmental Quality Act (CEQA) Guidelines require an environmental impact report to include an environmental setting section, which discusses the current environmental conditions in the vicinity of the project. This environmental setting constitutes the baseline physical conditions by which an impact is determined to be significant. (Cal. Code Regs., tit. 14 § 15125.) As discussed above in Chapter 1, the California Air Resources Board (ARB or Board) has a certified regulatory program and prepares an environmental analysis (EA) in lieu of an Environmental impact Report (EIR). This Revised Draft EA is a functional equivalent to an EIR under CEQA therefore, in an effort to comply with the policy objectives of CEQA, an environmental setting, as well as a regulatory setting with relevant environmental laws and regulations, has been included as Attachment A to this document.

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4.0 IMPACT ANALYSIS AND MITIGATION MEASURES

A. Approach to the Environmental Impacts and Mitigation Measures

This chapter contains an analysis of the potentially significant environmental impacts resulting from implementation of the Proposed Short-Lived Climate Pollutant Reduction Strategy (SLCP Strategy). The California Environmental Quality Act (CEQA) requires the baseline for determining the significance of environmental impacts to normally be the existing conditions at the time the environmental review is initiated. (Cal. Code Regs., tit.14, § 15125(a).) Therefore, significance determinations reflected in this Environmental Analysis (EA) are based on a comparison of the potential environmental consequences of implementation of measures in the SLCP Strategy with the regulatory setting and physical conditions in 2016 (see Attachment A).

1. Significant Adverse Environmental Impacts and Mitigation Measures

The analysis of adverse impacts on the environment, and significance determinations for those impacts, reflect the programmatic nature of the analysis of the anticipated reasonably foreseeable compliance actions resulting from implementation of the measures within the SLCP Strategy. These reasonably foreseeable compliance responses are described in more detail in Chapter 2. The Revised Draft EA analysis addresses broadly defined types of actions that may be taken by others in the future as a result of implementation of the measures in the SLCP Strategy.

This EA takes a conservative approach and considers some adverse environmental impacts as potentially significant because of the inherent uncertainties about the ultimate design of various measures described. The relationship between reasonably foreseeable physical actions carried out in response to implementation of the measures, as well as environmentally sensitive resources or condition that may be affected, are also taken into consideration. This conservative approach tends to overstate environmental impacts in light of these uncertainties and is intended to satisfy the good-faith, full-disclosure intention of CEQA.

If and when specific measures identified in the SLCP Strategy are proposed to be carried out by ARB, such as a proposed regulation, that proposal would be subject to a more detailed measure specific environmental review. ARB expects at that stage of a specific proposal, it will have more information about design options and the ability to make decisions about the regulatory requirement that can be included to avoid some potentially significant impacts. This is especially the case for any potential long-term air quality impacts that are identified at this stage of programmatic review because air quality is within ARB's jurisdiction, and ARB is more likely to be able to address these types of issues through the specific regulation or program design. In particular, ARB has continuing duties under its authorizing statutes and under Assembly Bill (AB) 32 in particular to ensure that measures it adopts and manages do not interfere with the State's progress towards attainment with public health standards, with a particular focus on health effects in disadvantaged communities. ARB strives to ensure that funding decisions are consistent with these core commitments as well. Therefore, staff can be expected to design, and the Board approve, measures identified in this SLCP Strategy in ways that protect and enhance air quality and avoid other negative environmental effects to the greatest extent possible.

Nonetheless, at this stage, due to uncertainty about the details of later specific measure design, this analysis takes a conservative approach and tends to overstate potential impacts by considering these potential impacts as significant and unavoidable.

For later actions carried out by others (e.g. regulated entities) in response to implementation of particular measures (e.g. construction of new facilities), it is expected that during project level environmental review many impacts identified in this Revised Draft EA can be avoided or reduced to a less-than-significant level by the local permitting authorities. If a potentially significant environmental effect cannot be feasibly mitigated with certainty, this Revised Draft EA identified it as significant and unavoidable.

Where applicable, consistent with ARB's certified regulatory program requirements (Cal. Code Regs., tit.17, § 60005 (b)), this Revised Draft EA also acknowledges potential beneficial impacts on the environment in each resource area that may result from implementation of the SLCP Strategy. Any beneficial impacts associated with the SLCP Strategy are included in the impact assessment for each resource area described in this chapter.

B. Resource Area Impacts and Mitigation Measures

Below is a programmatic analysis of the impacts resulting from the reasonably foreseeable compliance responses that could result from implementation of the SLCP Strategy that could lead to environmental impacts. The analysis of the impacts resulting from the proposed measures is organized by short-lived climate pollutant (SLCP) within each environmental resource area. Please refer back to Chapter II for the more detailed description of the proposed measures for each SLCP and the reasonably foreseeable compliance responses associated with those measures. Only those compliance responses that could lead to impacts are discussed; if there is no discussion of a compliance response, it is because it was determined there were no impacts resulting in the resource area from those actions.

The reasonably foreseeable compliance responses are analyzed in a programmatic manner for several reasons: (1) any individual action or activity would be carried out under the same program (i.e., the SLCP Strategy); (2) the reasonably foreseeable compliance response would result in generally similar environmental effects that can be mitigated in similar ways (Cal. Code Regs., tit.14, § 15168 (a)(4)); and (3) while the types of foreseeable compliance responses can be reasonably predicted, the specific location, design, and setting of the potential actions cannot feasibly be known at this time. If a later activity would have environmental impacts that are not examined within this Revised Draft EA, the public agency with authority over the later activity would be required to conduct additional environmental review as required by CEQA or other applicable statutes.

C. Aesthetics

1. Impacts Associated with Black Carbon Measures

Impact 1.1-a: Short-Term Construction and Long-Term Related Effects on Aesthetic Resources

Implementation of this measure would likely increase the replacement of fireplaces and woodstoves with United States Environmental Protection Agency (U.S. EPA)-certified devices, gas fireplaces, electric heaters, or gas heaters. This measure could also include encouraging the installation of non-wood burning centralized heating in new construction. Actions required to replace wood burning stoves and fireplaces, or install non-wood burning heating in new construction, would constitute minor construction activities that would occur within existing structures or existing construction sites and would not result in any actions that could substantially affect visual resources.

Therefore, short-term construction-related and long-term operational impacts on aesthetic resources associated with implementation of black carbon reduction measures of the SLCP Strategy would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 1.2-a: Short-Term Construction-Related Effects on Aesthetic Resources

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: development of new or modified digesters, either on-site or centralized, for dairies, landfills, and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Landscape character can be defined as the visual and cultural image of a geographic area. It consists of the combination of physical, biological, and cultural attributes that make each landscape identifiable or unique. Visual character may range from predominately natural to heavily influenced by human development. Its value is related, in part, to the importance of a site to those who view it, such as residents, motorists, and recreation users. Dairy farms are located throughout California, the majority of which exist in the Central Valley and coastal counties. Typically, agricultural sites are level areas of relatively large landholdings (e.g., hundreds of acres) that are separated from urban centers. Dairy structures include a main dairy barn, residences and offices, shaded corrals, water tanks, ponds, and lagoons. Conversion of flush-water manure management to solid manure collection and management practices at a dairy would require modifications to barns to support the use of scrape or vacuum equipment. During these activities, the presence of construction equipment, as well as activities associated with remodeling of barns, could alter the visual character of a site by introducing features that may not be expected.

In addition, implementation of the methane reduction measures could result in modifications to oil and gas facilities, including the installation of equipment such as low-bleed or zero-bleed pneumatic devices, vapor recovery systems, and pipelines, flanges, and valves. Installation of this equipment, and additional maintenance and inspection activities, would require increased use of trucks to and from facilities; however, this would not be substantially different for existing activities at oil and gas facilities, which rely on a steady stream of mobile delivery/shipping systems.

Additionally, potential compliance responses related to the methane reduction measures could include the construction of new anaerobic facilities to digest manure from dairies, sewage from wastewater treatment plants, and diverted organic waste from landfills. These may be associated with individual businesses, or larger centralized facilities may be constructed to support anaerobic digestion of several facilities. In addition to construction of new facilities, minor alterations, such as pipeline installation, could also occur at dairies, landfills, and wastewater treatment plants. The location and size of new or modified facilities is not currently known.

Construction activities could include the presence of heavy-duty equipment, vegetation removal, and grading. While there is a degree of uncertainty regarding the location of these facilities, construction of anaerobic digesters and other modifications to existing facilities could conceivably introduce or increase the presence of visible artificial elements in areas of scenic importance, such as visibility from State scenic highways. In addition, nighttime lighting could be installed for security of a project site or to improve visibility for construction workers.

Therefore, short-term construction-related impacts on aesthetics associated with implementation of the methane reduction measures under the SLCP Strategy could be potentially significant.

Potential scenic, light, and glare impacts could be reduced to a less-than-significant level by mitigation measures prescribed by local or State land use or permitting agencies with approval authority over specific development projects.

Mitigation Measure 1.2-a

The Regulatory Setting in Attachment A includes applicable laws and regulations that provide protection of aesthetic resources. ARB does not have the authority to require implementation of mitigation related to new or modified facilities or infrastructure that would be approved by other State agencies or local jurisdictions. The ability to require these measures is within the purview of jurisdictions with land use approval and/or permitting authority. Project-specific impacts and mitigation would be identified during the project review process and carried out by agencies with approval authority.

Recognized practices routinely required to avoid and/or minimize impacts to aesthetic resources include:

- Proponents of new facilities constructed as a result of reasonably foreseeable compliance responses would coordinate with State or local land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA). The local or State land use agency or governing body must follow all applicable environmental regulations as part of approval of a project for development.
- Based on the results of the environmental review, proponents would implement all feasible mitigation to reduce or substantially lessen the potentially significant scenic or aesthetic impacts of the project.
- To the extent feasible, the sites selected for use as construction staging and laydown areas would be areas that are already disturbed and/or are in locations of low visual sensitivity. Where feasible, construction staging and laydown areas for equipment, personal vehicles, and material storage would be sited to take advantage of natural screening opportunities provided by existing structures, topography, and/or vegetation. Temporary visual screens would be used where helpful, if existing landscape features did not screen views of the areas.
- All construction and maintenance areas would be kept clean and tidy, including the re-vegetation of disturbed soil and storage of construction materials and equipment would be screened from view and/or are generally not visible to the public, where feasible.
- Siting projects and their associated elements next to important scenic landscape features or in a setting for observation from State scenic highways, national historic sites, national trails, and cultural resources would be avoided to the greatest extent feasible.
- The project proponent would contact the lead agency to discuss the documentation required in a lighting mitigation plan, submit to the lead agency a plan describing the measures that demonstrate compliance with lighting requirements, and notify the lead agency that the lighting has been completed and is ready for inspection.

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and the programmatic level of analysis associated with this Revised Draft EA does not attempt to address project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation that may ultimately be implemented to reduce potentially significant scenic and nighttime lighting impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that short-term construction-related scenic and nighttime lighting impacts resulting from the development of new facilities associated with black carbon reduction measures would be **potentially significant and unavoidable**.

Impact 1.2-b: Long-Term Operational Effects on Aesthetics

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: operation of new or modified digesters, either on-site or centralized, for dairies, landfills, and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials ; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors).

Implementation of the methane reduction measures could involve conversion of flush-water manure management systems to scrape manure management at dairies. Adoption of solid manure collection and management practices could result in changes to the aesthetic character of existing dairies. The lagoons produced by flush-water systems could be reduced in size or completely replaced by on-site solid manure management such as compost piles, which would be mostly aerobically managed. Lagoons could also be covered to collect methane emissions for on- or off-site energy use. While some dairies are located along State scenic highways, modifications of existing buildings and construction of new facilities would not be expected to substantially damage visual character-defining features such as trees, rock outcroppings, and historic buildings.

In addition, implementation of the methane reduction measures could result in modifications to oil and gas facilities, including the installation of equipment such as low-bleed or zero-bleed pneumatic devices, vapor recovery systems, and pipelines, flanges, and valves when needed. Such improvements would consist of minor modifications, occur within the footprint of existing facilities, and would not substantially change the overall character of such facilities.

The methane reduction measures could include the operation of new anaerobic facilities to digest manure from dairies, sewage from wastewater treatment plans, and diverted organic waste from landfills. These may be associated with individual businesses, or larger facilities may be operated to support anaerobic digestion of several facilities. Operation may occur in the vicinity of a dairy, wastewater treatment plant, or near existing landfills. Larger, regional facilities could be located in strategic areas that could allow for several facilities to contribute materials to a plant; however, there is uncertainty regarding the location of these facilities. Operation of digesters and related equipment includes structures such as generator sets, fueling stations, and compression equipment. These types of equipment generally appear as large, metal-sided buildings that can be characterized as having an industrial appearance. Additionally, depending on the types of materials used, facility operation may introduce substantial sources of glare from metal-sided buildings. The structure of anaerobic digesters could conceivably introduce or increase the presence of visible artificial elements in areas of scenic importance, such as visibility from State scenic highways. The visual impact of such development would depend on several variables, including the type and size of facilities, distance and angle of view, visual prominence, and placement in the landscape.

Digesters and oil and gas facilities may install flares to dispose of collected methane vapors. However, flares at digesters would not be expected to operate except for emergency purposes; and, flares installed at oil and gas facilities would be enclosed and meet low-NOx standards.

Thus, long-term operational impacts on aesthetic resources associated with the presence of new structures could be potentially significant.

Mitigation Measure 1.2-b

The Regulatory Setting in Attachment A includes applicable laws and regulations that provide protection of aesthetic resources. ARB does not have the authority to require implementation of mitigation related to new or modified facilities or infrastructure that would be approved by other State agencies or local jurisdictions. The ability to require such measures is within the purview of jurisdictions with land use approval and/or permitting authority. Project-specific impacts and mitigation would be identified during the project review process carried out by agencies with approval authority. Recognized practices routinely required to avoid and/or minimize impacts to aesthetic resources include:

- Proponents of new facilities constructed as a result of reasonably foreseeable compliance responses would coordinate with State or local land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA). The local land use, State agency, or governing body must comply with applicable regulations as part of approval of a project for development.

- Based on the results of project level environmental review, all feasible mitigation to reduce or substantially lessen the potentially significant scenic or aesthetic impacts of the project would be implemented.
- The color and finish of the surfaces of all project structures and buildings visible to the public would be carried out to: (1) minimize visual intrusion and contrast by blending with the landscape; (2) minimize glare; and (3) comply with local design policies and ordinances. The project proponent would submit a surface treatment plan to the lead agency for review and approval.
- All operation and maintenance areas would be kept clean and tidy, including the re-vegetation of disturbed soil and storage of construction materials and equipment would be screened from view and/or are generally not visible to the public, where feasible.
- The project proponent would contact the lead agency to discuss the documentation required in a lighting mitigation plan, submit to the lead agency a plan describing the measures that demonstrate compliance with lighting requirements, and notify the lead agency that the lighting has been completed and is ready for inspection.

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and the programmatic level of analysis associated with this Revised Draft EA does not attempt to address project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation that may ultimately be implemented to reduce potentially significant scenic and nighttime lighting impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that long-term operational scenic and nighttime lighting impacts resulting from the development of new or modified facilities associated with black carbon reduction measures would be **potentially significant and unavoidable**.

3. Impacts Associated with HFC Measures

Impact 1.3-a: Short-Term Construction-Related Effects on Aesthetic Resources

The Hydrofluorocarbon (HFC) reduction measures in the SLCP Strategy contain actions to reduce HFC emissions within the State. These strategies could require replacing high-global warming potential (GWP) HFCs, used as refrigerants foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, carbon dioxide (CO_2), hydrocarbons, lower-GWP HFCs, and hydrofluoro-olefins (HFOs). These replacements could entail minor to moderate modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications. Also, some low-GWP refrigerants (e.g., hydrocarbons, ammonia) can power existing systems (U.S. EPA 2010). Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings and not significantly alter the visual character of the area.

Therefore, short-term construction-related and long-term operational impacts to aesthetics associated with the HFC reduction measures would be **less-than-significant**.

D. Agricultural and Forest Resources

1. Impacts Associated with Black Carbon Measures

Impact 2.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Agriculture and Forest Resources

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters and U.S. EPA-certified devices.

Black carbon reductions obtained by removing residential wood burning stoves and fireplaces, and replacing them with gas heaters and U.S. EPA-certified devices, would occur within the boundaries of existing structures, or would be incorporated into the design of future development projects. The change in stove use would not substantially contribute to the rate or location of future residential developments. Disposal of wood-burning appliances would occur at existing recycling facilities or landfills.

Therefore, short-term construction-related and long-term operational impacts associated with implementation of black carbon reduction measures on agriculture and forest resources would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 2.2-a: Short-Term Construction-Related and Long-Term Operational Effects on Agriculture and Forest Resources

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction and operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, digesters, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic materials diverted from landfills into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, such as pipeline installation and methods of disposal of methane vapors, and inspection and monitoring of equipment).

Implementation of the reasonably foreseeable compliance responses associated with the methane reduction measures related to modification of facilities (e.g., changes in manure management practices, modifications to wastewater treatment plant, minor upgrades and improvements to oil and gas collection and storage systems) would be anticipated to occur within areas currently zoned for industrial or otherwise developed for uses other than agricultural purposes. Pasturing of cattle is likely to occur in areas designated for grazing; however, if it were to occur in Important Farmland, it would not require conversion of agricultural land to non-agricultural uses. Thus, conversion of Important Farmland (i.e., Prime Farmland, Unique Farmland, or Farmland of Statewide Importance) would not be anticipated for these types of compliance responses. Likewise, these compliance responses would not be expected to affect, or be located, within forest land.

However, reasonably foreseeable compliance responses associated with the methane reduction measures could result in construction of new anaerobic facilities to digest manure from dairies, sewage from wastewater treatment plants, and diverted organic waste from landfills. These may be associated with individual businesses, or larger facilities may be constructed to support anaerobic digestion of several facilities. If facilities are proposed in response to the methane reduction measures, potential impacts to Prime Farmland, Unique Farmland, or Farmland of Statewide Importance, Williamson Act conservation contracts, or forest land or timberland, must be reviewed by local or State lead agencies in the context of future project approvals. Many local governments have adopted land use policies to protect important agricultural and forest land from conversion to urban development, including industrial facilities. While it is reasonable to anticipate that land use policies controlling the location of new anaerobic digestions facilities would generally avoid conversion of important agricultural land, forest land, and timberland, the potential cannot be entirely dismissed. If a facility were located on important farmland or property under a Williamson Act Contract, conversion of the agricultural land to industrial uses could occur.

Therefore, short-term construction-related and long-term operational impacts on agricultural and forest resources associated with implementation of the methane reduction measures could be potentially significant.

This impact could be reduced to a less-than-significant level by mitigation that can and should be implemented by local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 2.2-a

The Regulatory Setting in Attachment A includes applicable laws and regulations that provide protection of agricultural and forest resources. ARB does not have the authority to require implementation of mitigation related to new or modified facilities or infrastructure that would be approved by other State agencies or local jurisdictions. The ability to require such measures is within the purview of jurisdictions with land use approval and/or permitting authority. Project-specific impacts and mitigation would be identified during the project review process and carried out by agencies with approval authority. Recognized practices routinely required to avoid and/or minimize impacts to agriculture and forest resources include:

- Proponents of new facilities constructed as a result of reasonably foreseeable compliance response would coordinate with local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA). The local or State land use agency or governing body must comply with applicable regulations and would approve the project for development.
- Based on the results of project level environmental review, project proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the environmental impacts of the project.
- Any mitigation specifically required for a new or modified facility would be determined by the local lead agency and future environmental documents by local and State lead agencies should include analysis of the following:
- Avoidance of lands designated as Important Farmlands as defined by the Farmland Mapping and Monitoring Program.
- Analysis of the feasibility of using farmland that is not designated as Important Farmland prior to deciding on the conversion of Important Farmland.
- The feasibility, proximity, and value of the proposed project sites should be balanced before a decision is made to locate a facility on land designated as Important Farmland.
- Any action resulting in the conversion of Important Farmlands should consider mitigation for the loss of such farmland. Any such mitigation should be completed prior to the issuance of a grading or building permit by providing the permitting agency with written evidence of completion of the mitigation. Mitigation may include but is not limited to:

    - Permanent preservation of off-site Important Farmland (State defined Prime Farmland, Farmland of Statewide Importance, and Unique

Farmland) of equal or better agricultural quality, at a ratio of at least 1:1.

- Preservation may include the purchase of agricultural conservation easement(s); purchase of credits from an established agricultural farmland mitigation bank; contribution of agricultural land or equivalent funding to an organization that provides for the preservation of farmland towards the ultimate purchase of an agricultural conservation easement.

- Participation in any agricultural land mitigation program, including local government maintained that provides equal or more effective mitigation than the measures listed.

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and the programmatic level of analysis associated with this Revised Draft EA does not attempt to address project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation that may ultimately be implemented to reduce potentially significant impacts related to the conversion of agriculture and forest resources.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that short-term construction-related and long-term operational impacts to agriculture and forest resources resulting from the development of new facilities associated with reasonably foreseeable compliance responses to black carbon reduction measures would be **potentially significant and unavoidable**.

3. Impacts Associated with HFC Measures

Impact 2.3-a: Short-Term Construction-Related and Long-Term Operational Effects on Agricultural and Forest Resources

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications to refrigeration systems that would not substantially physically alter existing infrastructure. Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings, and additional land would not be required such that a land use conversion would occur.

As a result, short-term construction-related and long-term operational impacts to agriculture and forest resources associated with the HFC reduction measures would be **less-than-significant**.

E. Air Quality

1. Impacts associated with Black Carbon Measures

Impact 3.1-a: Short-Term Construction-Related Effects on Air Quality

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or would be incorporated into the design of future development projects. These are minor modifications that do not result in significant enough construction to contribute significantly to emissions.

As a result, short-term construction-related air quality impacts associated with black carbon reduction measures would be **less-than-significant**.

Impact 3.1-b: Long-Term Operational-Related Effects on Air Quality

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters and U.S. EPA-certified devices

A large-scale conversion from wood to natural gas or electric heaters could foreseeably change supply and demand characteristics in the wood market, though the impact of this change is speculative, and likely would not have a large effect on the market. Waste wood previously used in residential fireplaces, such as lumber byproducts or agricultural and forestry residues, would require an alternate disposal mechanism. These alternative disposal mechanisms, could contribute to new operational air emissions, but is too speculative to determine at this stage.

Although this measure would include increased operation of U.S. EPA-certified devices, gas fireplaces, electric heaters, or gas heaters, it would not result in increased use of wood burning devices. Rather, the measures would result in removal of old fireplaces and woodstoves and replacement with U.S. EPA-certified wood-burning devices, electric heaters, or gas fireplaces. Replacement of older fireplace and woodstove models can provide long-lasting reductions in emissions of black carbon, criterial pollutants, and air toxics in residential neighborhoods. Conversion from wood-burning devices to electric heating or gas fireplaces provides more certain emission reductions than conversion to certified wood-burning devices. While certified wood-burning devices reduce fine particulate emissions, certification values may not correlate well with in-home performance of wood heaters, and emission reductions are not as large as for non-wood technologies (U.S. EPA 2016). Electric heating or gas devices (including central HVAC) ensure local reductions of particulate matter, black carbon and air toxics. Overall, implementation of this measure would reduce the use of wood burning devices, thus decreasing their associated air emissions.

Thus, long-term operational-related impacts to air quality (e.g., changes in residential wood supply and demand characteristics, reduction in the use of wood burning devices) associated with black carbon reduction measures, although unknown at this time, are anticipated to be **beneficial**.

2. Impacts Associated with Methane Reduction Measures

Impact 3.2-a: Short-Term Construction-Related Effects on Air Quality

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, digesters, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Modifications to existing facilities or construction of new facilities would be required to secure local or State land use approvals prior to their implementation. Part of the development review and approval process for projects located in California requires environmental review consistent with California environmental laws (e.g., CEQA) and other applicable local requirements (e.g., local air quality management district rules and regulations). The environmental review process would include an assessment of whether or not implementation of such projects could result in short-term construction related air quality impacts.

At this time, the specific location, type, and number of construction activities is not known and would be dependent upon a variety of factors that are not subject to authority under ARB and not within its purview. Nonetheless, the analysis presented herein provides a good-faith disclosure of the general types of construction emission impacts that could occur with implementation of these reasonably foreseeable compliance responses. Further, subsequent environmental review would be conducted at such time that an individual project is proposed and land use or construction approvals are sought.

Generally, it is expected that during the construction phase for any facilities, criteria air pollutants and TACs could be generated from a variety of activities and emission sources. These emissions would be temporary and occur intermittently depending on the intensity of construction on a given day. Site grading and excavation activities would generate fugitive PM dust emissions, which is the primary pollutant of concern during construction. Fugitive PM dust emissions (e.g., PM_{10} and $PM_{2.5}$) vary as a function of several parameters, such as soil silt content and moisture, wind speed, acreage of disturbance area, and the intensity of activity performed with construction equipment.

Exhaust emissions from off-road construction equipment, material delivery trips, and construction worker-commute trips could also contribute to short-term increases in PM emissions, but to a lesser extent. Exhaust emissions from construction related mobile sources also include ROG and NOx. These emission types and associated levels fluctuate greatly depending on the particular type, number, and duration of usage for the varying equipment.

The site preparation phase typically generates the most substantial emission levels because of the on-site equipment and ground-disturbing activities associated with grading, compacting, and excavation. Site preparation equipment and activities typically include backhoes, bulldozers, loaders, and excavation equipment (e.g., graders and scrapers). Although detailed construction information is not available at this time, based on the types of activities that could be conducted, it would be expected that the primary sources of construction related emissions include soil disturbance and equipment related activities (e.g., use of backhoes, bulldozers, excavators, and other related equipment). Based on typical emission rates and other parameters for above-mentioned equipment and activities, construction activities could result in hundreds of pounds of daily NOx and PM emissions, which may exceed general mass emissions limits of a local or regional air quality management district depending on the location of generation. Thus, implementation of new regulations and/or incentives could generate levels that conflict with applicable air quality plans, exceed or contribute substantially to an existing or projected exceedance of State or national ambient air quality standards, or expose sensitive receptors to substantial pollutant concentrations.

As a result, short-term construction related air quality impacts associated with the methane reduction measures would be potentially significant.

Mitigation Measure 3.2-a

The Regulatory Setting in Attachment A includes applicable laws and regulations that provide protection of air quality. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that would be approved by local jurisdictions. The ability to require such measures is generally within the purview of jurisdictions with local or State land use approval and/or permitting authority with direct authority over the project. New or modified facilities in California would likely qualify as a "project" under CEQA because they would generally need a discretionary public agency approval and could affect the physical environment. The jurisdiction with primary approval authority over a proposed action is the lead agency, which is required to review the proposed action for compliance with CEQA. Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority. Recognized practices routinely required to avoid and/or minimize impacts to air quality include the following:

- Proponents of new facilities constructed as a result of reasonably foreseeable compliance responses would coordinate with local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA). The local jurisdiction with land use authority would determine that the environmental review process complied with CEQA and other applicable regulations, prior to project approval.
- Based on the results of the environmental review, proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the construction-related air quality impacts of the project.
- Project proponents would apply for, secure, and comply with all appropriate air quality permits for project construction from the local agencies with air quality jurisdiction and from other applicable agencies, if appropriate, prior to construction mobilization.
- Project proponents would comply with the federal Clean Air Act and the California Clean Air Act (e.g., New Source Review and Best Available Control Technology criteria, if applicable).
- Project proponents would comply with local plans, policies, ordinances, rules, and regulations regarding air quality-related emissions and associated exposure (e.g., construction-related fugitive PM dust regulations, indirect source review, and payment into offsite mitigation funds).
- For projects located in PM nonattainment areas, prepare and comply with a dust abatement plan that addresses emissions of fugitive dust during construction and operation of the project.

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and the programmatic level of analysis associated with this Revised Draft EA does not attempt to address project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation that may ultimately be implemented to reduce potentially significant impacts. With mitigation, construction emissions, though not likely, could still exceed local air district threshold levels of significance depending on the magnitude of construction activities.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that short-term construction-related air quality impacts associated with black carbon reduction measures would be **potentially significant and unavoidable**.

Impact 3.2-b: Long-Term Operational Effects on Air Quality

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: operation of new modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors).

Because the implementation details of many of the measures identified in the SLCP Strategy depend substantially on the design of future incentive and regulatory programs, and upon local permitting decisions, long-term air quality impacts at this point are difficult to categorize with certainty. There are methods available to implement the identified measures that may have beneficial impacts on long-term air quality through the replacement of more-polluting emissions sources and fuels. However, for the conservative purposes of this programmatic analysis, ARB also discloses implementation choices that could yield potentially significant impacts on air quality.

a) Agricultural Methane

At this time, the specific location, type, and number of dairies that would implement solid manure management practices or install digesters for various purposes cannot be known and would be dependent upon a variety of factors that are not within the control or authority of ARB. Options that could be implemented are discussed below. (See also Chapter VIII and Appendix D of the SLCP Strategy for more details.)

Using solid manure collection and management systems at existing dairies would reduce methane emissions by keeping manure out of lagoons. However, depending on conditions, solid manure management practices could lead to increased emissions, such as those associated with increased usage of on-farm equipment and trucking to handle and apply solid manure, as well as PM_{10}, ammonia, nitrous oxide, and volatile organic compounds (VOCs); the latter of which contributes to the creation of photochemical smog. However, existing lagoon systems typically produce ammonia, hydrogen sulfide, and VOCs. The use of digester systems in conjunction with dry manure management practices could potentially reduce odors, and emissions of VOCs, ammonia, and hydrogen sulfide associated with existing flush-water lagoon management systems.

Solid scrape or vacuum manure management and above ground tank or plug-flow anaerobic digestion systems, with biogas conditioning sufficient to produce renewable natural gas (RNG) meeting utility pipeline injection or vehicle fueling standards, may be used as a result of implementation of the SLCP Strategy. Combustion of RNG as a vehicle fuel may produce NOx emissions, but would be expected to potentially reduce mobile source NOx emissions from non-renewable petroleum fuels by replacing petroleum-based fuels. Natural gas vehicles may produce less NOx emissions (and potentially, substantially less) than vehicles using petroleum fuels, and may offer net reductions in other potentially harmful pollutants (e.g. diesel PM), especially when offsetting diesel fuels.

Increasing use of fuels that result in lower NOx emissions than gasoline and diesel would contribute to attaining ambient air quality standards. The lower NOx emission rates of RNG vehicle fuels, when compared to gasoline and diesel fuels, may result in a statewide net reduction in NOx emissions.

However, on a more local level, use of digesters could result in operational sources of fugitive dust, which would primarily be from processing equipment and truck movement over paved and unpaved surfaces. In addition, non-methane VOCs released from pre-digested substrate materials during the receipt and pre-processing activities at anaerobic digestion facilities would not be a regional change, but could result in an increase in local emissions. The operation of any digesters installed at existing or new dairies could potentially increase localized criteria pollutant emissions, but could also ultimately decrease them. The quantity and type of emission increases would be dependent of the type of digester technologies installed and the end use of captured biogas, but may include carbon monoxide (CO), PM, oxides of sulfur (SOx), VOCs, and NOx emissions.

Equipment associated with digesters and related manure management could also potentially increase regional NOx emissions, a precursor to the formation of ozone. Digesters may also install combustion systems to dispose of collected methane vapors. Although some combustion systems have very low criteria pollutant emissions, some do not. Any flaring of gas associated with digesters combined with biogas cleaning and compressing facilities could also potentially increase NOx emissions. However, flares at digesters would not be expected to operate except for emergency purposes. Moreover, permitting would be required on a district basis, which is intended ensure that an air basin does not go out of attainment for ambient air quality standards.

Where producing transportation fuel or pipeline injection would be less practical, manure could be digested and converted to electricity onsite. This control pathway uses solid manure management and above ground tank or plug-flow digesters to produce RNG for onsite electricity generation. Onsite generation, even with certified systems, could create locally a new and potentially substantial source of NOx emissions.

In the event that dairy operators choose to transport manure offsite for centralized digestion, NOx and PM emissions could increase with any increase in the use of internal combustion engines. However, the increased availability of RNG could encourage investment in RNG-powered trucks, which could then reduce harmful NOx and particulate matter emissions, as discussed above. In cases where biogas could not be easily connected to the natural gas pipeline or used along transportation corridors, manure methane emissions could be avoided by converting from flush to dry manure management systems. NOx emissions would not be expected to substantially increase with this approach.

In sum, the operation of digesters and dry manure management practices at dairies could decrease or increase criteria air pollutant emissions depending on many factors, including the quantity and type of digester technologies installed and the end use of captured biogas. The installation and operation of digester systems at dairies would be subject to stationary source permitting rules and regulations.

In addition, some dairies may convert to a pasture-based model where manure decays aerobically in the field; and, thus, would not generate methane. They would not increase NOx emissions, or otherwise result in increased criteria air pollutant and TAC emissions.

As part of a sector-wide strategy that emphasizes use of renewable natural gas in the transportation sector, pipeline injection, clean electricity generating technologies, and non-energy alternatives, manure methane emissions could be reduced significantly, while also improving air quality in surrounding communities. Negative impacts are also possible, however, depending on implementation choices. ARB and other implementing agencies will carefully consider these factors during program design and implementation going forward.

b) Waste Methane

The operation of new green waste composting facilities could potentially increase localized VOC and PM emissions, depending upon the type of composting activities (e.g., windrows, aerated static piles) employed. These facilities could also cause other criteria air pollutant emission increases associated with the various types of on-site heavy equipment typically used at compost facilities (e.g., tractors, compost turners, and grinders), and the off-site use of heavy equipment such as manure spreaders. The development of new green waste composting facilities could cause a significant increase in waste-haul truck traffic to and from these sites.

Air quality impacts associated with the operation of digesters and associated equipment at composting facilities could potentially increase long-term emissions. The quantity and type of potential emission increases would depend of the type of digester technologies installed and the end use of captured biogas, and may include CO, PM, SO_X, VOCs and NO_X emissions. Other long-term potential air quality impacts might include truck and vehicle fueling activities at these facilities, and increased odor from the storage and digestion of organic materials (as discussed below).

Although there would be emissions associated with these sources at anaerobic digestion and composting facilities, the operation of these facilities would divert organics out of landfills. By doing so, there would be less activity at landfills, such as potentially fewer pieces of off-road equipment and a potential decrease in the vehicle miles traveled (VMT) for haul trucks. The operation of anaerobic digestion facilities could also help offset other emission sources by generating electricity or producing biogas as a substitute for fossil vehicle fuels.

Air quality impacts associated with the operation of digesters and associated equipment at existing or new wastewater treatment facilities could also potentially increase long-term emissions. The quantity and type of potential emission increases would be dependent of the type of digester technologies installed and the end use of captured biogas, and may include CO, PM, SO_X, VOCs and NO_X emissions.

In addition, the potential re-design or expansion of existing wastewater treatment plants to process or co-digest regional sources of organic materials could result in vehicle emissions associated with this traffic. Other long-term potential air quality impacts might include truck and vehicle fueling activities at these facilities, and increased odor from the storage and digestion of organic materials (as discussed below). ARB and other implementing agencies will carefully consider these factors during program design and implementation going forward.

c) Oil and Gas Methane

Reasonably foreseeable compliance responses include emission control infrastructure additions to storage tanks, pipelines, and compressors within existing oil and gas processing and storage facilities. Some of these infrastructure control strategies are already in use by several local air districts, which have been controlling emissions of VOCs and NO_x within the oil and gas sector for over 30 years. This measure would uniformly expand control of such emission sources to all air districts and regulate additional infrastructure components (such as valves, flanges, and seals) that are not currently regulated by local district programs.

There are potential co-benefits from this measure of VOC and TAC emission reductions, although those co-benefits have not yet been estimated. ARB staff is investigating ways to ensure that there will be no substantial increase in criteria air pollutant emissions in cases where methane and VOC emissions would not be sent into existing sales lines, fuel lines, reinjection wells, or combustion devices, and would be instead captured, by installing new vapor collection devices on existing storage tanks, and combusted. ARB anticipates this proposed measure, including potential requirements to upgrade existing combustion devices to low-NOx devices if combustion is required, would likely result in beneficial impacts to air quality on net.

In this scenario, combustion systems installed at oil and gas facilities would be enclosed and meet low-NOx standards. Furthermore, installation and operation of these systems would generally be subject to permitting by local air quality districts. Thus, combustion undertaken as a result of implementation of this measure would not be expected to interfere with attainment of air quality standards and may well yield criteria pollutant benefits.

The proposed emergency regulation for underground gas storage facilities and related infrastructure, along with any measures ARB or the Division of Oil, Gas, and Geothermal Resources (DOGGR) take to improve monitoring for these facilities, are anticipated to increase the frequency of monitoring and inspection activities at these facilities, and may help reduce fugitive methane emission leaks at these storage facilities. It is anticipated that daily leak detection monitoring equipment would be installed on a permanent basis, but could potentially involve the daily transport leak detection equipment and staff to and from these storage sites.

d) Conclusion

Based on all of the above, it is expected that overall the methane measures could be implemented in ways that result in long-term operational air quality benefits, because there is not enough information at this time about ultimate design and implementation, this Revised Draft EA conservatively find this measures in aggregate (though not necessarily to any individual measure), could be potentially significant.

Mitigation Measure 3.2-b: Implement Mitigation Measure 3.2-a

As the measures identified in this SLCP Strategy are developed into regulations or other specific proposed activities, ARB is bound by its continuing duties, under its authorizing statutes and under SB 605, SB 1383, and AB 32 in particular, to ensure that measures it proposes to adopt and carry out do not interfere with the State's progress towards attainment with public health standards, and in particular the health effects in disadvantaged communities. ARB also strives to ensure that funding decisions it makes are consistent with these core commitments. Therefore, it is expected that at the specific measure development stage, ARB will design and implement the methane reduction measures in ways that protect and enhance air quality, while avoiding other negative environmental effects to the greatest degree feasible. At this stage of developing the SLCP Strategy, however, the precise design of the measures has not been determined as that will occur through the public processes during the specific measure development phase.

Moreover, for project-level specific impacts, the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects carried out in response to any measures ARB develops, and the programmatic level of analysis associated with this Revised Drat EA cannot and does not attempt to address project-specific details of mitigation. Therefore, there is inherent uncertainty in the degree of mitigation that may ultimately be implemented to reduce potentially significant long-term operational air quality impacts occurring due to project-level impacts.

Consequently, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that long-term operational impacts associated with the methane reduction measures would be **potentially significant and unavoidable**.

Impact 3.2-c: Short-term Construction-Related and Long-Term Operational Effects on Odors

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction and operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors). These measures could significantly expand the operational functions of dairies and wastewater treatment plants and create new systems and practices for managing organic wastes.

Modifications to existing oil and gas facilities could occur due to implementation of methane reduction measures. Improvements may include the installation of equipment such as low-bleed or zero-bleed pneumatic devices, vapor recovery systems, and pipelines, flanges, and valves when needed. These modifications would reduce fugitive methane emissions and increase the efficiency of oil and gas processes. This action would not result in an adverse release of odors near sensitive receptors.

With regard to the dairy sector, a potential compliance response could be modifications to manure management systems involving the replacement of flush-water lagoon systems with solid manure collection and management systems, including the construction of dairy digester facilities to process manure anaerobically to produce methane for capture. The current flush-water systems used by dairies involve flushing manure into lagoons where it undergoes natural decomposition resulting in the release of odorous compounds (e.g., ammonia and hydrogen sulfide) into the environment.

Dairies that singularly adopt digester systems could reduce impacts to odor associated with wastewater used in flush systems (Parker 2011).

The construction of digesters associated with dairies could result in the manure being placed into the digester rather than into on-site storage ponds or stockpiles. This could limit open air degradation (resulting in the breakdown of volatile organic compounds through anaerobic process that would occur in a closed system) and could result in more control over emissions than current conditions found at dairies that employ flush-water and scrape manure management systems (Regional Water Quality Control Board [RWQCB] 2010). Implementation of the methane reduction measures could result in increased construction and operation of anaerobic digesters. These may be small, and associated with individual businesses, or larger to accommodate regional needs. Wastewater treatment facilities and digesters constructed for manure and diverted organic waste would perform anaerobic digestions in a closed system; however, fugitive emissions of odorous compounds, such as ammonia and hydrogen sulfide, could be released into the environment (RWQCB 2010). These fugitive emissions of odorous compounds could be offensive to sensitive receptors, depending on their proximity, the design of anaerobic digesters, and exposure duration.

Further, the collection, transport, storage, and pre-processing activities of potentially odiferous organic substrates for digestion (e.g., manure, compost), in addition to the resulting digestate, could produce nuisance odors at or near anaerobic digesters. The development of new green waste composting facilities, which may include the operation of anaerobic digesters, could also result in the creation of new regional or localized sources of odors such as from the processing, storage, and aeration of compost materials.

Depending on location, sensitive receptors could include schools, hospitals, daycare facilities, playgrounds, parks, and residences. Thus, short-term construction –related and long-term operational odors associated with the methane reduction measures could result in a potentially significant impact.

Mitigation Measure 3.2-c

The Regulatory Setting in Attachment A includes applicable laws and regulations that govern odor emissions. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that would be approved by local jurisdictions. The ability to require such measures is within the purview of jurisdictions with local or state land use approval and/or permitting authority. New or modified facilities in California would likely qualify as a “project” under CEQA, because they would generally need a discretionary public agency approval and could affect the physical environment. The jurisdiction with primary approval authority over a proposed action is the Lead Agency, which is required to review the proposed action for compliance with CEQA. Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority.

Recognized practices routinely required to avoid and/or minimize impacts to odors include the following:

Proponents of new facilities constructed as a result of reasonably foreseeable compliance responses would coordinate with local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirement (e.g., CEQA). The local jurisdiction with land use authority would determine that the environmental review process complied with CEQA and other applicable regulations, prior to project approval.

Based on the results of the environmental review, proponents would implement all feasible mitigation identified in the environmental document to reduce or sustainably lessen the operational odor impacts of the project. Project proponents will comply with local plans, policies, ordinances, rules, and regulations for potentially odiferous processes, including setbacks and buffer areas from sensitive land uses.

Anaerobic digester facilities classified as a compostable material handling facility must develop an Odor Impact Minimization Plan (OIMP). (Cal. Code Regs., tit.14, § 17863.4.) Or, applicants shall develop and implement an Odor Management Plan (OMP) that incorporates similar odor reduction controls for digester operations. Odor control strategies that may be incorporated into these plans include, but are not limited to, the following:

- A list of potential odor sources;
- Identification and description of the most likely sources of odor; and
- Identification of potential, intensity, and frequency of odor from likely sources.
- A list of odor control technologies and management practices that could be implemented to minimize odor released. These management practices shall include the establishment of the following criteria:
- Establish time limit for on-site retention of undigested substrates;
- Require substrate haulage to the facilities within sealed containers;
- Provide enclosed, negative pressure buildings for indoor receiving and preprocessing. Treat collected foul air in a biofilter or air scrubbing system;
- Establish contingency plans for operating downtime;
- Manage delivery schedule to facilitate prompt handling of odorous substrates;
- Handle digestate within enclosed building and/or directly pump to sealed containers for transportation;
- Protocol for monitoring and recording odor events; and
- Protocol for reporting and responding to odor events.

Because the authority to determine project-level impacts and require project-level mitigation lies with the land use and/or permitting agencies for individual projects, and the programmatic level of analysis associated with this Revised Draft EA does not attempt to address project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation that may ultimately be implemented to reduce potentially significant impacts. With mitigation, operational emissions of odors could still exceed the threshold of significance for local land use plans, policies, rules, ordinances, and regulations.

Consequently, while impacts would be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusions and discloses, for CEQA compliance purposes, that short-term construction-related and long-term operational odor impacts resulting from the incorporation of solid manure collection and management systems and/or the development and operation of new anaerobic digester facilities associated with the methane reduction measures would be **potentially significant and unavoidable**.

3. Impacts Associated with HFC Measures

Impact 3.3-a: Short-Term Construction Related and Long-Term Operational Effects on Air Quality

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications. Also, some low-GWP refrigerants (e.g., hydrocarbons, ammonia) can power existing systems (U.S. EPA 2010). Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. These modifications would be carried out by small crews which would not cause a significant increase in worker trips or material delivery, would not require significant construction equipment or excavation activities, and would be temporary in nature. Therefore, it is expected these activities will not contribute significantly to emissions.

It is reasonably foreseeable that increased operational use of hydrocarbons, ammonia, and HFOs could result in additional emissions of VOCs from hydrocarbons, and particulate matter from ammonia from these modified facilities, as detailed below. Some of this would be expected to occur anyway due to the global HFC phasedown agreement, but in the interest of providing full information, the potential for these additional emissions are described below.

VOCs from hydrocarbons:

Increased VOC emissions could occur, but would be anticipated to be relatively low. If all smaller self-contained refrigeration units, refrigerated vending machines, and residential refrigerator-freezers were to theoretically begin using hydrocarbon refrigerants, the VOC emissions in California could increase by 3,000 pounds per day. (Assuming annual leak rates and equipment end-of-life loss rates remain unchanged from HFC refrigerants.) These added VOC emissions from refrigerants would increase the current statewide ROG emissions of 3.5 million pounds per day by 0.09 percent. (U.S. EPA 2014). According to the 2014 U.S. EPA analysis on the impacts of hydrocarbon refrigerants on ground level ozone, the maximum 8-hour ozone (O_3) increase could be as high as 6.61 parts per billion (ppb) compared to a maximum allowable level of 75 ppb; or a nine percent O_3 increase. However, the most realistic mix of hydrocarbon refrigerants used would increase the O_3 levels by 0.15 ppb, or 0.2 percent. The 2014 U.S. EPA analysis summary of findings states:

> "….it is concluded that non-attainment resulting from hydrocarbon refrigerant emissions is not likely to be a major concern for local air quality. Hydrocarbon refrigerants could potentially increase ground level ozone by less than 1 percent under Scenario 4 [the most likely scenario], but up to a 9 percent increase on a given day for the most reactive hydrocarbons (propylene) in the most extreme case. However, in most cases this upper bound level of increase is not likely, as most ozone nonattainment areas are not VOC-limited (i.e., the formation of ozone in these areas are not limited by VOC emissions, but by other compounds such as nitrogen oxides [NO_x]). In fact, Scenario 4, the "most realistic" scenario for hydrocarbon refrigerant emission usage, showed a less than 0.2 percent increase in ground level ozone for the most extreme case."

Particulate matter from ammonia:

Increased emissions of ammonia could also occur, as ammonia emissions could act as precursors for PM, but would be anticipated to be minimal. Ammonia refrigeration contributes one to two percent of all ammonia emissions nationally, with the largest sources from livestock (71 percent) and agricultural fertilizer (14 percent). If one-third to half of all larger-sized refrigeration units (charge size greater than 15 pounds) were to use ammonia refrigerant, and the emission rates remain the same as current HFC emissions rates, an additional 12,000 to 13,000 pounds of ammonia per day would be emitted statewide (Krauter et. al. 2002, NEI 2015). Added to the baseline of approximately 35,000 to 40,000 pounds of ammonia emitted daily from refrigeration, the new ammonia refrigeration increases emissions from this subsector up to 35 percent, but increases overall emissions only 0.3 percent from the current daily emissions of four to five million pounds of ammonia in California.

The emission inventory, monitoring data, and precursor sensitivity analyses all indicate that NOx rather than ammonia is the limiting precursor for ammonium nitrate formation in the major air basins in California, including the San Joaquin Valley and the South Coast, and therefore a small amount of extra ammonia emission is expected to have negligible effects on $PM_{2.5}$ formation (Chen et. al. 2014, Kelly et. al. 2014, Kleeman et. al. 2005). Thus, the increased use of hydrocarbons and ammonia would result in negligible amounts of emissions of VOCs and particulate matter.

Although some low-GWP replacements are known to have an objectionable odor (e.g., ammonia), these molecules are produced in sealed containers for use in refrigeration and air conditioning systems. Some replacements have a characteristically slight odor (i.e., CO_2, HFOs). Fugitive emissions leaks that could occur would be in very low amounts and would not result in a release of odors that could adversely affect a substantial number of people.

HFO-1234yf and HFO-1234ze, which are both currently being produced, have a slight ether-like odor. In the case that an accidental release of these compounds occurred during production or distribution, HFO-1234yf and HFO-1234ze would not constitute an objectionable odor such that a substantial number of people would be adversely affected (Honeywell 2015a, 2015b).

The short-term construction-related and long-term operational impacts to air quality and odors associated with the HFC reduction measures would be **less-than-significant**.

F. Biological Resources

1. Impacts Associated with Black Carbon Measures

Impact 4.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Biological Resources

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be incorporated into the design of future development projects. These are minor modifications that would not disturb new land and affect biological resources.

The amount of wood collected and used in fireplaces and woodstoves could be reduced as a result of the proposed black carbon measures. While firewood is supplied from a variety of sources, including agricultural-based orchards, some is derived from forests in the State through individual or commercial use. However, this reduction in wood collected would not substantially alter to fuels management practices and not substantially affect the amount of wood collected in forests and thereby not affect biological resources in wood collection areas.

Thus, the short-term construction related and long-term operational air quality impacts related to the black carbon measures would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 4.2-a: Short-Term Construction-Related and Long-Term Operational Effects on Biological Resources

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction and operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic materials diverted from landfills into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, such as pipeline installation and methods of disposal of methane vapors, and inspection and monitoring of equipment).

Construction activities related to these compliance responses could cause temporary direct and indirect adverse impacts to special status species and habitats. Modifications to oil and gas facilities as a compliance response would generally be minimal and above-ground. The potential for adverse construction-related effects on biological resources would be limited to installation of pipelines and temporary staging areas associated with facility modifications. Direct mortality could result from destruction of dens, burrows, or nests through ground compaction, ground disturbance, debris, or vegetation removal within oil and gas facility sites. Indirect impacts to animals could result from noise disturbance that might increase nest or den abandonment and loss of reproductive or foraging potential around the site during construction, transportation, or destruction of equipment.

Most oil and gas facilities presently exist on sites that are/have been subject to severe disturbance including grading, trenching, paving, and construction of roads and structures. Daily activities often include the presence of humans, movement of automobiles, trucks and heavy equipment, and operation of stationary equipment. In general, oil and gas facilities are not considered conducive to many biological resources. Vegetation is often removed or controlled and wildlife displaced to more suitable surroundings. Additionally, modifications associated with methane measures in the SLCP Strategy would occur within the well facility boundaries, which are highly disturbed and not likely to be supportive of biological species.

Nonetheless, there are plant and animal species that occur, or even thrive, in developed settings. Activities that require disturbance of undeveloped areas, such as the construction of new structures, boreholes, surface wells, roads or paving have the potential to adversely affect plant or animal species that may reside in those areas. Because of the possible presence of special status species or habitat that might be directly or indirectly adversely impacted by modifications to oil and gas facilities, biological resources could adversely be affected.

In addition to modifications at oil and gas facilities, implementation of the methane reduction measures could result in modifications to dairies and wastewater treatment plants. These modifications would occur within the footprint of existing facilities, in area that are already highly disturbed or within structures and would not be expected to adversely affect biological resources. Diversion of compostable materials from landfills would not be expected to result in take of individual species or adversely affect habitat.

Finally, methane reduction measures could result in construction of new or expansion of existing facilities. While there is uncertainty as to the exact location of any new facilities or modification made to existing facilities, construction could require disturbance of undeveloped areas, such as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways. The biological resources that could be affected by the construction of new anaerobic digestion facilities depend on the specific location of any necessary construction and its environmental setting. Adverse impacts could include modifications to existing habitat; including removal, degradation, and fragmentation of riparian systems, wetlands, or other sensitive natural wildlife habitat and plant communities; interference with wildlife movement or wildlife nursery sites; loss of special-status species; and/or conflicts with the provisions of adopted habitat conservation plans, natural community conservation plans, or other conservation plans or policies to protect natural resources.

Short-term construction-related and long-term operational impacts to biological resources associated with the methane reduction measures would be potentially significant.

This impact on biological resources associated with the methane reduction measures could be reduced to a less-than-significant level by mitigation that can and should be implemented by local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 4.2-a

The Regulatory Setting in Attachment A includes applicable laws and regulations that provide protection of biological resources. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that would be approved by local jurisdictions. The ability to require such measures is under the purview of jurisdictions with local or State land use approval and/or permitting authority. New or modified facilities in California would qualify as a "project" under CEQA. The jurisdiction with primary approval authority over a proposed action is the Lead Agency, which is required to review the proposed action for compliance with CEQA statutes.

Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority. Recognized practices that are routinely required to avoid and/or minimize impacts to biological resources include:

- Proponents of new facilities constructed as a result of reasonably foreseeable compliance response to new regulations would coordinate with local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA).
- The local or State land use agency or governing body must comply with applicable regulations and would approve the project for development.
- Based on the results of project level environmental review, project proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the environmental impacts of the project. Actions required to mitigate potentially significant biological impacts may include the following; (however, any mitigation specifically required for a new or modified facility would be determined by the local lead agency):
    - Retain a qualified biologist to prepare a biological inventory of site resources prior to ground disturbance or construction. If protected species or their habitats are present, comply with applicable federal and State endangered species acts and regulations. Construction and operational planning will require that important fish or wildlife movement corridors or nursery sites are not impeded by project activities.
    - Retain a qualified biologist to prepare a wetland survey of onsite resources. This survey shall be used to establish setbacks and prohibit disturbance of riparian habitats, streams, intermittent and ephemeral drainages, and other wetlands. Wetland delineation is required by Section 3030(d) of the Clean Water Act and is administered by the U.S. Army Corps of Engineers.
    - Prohibit construction activities during the rainy season with requirements for seasonal weatherization and implementation of erosion prevention practices.
    - Prohibit construction activities in the vicinity of raptor nests during nesting season or establish protective buffers and provide monitoring, as needed, to address project activities that could cause an active nest to fail.
    - Prepare site design and development plans that avoid or minimize disturbance of habitat and wildlife resources, and prevent stormwater discharge that could contribute to sedimentation and

degradation of local waterways. Depending on disturbance size and location, a National Pollution Discharge Elimination System (NPDES) construction permit may be required from the State Water Resources Control Board.

- Prepare spill prevention and emergency response plans, and hazardous waste disposal plans as appropriate to protect against the inadvertent release of potentially toxic materials.
- Plant replacement trees and establish permanent protection suitable habitat at ratios considered acceptable to comply with "no net loss" requirements.

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and the programmatic level of analysis associated with this Revised Draft EA does not attempt to address project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation that may ultimately be implemented to reduce potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that short-term construction-related long-term operational impacts to biological resources associated with black carbon reduction measures would be **potentially significant and unavoidable**.

3. Impacts Associated with HFC Measures

Impact 4.3-a: Short-Term Construction-Related Effects on Biological Resources

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Modifications to existing facilities to incorporate high-GWP refrigerants replacements would be minor in nature as several low-GWP refrigerants can be used in established systems (e.g., hydrocarbons, ammonia) (U.S. EPA 2010). These changes in use would occur within existing systems. Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. Since these renovation activities would occur within existing footprints that are previously disturbed and not disturb new areas, it is expected to not adversely affect biological resources.

Therefore, short-term, construction-related impacts to biological resources associated with the HFC reduction measures would be **less-than-significant**.

Impact 4.3-b: Long-Term Operational Effects on Biological Resources

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

As discussed in the previous section, incorporation of low-GWP refrigerants to existing residences and commercial buildings and facilities would not result in disturbance to plant and animal habitat or direct mortality of individuals as a result of construction-related activities.

However, operationally, HFO breakdown products include TFA, a mildly phytotoxic, water soluble compound. TFA accumulates in the atmosphere and, due to its high solubility, is deposited on the earth's surface during precipitation events. TFA does not degrade easily by biological and non-biological physiochemical processes, or photochemical breakdown (Russel et. al. 2012). The use of HFO would increase rates of TFA formation, which could potentially accumulate in aquatic environments, including wetlands (Cahill et. al. 2001).

Under Section 612 of the Clean Air Act, U.S. EPA reviews substitutes (i.e., chemicals that may replace one that is currently in use for a specific purpose) within a comparative risk framework. This process is implemented through U.S. EPA's Significant New Alternatives Policy (SNAP) program, which provides an evolving list of alternatives. In more than twenty years since the initial SNAP rule was promulgated, U.S. EPA has modified the SNAP lists many times, most often by expanding the list of acceptable substitutes, but in some cases by prohibiting the use of substitutes previously listed as acceptable. U.S. EPA makes decisions informed by the overall understanding of the environmental and human health impacts as well as the current knowledge regarding available substitutes. When U.S. EPA is determining whether to add a new substitute to the list, they compare the risk posed by the new substitute to the risks posed by other alternatives on the list and determine whether that specific new substitute poses more risk than already-listed alternatives for the same use. Section 612 provides that U.S. EPA must prohibit the use of a substitute where it has determined that there are other available substitutes that pose less overall risk to human health and the environment.

In March 2011, HFO-1234yf was approved as acceptable for use in new passenger cars and light-duty trucks under specific use conditions. As part of the approval process, public comments were received regarding the approval of HFO-1234yf on U.S. EPA's SNAP list. Several issues were addressed including potential environmental impacts, such as those described above associated with TFA's effects on algae. In response to these concerns, U.S. EPA summarized the issue and provided an overview of potential environmental effects. U.S. EPA determined that the projected maximum TFA concentration in rainwater and in surface water should not result in a significant risk of aquatic toxicology (76 Federal Register 17488) for the following stated reason:

> As [the U.S. EPA] developed the proposed rule, the data … relied on indicated that in the worst case, the highest monthly TFA concentrations in the area with the highest expected emissions, the Los Angeles area, could exceed the no observed adverse effect [level (NOAEL)] for the most sensitive plant species, but annual values would never exceed that value. Further, TFA concentrations would never approach levels of concern for aquatic animals (ICF 2009). In a more recent analysis, ICF (2010a, b, c, e) performed modeling for U.S. EPA using the kinetics and decomposition products predicted specifically for HFO-1234yf and considered revised emission estimates that were slightly lower than in a 2009 analysis (ICF 2009). The revised analysis found a maximum projected concentration of TFA in rainwater of approximately 1,700 ng/L, roughly one-thousandth of the estimate from our 2009 analysis (ICF 2010b). This maximum concentration is roughly 34 percent higher than the 1,264 ng/L reported by Luecken et al. (2009), reflecting the higher emission estimates we used (ICF 2010b). A maximum concentration of 1700 ng/L corresponds to roughly 1/600th of the NOAEL for the most sensitive algae species--thus, it is not a level of concern. We find these additional analyses confirm that the projected maximum TFA concentration in rainwater and in surface waters should not result in a significant risk of aquatic toxicity, consistent with our original proposal.

U.S. EPA's SNAP list considers substitutes based on their end use sector. That is, while HFO-1234yf is approved for use in new passenger cars and light-duty trucks, it would need to be reconsidered for use in other sectors such as commercial refrigeration. In addition, U.S. EPA may be petitioned to de-list alternatives from the SNAP list at any time. Thus, because use of HFOs must be subject to review and on-going monitoring under the U.S. EPA SNAP program, and must not pose a greater risk to the environment or human health than the chemical it is replacing, this impact would be **less-than-significant**.

G. Cultural Resources

1. Impacts associated with Black Carbon Measures

Impact 5.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Cultural Resources

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be

incorporated into the design of future development projects. These are minor modifications to already disturbed areas that do not result in disturbances to land that could affect cultural resources.

Thus, short-term construction-related and long-term operational impacts on cultural resources associated with black carbon reduction measures would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 5.2-a: Short-Term Construction-Related and Long-Term Operational on Cultural Resources

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Construction activities could require disturbance of undeveloped areas, such as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways. Demolition of existing structures may also occur before the construction of new buildings and structures. The cultural resources that could potentially be affected by ground disturbance activities could include, but are not limited to, prehistoric and historical archaeological sites, paleontological resources, tribal cultural resources, historic buildings, structures, or archaeological sites associated with agriculture and mining, and heritage landscapes.

Properties important to Native American communities and other ethnic groups, including tangible properties possessing intangible traditional cultural values, also may exist.

Historic buildings and structures may also be adversely affected by demolition-related activities. Such resources may occur individually, in groupings of modest size, or in districts. Because culturally sensitive resources can also be located in developed settings, historic, archeological, and paleontological resources, and places important to

Native American communities, could also be adversely affected by construction of new facilities.

New facilities constructed as a potential compliance response may be located in a region where significant prehistoric or historic-era cultural resources may have been recorded and there remains a potential that undocumented cultural resources could be unearthed or otherwise discovered during ground-disturbing and construction activities. Prehistoric materials might include flaked stone tools, tool-making debris, stone milling tools, shell or bone items, and fire affected rock or soil darkened by cultural activities; examples of significant discoveries would include villages and cemeteries. Historic material might include metal, glass, or ceramic artifacts. Examples of significant discoveries might include former privies or refuse pits (middens).

Due to the possible presence of undocumented cultural resources and paleontological resources, short-term construction-related and long-term operational impacts on cultural resources associated with the methane reduction measures would be potentially significant.

This impact could be reduced to a less-than-significant level by mitigation that can and should be implemented by local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 5.2-a

The Regulatory Setting in Attachment A includes applicable laws and regulations that provide protection of cultural resources. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that would be approved by local jurisdictions. The ability to require such measures is under the purview of jurisdictions with local or State land use approval and/or permitting authority. New or modified facilities in California would qualify as a “project” under CEQA. The jurisdiction with primary approval authority over a proposed action is the Lead Agency, which is required to review the proposed action for compliance with CEQA statutes. Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority. Recognized practices that are routinely required to avoid and/or minimize impacts to cultural resources include:

- Proponents of new facilities constructed as a result of reasonably foreseeable compliance responses to new regulations would coordinate with local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA).
- The local or State land use agency or governing body must comply with applicable regulations and would approve the project for development.
- Based on the results of project level environmental review, project proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the

environmental impacts of the project. The definition of actions required to mitigate potentially significant cultural impacts may include the following; however, any mitigation specifically required for a new or modified facility would be determined by the local lead agency.

- Retain the services of cultural resources specialists with training and background that conforms to the U.S. Secretary of Interior's Professional Qualifications Standards, as published in Title 36, Code of Federal Regulations, part 61.
- Seek guidance from the State and federal lead agencies, as appropriate, for coordination of Nation-to-Nation consultations with the Native American Tribes.
- Provide notice to Native American Tribes of project details to identify potential Tribal Cultural Resources (TCRs). In the case that a TRC is identified, prepare mitigation measures that:
    - avoid and preserve the resources in place,
    - treat the resource with culturally appropriate dignity,
    - employ permanent conservation easements, and protect the resource.
    - Consult with lead agencies early in the planning process to identify the potential presence of cultural properties. The agencies will provide the project developers with specific instruction on policies for compliance with the various laws and regulations governing cultural resources management, including coordination with regulatory agencies and Native American Tribes.
- Define the area of potential effect (APE) for each project, which is the area within which project construction and operation may directly or indirectly cause alterations in the character or use of historic properties. The APE should include a reasonable construction buffer zone and laydown areas, access roads, and borrow areas, as well as a reasonable assessment of areas subject to effects from visual, auditory, or atmospheric impacts, or impacts from increased access.
- Retain the services of a paleontological resources specialist with training and background that conforms with the minimum qualifications for a vertebrate paleontologist as described in Measures for Assessment and Mitigation of Adverse Impacts to Non-Renewable Paleontologic Resources: Standard Procedures (Society of Vertebrate Paleontology 2010).
- Conduct initial scoping assessments to determine whether proposed construction activities would disturb formations that may contain important paleontological resources. Whenever possible potential impacts to paleontological resources should be avoided by moving the site of construction or removing or reducing the need for surface disturbance. The scoping assessment should be conducted by the qualified paleontological resources specialist in accordance with applicable agency requirements.

The project proponent's qualified paleontological resources specialist would determine whether paleontological resources would likely be disturbed in a project area on the basis of the sedimentary context of the area and a records search for past paleontological finds in the area. The assessment may suggest areas of high known potential for containing resources. If the assessment is inconclusive a surface survey is recommended to determine the fossiliferous potential and extent of the pertinent sedimentary units within the project site. If the site contains areas of high potential for significant paleontological resources and avoidance is not possible, prepare a paleontological resources management and mitigation plan that addresses the following steps:

- a preliminary survey (if not conducted earlier) and surface salvage prior to construction;
- physical and administrative protective measures and protocols such as halting work, to be implemented in the event of fossil discoveries;
- monitoring and salvage during excavation;
- specimen preparation;
- identification, cataloging, curation and storage; and
- a final report of the findings and their significance.

Because the authority to determine project-level impacts and require project-level mitigation lies with the land use approval and/or permitting agency for individual projects, and that the programmatic analysis does not allow project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation ultimately implemented to reduce the potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that the potentially significant short-term construction-related impacts regarding cultural resources associated with black carbon reduction measures could be **potentially significant and unavoidable**.

3. Impacts Associated with HFC Measures

Impact 5.3-a: Short-Term Construction-Related and Long-Term Operational Effects on Cultural Resources

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate high-GWP refrigerants replacements could require minor modifications. Also, some low-GWP refrigerants (e.g., hydrocarbons, ammonia) can power existing systems (U.S. EPA 2010). Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. As it is expected there would be no additional land conversion, there would be no effect on resources considered historically and culturally significant. Thus, short-term construction-related and long-term operational impacts on cultural resources associated with HFC reduction measures would be **less-than-significant**.

H. Energy Demand

1. Impacts Associated with Black Carbon Measures

Impact 6.1-a: Short-Term Construction-related and Long-Term Operational Effects on Energy Demand

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be incorporated into the design of future development projects. While energy would be required to complete construction, it would be temporary and limited in magnitude and not substantially affect energy demand.

The replacement of residential wood burning stoves and fireplaces would gradually cause a shift in fuel types used and could lead to increased winter electricity and gas demand. However, gas and electricity demand would be consistent with typical household consumption, and would not be considered excessive.

When gas pipelines are not available, U.S. EPA-certified or other lower-emitting devices could be used that would not result in a change to the type of fuel used (e.g., wood). Because new wood burning devices are more efficient, the amount of wood fuel needed per household is expected to decline.

Therefore, the short-term construction related and long-term operational impacts to energy demand associated with black carbon reduction measures of the SLCP Strategy would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 6.2-a: Short-Term Construction-Related Effects on Energy Demand

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction

of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Temporary increases in energy demand associated with the construction of new facilities and modification of existing facilities would include the use of fuels, and gas and energy demands. Typical earth-moving equipment that may be necessary for construction includes: graders, scrapers, backhoes, jackhammers, front-end loaders, generators, water trucks, and dump trucks. While energy would be required to complete construction for any new or modified facilities, it would be temporary and limited in magnitude such that a reasonable amount of energy would be expended.

The short-term construction-related impacts on energy demand associated with the methane reduction measures would be **less-than-significant**.

Impact 6.2-b: Long-Term Operational Effects on Energy Demand

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors).

The vapor collection and control requirements related to oil and gas regulations may result in collected vapors being stored temporarily at the collection site and then transferred via truck for disposal in the sales gas system, microturbines, fuel gas system or underground injection well. The potential for an increase in fuel consumption would be site-specific and dependent on the particular methods used to dispose of vapors. However, any increases in energy consumption would be minimal and not substantial in comparison to the demand associated with an oil and gas facility. Furthermore, in the case that vapor disposal methods use microturbines, energy demand could be decreased as these systems produce electricity that could offset energy needs associated with facilities.

The adoption of solid manure collection and management practices in lieu of current flush-water systems could shift the types of energy use. Flush-water systems rely on large quantities of water that must be pumped and piped in order to be applied. In contrast, solid manure collection practices typically require the use of a skidsteer or mechanical loader with a scraping attachment or a vacuum-type device. The difference in the amount of energy required to power could require different types of fuels (e.g., diesel, electricity) depending on the type of equipment used. This energy use is necessary to maintain sanitary conditions on dairies, and the minimal amount necessary would be used.

Implementation of the methane strategy would create a net increase in traffic and transportation impacts due to the movement of various organic wastes (e.g., manure, solid waste, food waste) to respective anaerobic digesters constructed as a compliance response to the methane reduction measures. For example, dairy farm owners using scrape manure management systems may have increased opportunity to sell or send digested manure to be used for soil amendments or other farm-related practices (e.g., animal bedding). Organic waste that would otherwise decompose in a landfill may need transport to a digester. Further, digestate, a byproduct of anaerobic digestion, would require a system for distribution to agricultural areas and possibly landfills.

However, organic wastes, such as manure and food waste, can be converted to collectable methane from anaerobic digesters. The process involves compressing organic waste combined with various bacteria in an airtight container and allowing respiration to occur in an oxygen free environment. The process produces biogas which is composed of methane and carbon dioxide. Biogas can be collected and refined to fuel quality or pipeline quality methane. This methane can then be used to power on-site activities (e.g., electricity and heat), and/or transported for off-site use (e.g., converted to transportation fuel).

Dairy farms that elect to either build on-site digesters or ship manure to larger digesters could experience energy benefits from methane derived from biogas. Dairy farms with on-site digesters could directly use methane to heat their facilities, and power pumps and machinery. Also, off-site digesters could, when feasible, use methane to add power to the energy grid, which could provide an affordable source of electricity and heat for residences and facilities. In addition, fugitive emissions of methane that would otherwise have leaked from landfills, dairies, and oil and gas facilities can be captured, contained, and used as a cleaner fuel source than petroleum, diesel, and coal. Further, sources of this methane derived from biogas can be considered reliable and renewable resources; therefore, methane derived from biogas can be considered a renewable energy source.

To summarize the effects on energy demand related to the reasonably foreseeable compliance responses: adoption of solid manure collection and management systems in lieu of flush-water systems could result in changes to energy demand and the type of energy used to power operational equipment. This is not expected to result in a substantial demand increase on local or regional energy supplies. In addition, operation of anaerobic digesters (i.e., dairy digesters, wastewater treatment plants, and organic digesters) could supplement the State's energy grid with a source of renewable energy.

Thus, the long-term operational impacts to energy demand associated with the methane reduction measures would be **less-than-significant**.

3. Impacts Associated with HFC Measures

Impact 6.3-a: Short-Term Construction-Related and Long-Term Operational Effects to Energy Demand

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

While energy would be required to complete construction for any modified facilities, this would occur within the existing footprint of existing buildings and facilities and the energy demand would be short-term and negligible in amount.

The operational use of 100 percent CO_2 refrigeration systems in hot climates could produce greater demand for energy; however, ARB does not recommend that CO_2 be used in such cases. In addition, hybrid CO_2 and HFC refrigerant systems, or cascade systems, show no energy penalty in hot climates (Pederson 2012).

Therefore, the short-term construction-related impacts and long-term operational impacts on energy demand associated with the HFC reduction measures under the SLCP Strategy would be **less-than-significant**.

I. Geology, Seismicity, and Soils

1. Impacts Associated with Black Carbon Measures

Impact 7.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Geology, Seismicity, and Soils

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be

incorporated into the design of future development projects. These are minor modifications that would occur inside structures and would not substantially affect geology, seismicity, and soils.

Removal of wood-burning stoves, heaters, and fireplaces would not cause any operational effects associated with geology, seismicity, and soil such that the structural integrity of a building would be diminished and subsequently vulnerable to seismic-related risks.

Thus, short-term construction related and long-term operational impacts to geology and soils associated with black carbon reduction measures would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 7.2-a: Short-Term Construction-Related Effects on Geology, Seismicity, and Soils

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Although it is reasonably foreseeable that construction could occur, there is uncertainty as to the exact location of any new facilities or modification of existing facilities. Construction activities could require disturbance of undeveloped areas, such as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways. These activities would have the potential to adversely affect soil and geologic resources in construction areas.

New facilities could be located in a variety of geologic, soil, and slope conditions with varying amounts of vegetation that would be susceptible to soil compaction, soil erosion, and loss of topsoil during construction. The level of susceptibility varies by location. However, the specific design details, siting locations, and soil compaction and erosion hazards for particular manufacturing facilities are not known at this time and would be analyzed on a site-specific basis at the project level.

Short-term construction-related impacts to geology and soils associated with the methane reduction measures would be potentially significant.

The impacts to soil and geologic resources could be reduced to a less-than-significant level by mitigation that can and should be implemented by federal, State, and local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 7.2-a

The Regulatory Setting in Attachment A includes applicable laws and regulations that provide protection of geology and soils. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that would be approved by local jurisdictions. The ability to require such measures is under the purview of jurisdictions with local or State land use approval and/or permitting authority. New or modified facilities in California would qualify as a "project" under CEQA. The jurisdiction with primary approval authority over a proposed action is the Lead Agency, which is required to review the proposed action for compliance with CEQA statutes.

Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority. Recognized practices that are routinely required to avoid and/or minimize impacts to geology and soils include:

- Proponents of new facilities constructed as a result of reasonably foreseeable compliance responses to new regulations would coordinate with local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA). The local or State land use agency or governing body must comply with applicable regulations and would approve the project for development.
- Based on the results of project level environmental review, project proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the environmental impacts of the project The definition of actions required to mitigate potentially significant geology and soil impacts may include the following; however, any mitigation specifically required for a new or modified facility would be determined by the local lead agency.
- Prior to the issuance of any development permits, proponents of new or modified facilities or infrastructure would prepare a geotechnical investigation/study, which would include an evaluation of the depth to the water table, liquefaction potential, physical properties of subsurface soils including shrink-swell potential (expansion), soil resistivity, slope stability, mineral resources, and the presence of hazardous materials.

- Proponents of new or modified facilities or infrastructure would provide a complete site grading plan, and drainage, erosion, and sediment control plan with applications to applicable lead agencies. Proponents would avoid locating facilities on steep slopes, in alluvial fans and other areas prone to landslides or flash floods, or with gullies or washes, as much as possible. Disturbed areas outside of the permanent construction footprint would be stabilized or restored using techniques such as soil loosening, topsoil replacement, revegetation, and surface protection (i.e., mulching).

Because the authority to determine project-level impacts and require project-level mitigation lies with the land use approval and/or permitting agency for individual projects, and that the programmatic analysis does not allow project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation ultimately implemented to reduce the potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that short-term construction-related impacts to soil and geologic resources associated with black carbon reduction measures would be **potentially significant and unavoidable**.

Impact 7.2-b: Long-Term Operational Effects on Geology, Seismicity, and Soils

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic materials diverted from landfills into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, such as pipeline installation and methods of disposal of methane vapors, and inspection and monitoring of equipment).

In terms of new requirements at oil and gas facilities, collected methane may be injected into an underground injection well. Based on discussion between ARB and DOGGR, use of underground injections wells would not be substantial (i.e., a 3 percent increase in the amount of methane injected into one well). Furthermore, in the case that an oil and gas facility would need to inject additional gas into an existing well or repurpose an existing extraction well into a gas injection well, DOGGR analysis and approval would be required. Permitting of a Class II well requires submission of a geologic study and injection plan that identifies all geologic units, formations, freshwater aquifers, and oil or gas zones. (Cal Code Regs., tit. 14, § 1724.7 (b)). Class II permit requirements ensure that injection of hazardous materials would occur at a depth that would prevent surface contamination of soil and water, and minimize risks to the environment.

Manure management practices under the methane reduction measures would occur within existing dairy sites that are likely to contain substantial disturbance to soils. Changing manure practices, such as creating piles of manure or pasturing, could result in increased disturbance to geologic resources, such as compaction and loss of top soil due to trampling and reductions in vegetation. However, dairies are generally located in lands designated for agricultural use, where soil disruption is typical. Manure piles would likely be located in discrete areas. Pasturing cattle typically occurs on a rotational schedule, and maintenance of vegetation is necessary for feeding. Thus, changes in manure management practices should not substantially affect soil resources.

Long-term operational impacts on geology, seismicity, and soils, associated with methane reduction measures, would be **less-than-significant**.

3. Impacts Associated with HFC Measures

Impact 7.3-a: Short-Term Construction- Related and Long-Term Operational Effects on Geology, Seismicity, and Soils

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications. Also, some low-GWP refrigerants (e.g., hydrocarbons, ammonia) can power existing systems (U.S. EPA 2010). Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. Additional land would likely not be required such that geologic-related resources would be impacted by construction activities.

Operation of these modified residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements would not be expected to operationally affect geology or soils because they occur within the existing footprint of these facilities.

Therefore, the short-term construction related and long-term operational impacts to geology and soil resources, related to HFO reduction measures, would be **less-than-significant**.

J. Greenhouse Gases

1. Impacts Associated with Black Carbon Measures

Impact 8.1-a: Short-Term Construction-Related Effects on Greenhouse Gases

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

The minor construction associated with replacing residential wood burning stoves and fireplaces, or installation at new construction, would be minor construction projects that would not lead to significant GHG emissions.

Therefore, short-term construction-related impacts to GHG associated with black carbon reduction measures of the SLCP Strategy are **less-than-significant.**

Impact 8.1-b: Long-Term Operational-related Effects on Greenhouse Gases

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters and U.S. EPA-certified devices. This would reduce black carbon emissions associated with residential fireplaces and woodstove, thereby reducing the climate pollutant emissions from these sources.

Black carbon contributes to climate change both directly by absorbing sunlight and indirectly by depositing on snow and by interacting with clouds and affecting cloud formation. In addition to its climate and health impacts, black carbon disrupts cloud formation, precipitation patterns, water storage in snowpack and glaciers, and agricultural productivity.

Conversion of wood burning devices to natural gas fireplaces could result in methane leaks from such devices. These leaks would be similar in magnitude to leaks from other residential natural-gas powered devices such as stoves and water heaters and are anticipated to be minimal and therefore less-than-significant.

With the reduction of black carbon, overall the operational impact would be **beneficial.**

2. Impacts Associated with Methane Reduction Measures

Impact 8.2-a: Short-Term Construction-Related Effects on Greenhouse Gases

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction

of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Although it is reasonably foreseeable that construction activities associated with new or modified facilities could occur, there is uncertainty as to the exact location of any new facilities or the reconstruction or modification of existing facilities. Typical earth-moving equipment that may be necessary for these types of construction activities includes: graders, scrapers, backhoes, jackhammers, front-end loaders, generators, water trucks, and dump trucks. Specific, project-related construction activities would result in increased generation of GHG emissions associated with the use of heavy-duty off-road equipment, materials transport, and worker commutes for the duration of the construction phase. Therefore, construction-related GHG emissions are expected to be short-term and limited in amount.

Local agencies, such as air pollution control districts, are generally charged with determining acceptable thresholds of GHG emissions $MTCO_2e$/year. Quantification of short-term construction-related GHG emissions is generally based on a combination of methods, including the use of exhaust emission rates from emissions models, such as OFFROAD 2007 and EMFAC 2014. These models require consideration of assumptions, including construction timelines and energy demands (e.g., fuel and electricity). However, a majority of local agencies (e.g., air pollution control districts) do not recommend or require the quantification of short-term construction-generated GHGs for typical construction projects because these only occur for a finite period of time (e.g., during periods of construction) that is typically much shorter than the operational phase. Thus, local agencies generally recommended that GHG analyses focus on operational phase emissions, as discussed in the next impact section, unless the project is of a unique nature requiring atypical (e.g., large scale, long-term) activity levels (e.g., construction of a new dam or levee) for which quantification and consideration (e.g., amortization of construction emissions over the lifetime of the project) may be recommended.

When these short-term construction-related GHG emissions associated with construction activities are considered in relation to the overall long-term operational GHG benefits discussed below, they are not considered substantial.

Therefore, short-term construction-related impacts to GHG associated with the methane reduction measures under the SLCP Strategy are **less-than-significant**.

Impact 8.2-b: Long-Term Operational Effects on Greenhouse Gases

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors).

Methane is the principal component of natural gas and is also produced biologically under anaerobic conditions in ruminants (animals with a four-part stomach, including cattle and sheep), landfills, and waste handling. Atmospheric methane concentrations have been increasing as a result of human activities related to agriculture, fossil fuel extraction and distribution, and waste generation and processing. The atmospheric lifetime of methane is about 12 years. It is well-mixed within the atmosphere, and like other GHGs, warms the atmosphere by blocking infrared radiation (heat) that is re-emitted from the earth's surface from reaching space. Almost all of methane's impact occurs within the first two decades after it is emitted.

Methane is responsible for about 20 percent of current global warming (Kirschke et al. 2013), and methane emissions continue to increase globally. There is particular concern among scientists that continued climate warming may cause massive releases of methane from thawing artic permafrost, and dissolve frozen methane clathrate deposits trapped within shallow ocean sea floors.

Implementation of the methane reduction measures are aimed to reduce methane emissions from dairies, wastewater treatment plants and oil and gas facilities, and landfills. Although implementation of these measures would likely ultimately replace the use of compliance offset protocol measures now reducing methane in the livestock sector as part of the Cap-and-Trade Regulation, that protocol is responsible for only a relatively small amount of methane reductions (just over 0.5 million tons of offsets to date over the life of the Cap-and-Trade Regulation, plus early action offsets),[3] and many projects benefitting economically under that program would likely continue operating after their crediting period if they have amortized their start-up costs and the regulatory and economic setting has changed to encourage continued operation. Similarly, though the value of LCFS credits would likely be reduced for new projects after the beginning of regulation, existing projects could continue to capture value for a lengthy crediting period. SB 1383 requires ARB to publish guidance confirming that this crediting period will continue. The guidance development process will provide ARB with an opportunity to fully understand factors bearing upon the continued operation of these projects.

Even if the majority of these projects were to cease operating after their ten-year initial crediting periods, which is not reasonably foreseeable given the regulatory and incentives measures in play, including the effect of financing from offsets and LCFS credits during that period, the total reductions of greenhouse gases produced by the measures in the SLCP Strategy substantially exceed the plausible foregone reductions associated with limitations to the compliance offset protocol. [4]

Accordingly, the reasonably foreseeable compliance responses would result in net reduction of GHGs in the State and nationally in these sectors. This impact would be **beneficial**.

3. Impacts Associated with HFC Measures

Impact 8.3-a: Short-Term Construction Related Effects on Greenhouse Gases

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications. Also, some low-GWP refrigerants (e.g., hydrocarbons, ammonia) can power existing systems (U.S. EPA 2010). Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings and would not constitute major construction. Therefore, construction-related GHG emissions are expected to be short-term and limited in amount.

[3] See ARB, ARB Offset Credits Issued (Feb. 24, 2016) http://www.arb.ca.gov/cc/capandtrade/offsets/issuance/arb_offset_credit_issuance_table.pdf

[4] This analysis also applies to other resource areas potentially affected by this shift in the livestock offset program and LCFS program. ARB generally anticipates limited shifts in compliance responses after the crediting periods expire, and correspondingly limited environmental impacts specifically from these shifts.

Thus, short-term construction-related impacts to GHG associated with the HFC reduction measures under the SLCP Strategy are **less-than-significant**.

Impact 8.3-b: Long-Term Operational Effects on Greenhouse Gases

HFCs are synthetic gases used in refrigeration, air conditioning, insulating foams, solvents, aerosol products, and fire protection. They are primarily produced for use as substitutes for ozone-depleting substances, including chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs), which are being phased out under the Montreal Protocol. Currently, HFCs are a small fraction of the total climate forcing, but they are the fastest growing source of GHG emissions in California and globally, primarily driven by the increased demand for refrigeration and air conditioning.

The operational effects on GHG emissions by requiring low-GWP refrigeration and air-conditioning systems would be a significant net decrease in GHG emissions from facilities using low-GWP equipment. The lifecycle impact of low-GWP refrigeration and air-conditioning is consistently lower than using traditional high-GWP HFC refrigerants, with the significantly lower GWPs of alternate refrigerants far outweighing the impacts of installing the low-GWP equipment. For example, if R-404A HFC blend refrigerant with a GWP of 3922 is used in a supermarket using 3,000 pounds of refrigerant, with a 20% annual leak rate, the direct GHG impact from refrigerant emissions over an average 15-year equipment lifetime is 16,000 metric tonnes of CO_2-equivalents ($MTCO_2E$), compared to 4 metric tonnes for a similar system using CO_2 as refrigerant. According to the U.S. EPA Greenhouse Gas Equivalencies Calculator, 16,000 MTCO2E is equivalent to 3,380 passenger vehicles driven for a year, or 1.8 million gallons of gasoline consumed. When multiplied by the thousands of facilities in California using high-GWP HFCs, the GHG reductions become significant, far outweighing GHGs produced by any short-term limited construction activity.

Ironically, HFC refrigerants have such high GWPs, that carbon dioxide, a greenhouse gas with a GWP of one, is seen as a low-GWP option to replace HFCs. On a statewide level, substantial GHG reductions could be realized from using CO_2 instead of HFC refrigerants with GWPs between 1300 and 4000. For example, if all the HFC usage in CA were to be replaced by CO_2, the GHG emissions impact would be reduced from 18 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) annually to less than .013 $MMTCO_2e$ annually, a 1400-fold reduction. Additionally, the CO_2 used as refrigerant can be considered a zero net emissions, because the CO_2 is captured from processes where the CO_2 would have been emitted as a by-product.

Thus, because the HFC reduction measures would replace synthetic gases used in refrigeration, air conditioning, insulating foams, solvents, aerosol products, and fire protection with lower-GWP chemicals, this impact would be **beneficial**.

K. Hazards and Hazardous Materials

1. Impacts Associated with Black Carbon Measures

Impact 9.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Hazards and Hazardous Materials

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be incorporated into the design of future development projects. These involve minor construction activities that do not increase the transport, use, or disposal of hazardous materials.

Burning of materials indoors has the potential to release carbon monoxide, an odorless gas that can cause asphyxiation and lead to death. However, various regulations address this potential issue, including the California Building Code which requires any installed gas fireplace to operate using a direct-vent and sealed combustion. Compared to older models, U.S. EPA-certified wood stoves are designed with better insulation and improved air flow, thus resulting in more efficient burning. More efficient burning results in a decrease in CO emissions. This would not increase risks, such as chimney fire or other potential hazards associated with fireplaces and woodstove as operation would be very similar to the older devices. Thus, risks associated with the use of U.S. EPA-certified and gas fireplaces would be similar and not lead to increased risk compared to existing use of older woodstoves and fireplaces.

Therefore, short-term construction related and long-term operational impacts related to hazards and hazardous materials and fire risk associated with black carbon reduction measures would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 9.2-a: Short-Term Construction-Related Effects on Hazards and Hazardous Materials

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Construction activities may require the transport, use, and disposal of hazardous materials. Construction activities generally use heavy-duty equipment requiring periodic refueling and lubricating fluids. Large pieces of construction equipment (e.g., backhoes, graders) are typically fueled and maintained at the construction site as they are not designed for use on public roadways. Thus, such maintenance uses a service vehicle that mobilizes to the location of the construction equipment. It is during the transfer of fuel that the potential for an accidental release is most likely. Although precautions would be taken to ensure that any spilled fuel is properly contained and disposed, and such spills are typically minor and localized to the immediate area of the fueling (or maintenance), the potential still remains for a substantial release of hazardous materials into the environment. Consequently, the construction activities could create a substantial hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment.

The short-term construction-related impact associated with the methane reduction measures on hazards and hazardous materials would be potentially significant.

The impacts could be reduced to a less-than-significant level by mitigation that can and should be implemented by federal, State, and local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 9.2-a:

The Regulatory Setting in Attachment A includes applicable laws and regulations that pertain to hazards and hazardous materials. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that would be approved by local jurisdictions. The ability to require such measures is under the purview of jurisdictions with local or State land use approval and/or permitting authority. New or modified facilities in California would qualify as a “project” under CEQA. The jurisdiction with primary approval authority over a proposed action is the Lead Agency, which is required to review the proposed action for compliance with CEQA statutes. Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority. Recognized practices that are routinely required to avoid upset and accident-related impacts include:

Proponents of new or modified facilities constructed as a compliance response would coordinate with local land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA). The local or State land use agency or governing body must comply with applicable regulations and would approve the project for development.

Based on the results of project level environmental review, project proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the environmental impacts of the project. The definition of actions required to mitigate potentially significant upset and accident-related hazard impacts may include the following; however, any mitigation specifically required for a new or modified facility would be determined by the local lead agency.

Handling of potentially hazardous materials/wastes should be performed under the direction of a licensed professional with the necessary experience and knowledge to oversee the proper identification, characterization, handling and disposal or recycling of the materials generated as a result of the project. As wastes are generated, they would be placed, at the direction of the licensed professional, in designated areas that offer secure, secondary containment and/or protection from stormwater runoff. Other forms of containment may include placing waste on plastic sheeting (and/or covering with same) or in steel bins or other suitable containers pending profiling and disposal or recycling.

The temporary storage and handling of potentially hazardous materials/wastes should be in areas away from sensitive receptors such as schools or residential areas. These areas should be secured with chain-link fencing or similar barrier with controlled access to restrict casual contact from non-Project personnel. All project personnel that may come into contact with potentially hazardous materials/wastes will have the appropriate health and safety training commensurate with the anticipated level of exposure.

Because the authority to determine project-level impacts and require project-level mitigation lies with the land use approval and/or permitting agency for individual projects, and that the programmatic analysis does not allow project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation ultimately implemented to reduce the potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that short-term construction impacts regarding upset and accident-related hazards associated with the methane reduction measures would be **potentially significant and unavoidable**.

Impact 9.2-b: Long-Term Operational Effects on Hazards and Hazardous Materials

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors).

Implementation of strategies to reduce methane would include the modification of existing wastewater treatment plants to include or expand anaerobic digesters, and the construction of dairy and organic waste digesters. Through the use of anaerobic digestion, methane that would otherwise emit into the atmosphere is captured to fuel on- and off-site uses. The respiration of bacteria in an oxygen-free environment produces biogas, a gaseous mixture of methane and carbon dioxide. Unintentional releases of biogas from anaerobic digesters or pipelines could pose risks to human health and safety. For example, biogas could be released from a leak or rupture of a facility or one of the pipe segments. If the gas reaches a combustible mixture and an ignition source is present, a fire and/or explosion could occur, resulting in possible injuries and/or deaths.

Compliance with existing safety regulations and widely-accepted industry standards would minimize the hazard to the public and the environment. Operation of facilities would comply with the California fire code, local building codes (including requirements for the installation of fire suppression systems), and gas pipeline regulations. The local fire agency would be responsible for enforcing the provisions of the fire code. The California Public Utilities Commission (CPUC) regulates the safety of gas transmission pipelines. Standard safety measures for anaerobic treatment facilities that would minimize the potential for exposure to biogas include leak detection systems, warning signals, and safety flares to reduce excess gas capacity. If released to the environment, methane would be dispersed rapidly in air, minimizing the hazards of exposure.

Operation of anaerobic digesters could result in risks to human health. The digesters are compressed to seal out oxygen to permit anaerobic respiration to occur. In the case that a person gained entry by accident, asphyxiation would occur; however, California Occupational Safety and Health Administration (Cal/OSHA) is responsible for enforcing workplace safety standards, which include confined space and lockout procedures (California Department of Resources Recycling and Recovery [CalRecycle] 2011).

Although there is uncertainty as to the exact locations of new anaerobic digesters and modifications to wastewater treatment plants and oil and gas facilities, these would likely occur within existing footprints or in areas with consistent zoning where hazardous materials are currently in use. Thus, implementation of the methane reduction measures would not be anticipated to result in locating new plants, stations, or modifications near schools, public (or public use) airports, private airstrips, or wildlands; or on sites included on a list of hazardous materials sites or impair implementation of or physically interfere with an adopted emergency response or evacuation plan. Thus, the potential for spills of hazardous materials that could affect the general public or sensitive receptors (e.g., schools) would not be anticipated. In addition, as noted above, the handling of hazardous materials would be required to comply with all applicable federal, State and local laws. As a result, this impact would be less-than-significant.

Thus, the effect of hazards and hazardous materials as a result of implementation of the methane reduction measures under the SLCP Strategy would be **less-than-significant**.

3. Impacts Associated with HFC Measures

Impact 9.3-a: Short-Term Construction-Related and Long-Term Operational Effects on Hazards and Hazardous Materials

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications. Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment). However, it is expected that this level of upgrade would not increase the handling of hazardous materials during construction and the handling of hazards materials would be required to comply with all applicable federal (e.g., Cal/OSHA), State, and local laws.

Implementation of low-GWP compliance measures may result in the use or increase in use of hazardous chemicals. The phase out of high-GWP HFCs would increase demand for low-GWP substitutes including ammonia, CO_2, hydrocarbons, low-GWP HFCs, and HFOs. Depending on the replacement chemical used, there may be an increased risk to public safety. For example, while the hydrocarbon, cyclopentane, and cyclopentane blends have a lower GWP than HFCs currently in use to make polyurethane insulation, cyclopentane is highly flammable in its pure form; however, once foamed, it is no more hazardous than other blowing agents currently in use. As with any manufacturing processes, a wide variety of redundant engineering and operational safeguards are typically integrated, along with compliance with federal, State, and local environmental and health and safety laws and regulations which address the management and use of flammable and toxic chemicals.

Some potential heat transfer fluids that could be used to replace high-GWP refrigerants, such as propane and ammonia, are highly flammable. HFO-1234yf, a replacement HFO for light-duty vehicle air conditioners, is considered a Category 1 flammable gas and a simple asphyxiant (Honeywell 2015a). Heavier-than-air refrigerants can concentrate at floor levels and displace breathable oxygen. Inhalation of certain fumes, during accidental release, can also cause human health effects ranging from nausea to death.

However, Chapter 11 of the California Mechanical Code regulates the use of refrigeration systems, equipment, and devices, including the replacement of parts, alterations, and substitution of different refrigerants. This includes requirements for ventilation and exhaust systems, emergency control systems, and alarms. Operational impacts associated with proximity (e.g., for schools and airports) to hazardous materials manufacturing sites would not occur because facilities handling low-GWP replacements would be expected to be located in areas of consistent zoning for industrial use.

Therefore, the short-term construction related and long-term operational impacts to hazards and hazardous materials associated with the phase out of high-GWP HFCs would be **less-than-significant**.

L. Hydrology and Water Quality

1. Impacts Associated with Black Carbon Measures

Impact 10.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Hydrology and Water Quality

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be incorporated into the design of future development projects. These minor modifications to already disturbed areas do not result in significant construction activities that could impact hydrologic resources, rates of discharge, or ground or surface water quality.

Therefore, short-term construction related and long-term operational hydrology and water quality-related impacts from the black carbon measures would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 10.2-a: Short-Term Construction-Related Effects on Hydrology and Water Quality

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Construction activities could require disturbance of undeveloped areas, such as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways. Specific construction projects would be required to comply with applicable erosion, water quality standards, and waste discharge requirements (e.g., NPDES, SWPPP). However, construction project may add impervious surfaces that could increase runoff on an on-going basis, encounter groundwater resources during excavation activities, and cause erosion that could degrade water quality. In addition, depending on the location of a proposed project, people or structures could be located in a floodplain.

Short-term construction-related impacts to hydrologic resources associated with the methane reduction measures would be potentially significant.

Impacts to hydrologic resources could be reduced to a less-than-significant level by mitigation that can and should be implemented by federal, State, and local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 10.2-a:

The Regulatory Setting in Attachment A includes applicable laws and regulations in regards to hydrology and water quality. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that would be approved by local jurisdictions. The ability to require such measures is under the purview of jurisdictions with local or State land use approval and/or permitting authority. New or modified facilities in California would qualify as a “project” under CEQA. The jurisdiction with primary approval authority over a proposed action is the Lead Agency, which is required to review the proposed action for compliance with CEQA statutes.

Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority. Recognized practices that are routinely required to avoid and/or mitigate hydrology and water quality-related impacts include the following:

- Proponents of new facilities constructed as a result of reasonably foreseeable compliance responses to the SLCP Strategy would coordinate with local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA). The local or State land use agency or governing body must comply with applicable regulations and would approve the project for development.

- Based on the results of project level environmental review, project proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the environmental impacts of the project. The definition of actions required to mitigate potentially significant hydrology and water quality impacts may include the following; however, any mitigation specifically required for a new or modified facility would be determined by the local lead agency.
- Under the oversight of the local lead agency, prior to issuance of any construction permits, the proponents for proposed projects would prepare a stormwater drainage and flood control analysis and management plan. The plans would be prepared by a qualified professional and would summarize existing conditions and the effects of project improvements, and would include all appropriate calculations, a watershed map, changes in downstream flows and flood elevations, proposed on- and off-site improvements, features to protection downstream uses, and property and drainage easements to accommodate downstream flows from the site. Project drainage features would be designed to protect existing downstream flow conditions that would result in new or increased severity of offsite flooding.
- Establish drainage performance criteria for off-site drainage, in consultation with county engineering staff, such that project-related drainage is consistent with applicable facility designs, discharge rates, erosion protection, and routing to drainage channels, which could be accomplished by, but is not limited to: (a) minimizing directly connected impervious areas; (b) maximizing permeability of the site; and, (c) stormwater quality controls such as infiltration, detention/retention, and/or biofilters; and basins, swales, and pipes in the system design.
- The project proponent would design and construct new facilities to provide appropriate flood protection such that operations are not adversely affected by flooding and inundation. These designs would be approved by the local or State land use agency. The project proponent would also consult with the appropriate flood control authority on the design of offsite stream crossings such that the minimum elevations are above the predicted surface-water elevation at the agency's designated design peak flows. Drainage and flood prevention features shall be inspected and maintained on a routine schedule specified in the facility plans, and as specified by the county authority.
- As part of subsequent project-level planning and environmental review, the project proponent shall coordinate with the local groundwater management authority and prepare a detailed hydrogeological analysis of the potential project-related effects on groundwater resources prior to

issuance of any permits. The proponent shall mitigate for identified adverse changes to groundwater by incorporating technically achievable and feasible modifications into the project to avoid offsite groundwater level reductions, use alternative technologies or changes to water supply operations, or otherwise compensate or offset the groundwater reductions.

Because the authority to determine project-level impacts and require project-level mitigation lies with the land use approval and/or permitting agency for individual projects, and that the programmatic analysis does not allow project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation ultimately implemented to reduce the potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that short-term construction-related impacts to hydrology and water quality associated with the methane reduction measures would be **potentially significant and unavoidable**.

Impact 10.2-b: Long-Term Operational Effects on Hydrology and Water Quality

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors).

Modifications to oil and gas facilities would not involve an increased use of water resources nor result in the contamination of surface and groundwater. These activities would be minor. Further, improvements to oil and gas facilities would reduce leaks of methane and oil which could otherwise contaminate sources of surface and groundwater. By preventing leaks from occurring, water quality would be maintained or improved.

Flush-water lagoon management systems are currently used for the majority of milking cows in California. The process requires large quantities of water to sweep manure into a localized area, typically lagoons, where it undergoes anaerobic fermentation. The liquid manure effluent is then diluted with irrigation water (typically groundwater) and applied to croplands and fields by way of flood irrigation. As California enters into a more uncertain future with regards to water security, methods of water conservation should be encouraged and implemented. The only way currently known to reduce dairy water consumption significantly is by switching away from water-inefficient flood irrigation of dairy feed crops into more water-efficient irrigation, and that typically requires switching away from flushwater manure management. Under the SLCP Strategy, dairy operators could implement solid manure collection and management systems, which helps open up more opportunities for using more water-efficient irrigation practices which could require substantially less water than typical systems that utilize flush-water management combined with flood irrigation. Thus, the potential for decreasing groundwater supply needs could be reduced with solid manure management systems compared to flush-water lagoon management systems.

Dairy operators may also implement digester facilities. Due to the fact that anaerobic digesters (i.e., dairy digesters, wastewater treatment plants, organic waste digesters) themselves do not significantly change nutrient management compared to lagoons, they could still result in the contamination of local waterways and groundwater resources. Dairy manure contains nutrients, organic matter, salts, microorganisms, pathogens, and fecal bacteria. If improperly managed, constituents and/or byproducts of anaerobic digestion could continue to pollute water quality by contributing excess nutrients, bacterial pathogens, and oxygen-demanding materials (RWQCB 2010). Application of manure, digestate, and/or improper application timing or rates of manure to agricultural land may lead to increased nitrogen oxide and nitrous oxide emissions, soil contamination, and/or nutrient leaching, etc. However, Wastewater Discharge Requirements (WDRs) are required for each facility to address surface water discharges of digestate or manure constituents. In addition, regulations prohibit surface water discharges (unless covered by an NPDES permit), appropriate setbacks for facilities from surface water bodies, lined detention ponds, application of digestate at agronomic rates to surrounding lands, and implementation of a groundwater monitoring system to detect when leaks occur.

Finally, dairy operators may pasture cattle herds or store manure on-site to reduce methane emissions from manure. Pasturing of cattle or drying of manure on-site may result in contamination of groundwater and discharge of contaminates into surface water. Irrigation required to maintain pastures, and rain events, may increase rates of polluted runoff that can result in adverse water quality. The extent to which adverse water quality effects could occur depends on various factors including unique hydrology, topography, climate, and land uses of specific regions. However, dairies that could be converted from lagoon-based manure management systems to pasture or open drying systems, as a result of implementation of the SLCP Strategy, contain physical features (e.g., no off-property discharge) and/or have obtained appropriate permits (e.g., NPDES, WDRs). Physical features of specific properties and permit requirements could help reduce the likelihood that there would be substantial adverse effects related to water quality.

Thus, overall the long-term operational impacts related to the methane reduction measures, would be **less-than-significant**.

3. Impacts Associated with HFC Measures

Impact 10.3-a: Short-Term Construction Related and Long-Term Operational Effects on Hydrology and Water Quality

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications. Also, some low-GWP refrigerants (e.g., hydrocarbons, ammonia) can power existing systems (U.S. EPA 2010). Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. These construction-related activities would not be anticipated to generate substantial wastewater outflow such that ground or surface water contamination would occur. Such activities would be minor and would not cause alteration of an existing drainage pattern. Further, as modifications would be associated with existing buildings and facilities there would not be increased exposure to seiche, mudflow, or flood. Thus, there would be no effect on hydrology and water quality associated with the minor modifications potentially needed on existing residences, commercial buildings and facilities.

Implemented the HFC reduction measures could result in an increased use of HFOs, which have the potential to result in a long-term effect on hydrology and water quality. Some of these effects would occur because of the global HFC phase-down, and the SLCP Strategy would cause only possible incremental increased use of these replacement compounds. Nonetheless, these potential effects are discussed here for full information purposes. Long-term effects of emissions of HFOs as a result of HFC reduction measures on water quality are not well known at this time, but the decomposition of HFOs in the atmosphere lead to the formation of TFA which can affect water quality. HFOs react with OH to form trifluoroacetyl fluoride, which is rapidly hydrolyzed in the presence of atmospheric moisture to form TFA. TFA leaves the atmosphere by dry deposition or precipitation onto the land and surface waters. TFA is mildly phytotoxic and a strong organic acid. It is highly soluble and persistent, with no known degradation mechanism in water. Most freshwater and marine aquatic species that have been tested are relatively insensitive to TFA, although algal species appear to have a wider range of sensitivity to TFA, with some algal species being highly sensitive (Russell et al. 2012).

Increased TFA from the breakdown of HFO emissions in the atmosphere currently appears to be negligible, although HFO emissions would be expected to increase significantly as they replace high-GWP HFCs. If half of all current HFC uses and emissions were to be comprised of HFOs, the daily emissions of HFOs into the atmosphere of California would be approximately 80,000 pounds per day.

Earlier studies indicated that naturally-occurring TFA concentrations were far in excess of those that could occur as a result of atmospheric oxidation of human-made fluorocarbons, and TFA from HFOs would have a negligible impact on the environment (Hurley et al. 2008, Boutonnet et al. 1999). As a naturally occurring chemical, more than 200,000,000 tonnes of TFA is present in the oceans, having apparently accumulated over many million years from chemical reactions in or around sub-sea volcanic vents (Frank et. al. 2002).

However, more recent studies concluded that TFAs from human-made hydrofluorocarbons, especially those that would be converted from future HFO emissions, would by far exceed naturally-occurring TFA concentrations. Researchers who modeled only light-duty mobile vehicle air-conditioning emissions of HFOs concluded that the effect on the environment would be negligible and 60 to 80 times lower than the lowest safe levels of TFA (to aquatic species) (Luecken et. al. 2010, Henne et. al. 2012)). Studies are lacking that show the effects of TFA from a full conversion of HFCs to HFOs. ARB data indicate that light-duty mobile vehicle air-conditioning comprise only 10 percent of HFC emissions by simple mass (metric tonnes or pounds) (Gallagher et. al. 2014). Therefore, it is reasonable to conclude that the TFA impact would be ten times greater if all HFC uses were to convert to HFOs. The TFA levels in water would then be 6 to 8 times lower than the lowest safe levels of TFA instead of 60 to 80 times lower.

As discussed above under Impact 4.3-b, U.S. EPA's SNAP list considers substitutes (i.e., chemicals that may replace one that is currently in use for a specific purpose) based on their end use sector. That is, while HFO-1234yf is approved for use in new passenger cars and light-duty trucks, it would need to be reconsidered for use in other sectors such as commercial refrigeration. U.S. EPA makes decisions informed by the overall understanding of the environmental and human health impacts as well as the current knowledge regarding available substitutes. When U.S. EPA is determining whether to add a new substitute to the list, they compare the risk posed by the new substitute to the risks posed by other alternatives on the list and determine whether that specific new substitute poses more risk than already-listed alternatives for the same use. Section 612 provides that U.S. EPA must prohibit the use of a substitute where it has determined that there are other available substitutes that pose less overall risk to human health and the environment. In addition, U.S. EPA may be petitioned to de-list alternatives from the SNAP list at any time.

As described above, implementation of the SLCP Strategy would not be expected to result in exceedance of the lowest safest level of TFA in water. In addition, use of HFOs must be subject to review and on-going monitoring under the U.S. EPA SNAP program, and must not pose a greater risk to the environment or human health than the chemical it is replacing.

Therefore, the short-term construction related and long-term operational impacts to hydrology and water quality associated with the phase out of high-GWP HFCs would be **less-than-significant**.

M. Land Use and Planning

1. Impacts Associated with Black Carbon Measures

Impact 11.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Land Use and Planning

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be incorporated into the design of future development projects. These are minor modifications to already developed areas and would not affect land use and planning.

Therefore, short-term construction related and long-term operational land use and planning impacts from the black carbon measures would be **less-than-significant**.

Potential environmental impacts associated with land use change on agriculture and forestry, biology, geology and soils, and hydrology are discussed in further detail under Impacts 2.1-a, 4.1-a, 7.1-a, and 10.1-a.

2. Impacts Associated with Methane Reduction Measures

Impact 11.2-a: Short-Term Construction-Related and Long-Term Operational Effects on Land Use and Planning

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction and operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic materials diverted from landfills into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, such as pipeline installation and methods of disposal of methane vapors, and inspection and monitoring of equipment).

Short-term construction-related and long-term operational impacts on land use and planning associated with implementation of the methane reduction measures under the SLCP Strategy may not be consistent with existing and planned land uses (e.g., vehicle fueling stations within lands zoned for agricultural uses). The environmental consequences of land use changes are considered in their respective sections of the Revised Draft EA.

Potential environmental impacts associated with land use change on agriculture and forestry, biology, geology and soils, and hydrology and their related mitigation measures are discussed in further detail under Impacts 2.2-a, 2.2-b, 4.2-.a, 4.2-b, 72-.a, 7.2-b, 10.2-a, and 10.2-b.

3. Impacts Associated with HFC Measures

Impact 11.3-a: Short-Term Construction-Related and Long-Term Operational Effects on Land Use and Planning

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications. Also, some low-GWP refrigerants (e.g., hydrocarbons, ammonia) can power existing systems (U.S. EPA 2010). Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings, which in areas with consistent zoning, where original permitting and analyses considered land use and planning issues.

Therefore, short-term construction related and long-term operational impacts on land use and planning associated with implementation of the HFC reduction measures would not lead to any inconsistencies with existing and planned land uses and this impact is **less-than-significant.**

Potential environmental impacts associated with land use change on agriculture and forestry, biology, geology and soils, and hydrology are discussed in further detail under Impacts 2.3-a, 4.3-a, 4.3-b, 7.3-a, 10.3-a.

N. Mineral Resources

1. Impacts Associated with Black Carbon Measures

Impact 12.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Mineral Resources

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be incorporated into the design of future development projects. Because the construction would occur in areas already disturbed, there would be no land use changes that would affect the availability of mineral resources or a mineral resource recovery site during either construction or operation.
Thus, short-term construction-related and long-term operational mineral resources impacts associated with black carbon reduction measures would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 12.2-a: Short-Term Construction-Related and Long-Term Operational Effects on Mineral Resources

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction and operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic materials diverted from landfills into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, such as pipeline installation and methods of disposal of methane vapors, and inspection and monitoring of equipment).

Implementation of strategies to reduce methane would include the modification of existing wastewater treatment plants to include or expand anaerobic digesters, and the construction of dairy and organic waste digesters. Although it is reasonably foreseeable that construction activities could occur, the location and extent of construction activities related to new or modified manufacturing facilities cannot be determined at this time.

However, new facilities would likely occur within existing footprints or in areas with consistent zoning, where original permitting and analyses considered these issues. As a result, construction and operation of new facilities for anaerobic digestion would not affect the availability of a known mineral resource or recovery site. Compliance responses that would involve modifications to existing facilities would not affect the availability of known mineral resources because construction and operation would occur within existing sites that contain buildings or are otherwise highly disturbed.

Thus, short-term construction-related and long-term operational mineral resources impacts associated with the methane reduction measures would be **less-than-significant**.

3. Impacts Associated with HFC Measures

Impact 12.3-a: Short-Term Construction-Related and Long-Term Operational Effects on Mineral Resources

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications. Also, some low-GWP refrigerants (e.g., hydrocarbons, ammonia) are already used in existing systems (U.S. EPA 2010). Buildings could be required to undergo extensive retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. Thus, supplemental land would not be required such that the availability of a known mineral source would be affected.

Thus, short-term construction related and long-term operational mineral resources impacts associated with the HFC reduction measures would be **less-than-significant**.

O. Noise

1. Impacts Associated with Black Carbon Measures

Impact 13.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Noise

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be

incorporated into the design of future development projects. These are minor short-term construction projects that would be expected to be performed internally such that construction generated noise would not expose persons to excessive or adverse noise. Operation of the replacement gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices does not lead to any significant increase in noise.

Therefore, short-term construction related and long-term operational impacts on noise from the black carbon measures would be **less-than-significant**.

Mitigation Measure 13.1-b

2. Impacts Associated with Methane Reduction Measures

Impact 13.2-a: Short-Term Construction-Related Effects on Noise

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Construction noise levels that could result from reasonably foreseeable compliance responses would fluctuate depending on the particular type, number, size, and duration of usage for the varying equipment. The effects of construction noise largely depend on the type of construction activities occurring on any given day, noise levels generated by those activities, distances to noise sensitive receptors, and the existing ambient noise environment in the receptor’s vicinity. Construction generally occurs in several discrete stages, each phase requiring a specific complement of equipment with varying equipment type, quantity, and intensity. These variations in the operational characteristics of the equipment change the effect they have on the noise environment of the project site and in the surrounding community for the duration of the construction process.

To assess noise levels associated with the various equipment types and operations, construction equipment can be considered to operate in two modes, mobile and stationary. Mobile equipment sources move around a construction site performing tasks in a recurring manner (e.g., loaders, graders, dozers). Stationary equipment operates in a given location for an extended period of time to perform continuous or periodic operations. Operational characteristics of heavy construction equipment are additionally typified by short periods of full-power operation followed by extended periods of operation at lower power, idling, or powered-off conditions.

Additionally when construction-related noise levels are being evaluated, activities that occur during the more noise-sensitive evening and nighttime hours are of increased concern. Because exterior ambient noise levels typically decrease during the late evening and nighttime hours as traffic volumes and commercial activities decrease, construction activities performed during these more noise-sensitive periods of the day can result in increased annoyance and potential sleep disruption for occupants of nearby residential uses.

The site preparation phase typically generates the most substantial noise levels because of the on-site equipment associated with grading, compacting, and excavation, which uses the noisiest types of construction equipment. Site preparation equipment and activities include backhoes, bulldozers, loaders, and excavation equipment (e.g., graders and scrapers). Construction of large structural elements and mechanical systems could require the use of a crane for placement and assembly tasks, which may also increase noise levels. Although a detailed construction equipment list is not currently available, based on this project type it is expected that the primary sources of noise would include backhoes, bulldozers, and excavators. Noise emission levels from typical types of construction equipment can range from approximately 74 to 94 dBA at 50 feet.

Based on this information and accounting for typical usage factors of individual pieces of equipment and activity types, on-site construction could result in hourly average noise levels of 87 dBA L_{eq} at 50 feet and maximum noise levels of 90 dBA L_{max} at 50 feet from the simultaneous operation of heavy-duty equipment and blasting activities, if deemed necessary. Based on these and general attenuation rates, exterior noise levels at noise-sensitive receptors located within thousands of feet from project sites could exceed typical standards (e.g., 50/60 dBA L_{eq}/L_{max} during the daytime hours and 40/50 dBA L_{eq}/L_{max} during the nighttime hours). Additionally, construction activities may result in varying degrees of temporary groundborne noise and vibration, depending on the specific construction equipment used and activities involved. Groundborne noise and vibration levels caused by various types of construction equipment and activities (e.g., bulldozers, blasting) range from 58 – 109 VdB and from 0.003 – 0.089 in/sec PPV at 25 feet. Similar to the above discussion, although a detailed construction equipment list is not currently available, based on this project type it is expected that the primary sources of groundborne vibration and noise would include bulldozers and trucks. According to the FTA, levels associated with the use of a large bulldozer and trucks are 0.089 and 0.076 in/sec PPV (87 and 86 VdB) at 25 feet, respectively. With respect to the prevention of structural damage, construction-related activities would not exceed recommended levels (e.g., 0.2 in/sec PPV). However, based on FTA's recommended procedure for applying a propagation adjustment to these reference levels, bulldozing and truck activities could exceed recommended levels with respect to the prevention of human disturbance (e.g., 80 VdB) within 275 feet.

Thus, implementation of reasonably foreseeable compliance responses could result in the generation of short-term construction noise in excess of applicable standards or that result in a substantial increase in ambient levels at nearby sensitive receptors, and exposure to excessive vibration levels.

Short-term construction-related impacts on noise associated with the methane reduction measures would be potentially significant.

This impact could be reduced to a less-than-significant level by mitigation that can and should be implemented by local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 13.2-a:

The Regulatory Setting in Attachment A includes, but is not limited to, applicable laws and regulations that pertain to noise. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that could be approved by local jurisdictions. The ability to require such measures is under the purview of jurisdictions with local or State land use approval and/or permitting authority. New or modified facilities in California would qualify as a “project” under CEQA. The jurisdiction with primary approval authority over a proposed action is the Lead Agency, which is required to review the proposed action for compliance with CEQA statutes. Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority. Recognized practices that are routinely required to avoid and/or minimize noise include:

- Proponents of new facilities constructed under the reasonably foreseeable compliance responses would coordinate with local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA). The local or State land use agency or governing body must comply with applicable regulations and would approve the project for development.
- Based on the results of project level environmental review, project proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the environmental impacts of the project The definition of actions required to mitigate potentially significant noise impacts may include the following; however, any mitigation specifically required for a new or modified facility would be determined by the local lead agency.
- Ensure noise-generating construction activities (including truck deliveries, pile driving, and blasting) are limited to the least noise- sensitive times of day (e.g., weekdays during the daytime hours) for projects near sensitive receptors.

- Consider use of noise barriers, such as berms, to limit ambient noise at property lines, especially where sensitive receptors may be present.
- Ensure all project equipment has sound-control devices no less effective than those provided on the original equipment.
- All construction equipment used would be adequately muffled and maintained.
- Consider use of battery-powered forklifts and other facility vehicles.
- Ensure all stationary construction equipment (i.e., compressors and generators) is located as far as practicable from nearby sensitive receptors or shielded.
- Properly maintain mufflers, brakes and all loose items on construction and operation related vehicles to minimize noise and address operational safety issues. Keep truck operations to the quietest operating speeds. Advise about downshifting and vehicle operations in sensitive communities to keep truck noise to a minimum.
- Use noise controls on standard construction equipment; shield impact tools.
- Consider use of flashing lights instead of audible back-up alarms on mobile equipment.
- Install mufflers on air coolers and exhaust stacks of all diesel and gas-driven engines.
- Equip all emergency pressure relief valves and steam blow-down lines with silencers to limit noise levels.
- Contain facilities within buildings or other types of effective noise enclosures.
- Employ engineering controls, including sound-insulated equipment and control rooms, to reduce the average noise level in normal work areas.

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and the programmatic analysis does not allow project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation ultimately implemented to reduce the potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that the potentially significant short-term construction-related impact regarding noise resulting from the construction of new facilities or reconstruction of existing facilities associated with the methane reduction measures could be **potentially significant and unavoidable**.

Impact 13.2-b: Long-Term Operational Effects on Noise

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors).

New sources of noise associated with implementation of the methane reduction measures could include operation of new facilities, such as dairy and wastewater treatment anaerobic digesters; and installation of new equipment (i.e. generator sets) associated with modification to dairies, and wastewater treatment and oil and gas facilities. Flares, which can emit high levels of noise, may be used at digesters and oil and gas facilities to dispose of methane vapors. However, flares at digesters would not be expected to operate except for emergency purposes; and, flares installed at oil and gas facilities would be enclosed and meet low-NOx standards. Thus, flares installed as a result of implementation of the SLCP Strategy would not substantially affect noise levels. Depending on the proximity to existing noise-sensitive receptors, digester and new equipment noise levels could exceed applicable noise standards and result in a substantial increase in ambient noise levels.

Long-term operational noise impacts associated with methane reduction measures could be potentially significant.

Mitigation Measure 13.2-b:

The Regulatory Setting in Attachment A includes, but is not limited to, applicable laws and regulations that pertain to noise. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that could be approved by local jurisdictions. The ability to require such measures is under the purview of jurisdictions with local or State land use approval and/or permitting authority. New or modified facilities in California would qualify as a “project” under CEQA. The jurisdiction with primary approval authority over a proposed action is the Lead Agency, which is required to review the proposed action for compliance with CEQA statutes. Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority. Recognized practices that are routinely required to avoid and/or minimize noise include:

- All powered equipment shall be used and maintained according to manufacturer's specifications.

- Public notice of activities shall be provided to nearby noise-sensitive receptors of potential noise-generating activities.

- All motorized equipment shall be shut down when not in use. Idling of equipment or trucks shall be limited to 5 minutes.

- All heavy equipment and equipment staging areas shall be located as far as possible from nearby noise-sensitive land uses (e.g., residential land uses, schools, hospitals, places of worship, recreation resources).

- To achieve an interior noise level less than applicable noise standards, the installation of double pane windows and building insulation shall be offered to residences directly affected by significant operational noise levels generated by the noise-generating facility. If accepted by the home owner, the project applicant shall provide the funding necessary to install the appropriate noise-reducing building improvements.

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and the programmatic analysis does not allow project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation ultimately implemented to reduce the potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that the potentially significant long-term operational-related impacts regarding noise resulting from the operation of new or existing facilities and equipment associated with the methane reduction measures could be **potentially significant and unavoidable**.

3. Impacts Associated with HFC Measures

Impact 13.3-a: Short-Term Construction-Related and Long-Term Operational Effects on Noise

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerants replacements could require minor modifications. Also, some low-GWP refrigerants (e.g., hydrocarbons, ammonia) can power existing systems (U.S. EPA 2010). Buildings could be required to undergo moderate retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. Construction-related activity would be expected to be performed internally such that construction generated noise would not expose persons to excessive or adverse noise.

Replacing high-GWP refrigerants, foam expansion agents, aerosol propellants, and other related uses for HFC would not change operations of the related devices. Similarly, existing facilities that incorporate low-GWP compounds into their manufacture process would not generate additional levels of noise as compared to current conditions. Thus, there would be no substantial increases in noise associated with the operational use of low-GWP compounds.

Therefore, the short-term construction related and long-term operational noise impacts associated with the HFC reduction measures would be **less-than-significant**.

P. Population and Housing

1. Impacts Associated with Black Carbon Measures

Impact 14.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Population and Housing

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Replacing residential wood burning stoves and fireplaces are relatively minor construction projects carried out by individuals or small crews and employment would be short term in nature. These activities would not be expected to substantially affect the employment base or where local jurisdictions have planned for increased population and employment growth. Thus, both the construction and operational activities would not require new additional housing to accommodate or generate changes in land use.

Therefore, short-term construction-related and long-term operational impacts associated with black carbon reduction measures on population and housing would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 14.2-a: Short-Term Construction-Related and Long-Term Operational Effects on Population and Housing

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction

and operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic materials diverted from landfills into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, such as pipeline installation and methods of disposal of methane vapors, and inspection and monitoring of equipment).

Construction activities would be anticipated to require relatively small crews, and demand for these crews would be temporary (e.g., 6 – 12 months per project). Therefore, a substantial amount of construction worker migration would not be likely to occur, and a sufficient construction employment base would likely be available.

Operation of these new facilities would not be expected to require new additional housing or generate changes in land use that could conflict with adopted plans.

The implementation of the methane reduction measures under the SLCP Strategy is not expected to lead to job losses or large-scale worker displacement. Operation of new digestion facilities for diverted organic waste and manure would create job opportunities for communities located near digester sites.

Although anaerobic digesters constructed in response to the methane reduction measures would vary in size, it should be noted that medium-sized digesters can be maintained by as few as two to three employees. Large-scale digesters could require up to 16 employees (Institute for Self Reliance 2010). Operation of the facilities could be automatically run with little staff involvement required. The minimal increase in employment opportunity would not require the construction of additional housing within communities containing digesters.

Therefore, short-term construction-related and long-term operational impacts on population growth, and displacement of housing or people associated with the methane reduction measures would be **less-than-significant**.

3. Impacts Associated with HFC Measures

Impact 14.3-a: Short-Term Construction-Related and Long-Term Operational Effects on Population and Housing

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Buildings and facilities that adopt low-HFC refrigerants, foaming agents, and aerosols could be required to undergo moderate retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. Construction activities could be performed by relatively small crews and employment would be short term in nature. Once new systems have been installed, the current employment base would continue to operate commercial facilities. Construction- and operational impacts to population and housing associated with modifications to existing facilities would not be substantial.

Thus, short-term construction-related and long-term operational impacts to population and housing associated with the HFC reduction measures under the SLCP Strategy would be **less-than-significant**.

Q. Public Services

1. Impacts Associated with Black Carbon Measures

Impact 15.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Public Services

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be incorporated into the design of future development projects. This consists of minor temporary construction projects in areas with appropriate zoning and would not lead to a substantial increase in job or population growth that could adversely impact schools, parks, or police and fire protection and any increased demand on public services or new or physically altered governmental facilities.

As a result, short-term construction-related and long-term operational impacts, associated with black carbon reduction measures on public services would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 15.2-a: Short-Term Construction-Related and Long-Term Operational Effects on Public Services

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction and operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic materials diverted from landfills into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, such as pipeline installation and methods of disposal of methane vapors, and inspection and monitoring of equipment).

Although it is reasonably foreseeable that activities associated with new or modified facilities could occur, there is uncertainty as to the exact location or character of any new facilities or modification of existing facilities. However, these would likely occur within footprints of existing facilities, or in areas with zoning that would permit the development of manufacturing or industrial uses. Construction activities would be anticipated to require relatively small crews, and demand for these crews would be temporary (e.g., 6 – 12 months per project). Therefore, it would be anticipated that the need for a substantial amount of construction worker migration would not occur and that a sufficient construction employment base would likely be available.

Operation of new or modified facilities would create employment opportunities for surrounding communities; however, operational activities would not require new additional housing to accommodate or generate changes in land use and, therefore, would not affect the provision of public services.

Although anaerobic digesters constructed in response to the methane reduction measures would vary in size, it should be noted that medium-sized digesters can be maintained by a few as two to three employees. Large-scale digesters could require up to 16 employees (Institute for Self Reliance 2010). Operation of the facilities could be automatically run with little staff involvement required. The minimal increase in employment opportunity would not place substantially greater strain on public services within communities containing digesters.

As a result, short-term construction-related and long-term operational impacts, associated with the methane reduction measures, on response time for fire protection, police protection, schools, parks, and other public facilities would be **less-than-significant**.

3. Impacts Associated with HFC Measures

Impact 15.3-a: Short-Term Construction Related Effects on Public Services

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Buildings and facilities that adopt low-HFC refrigerants, foaming agents, and aerosols could be required to undergo moderate retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. Construction activities could be performed by relatively small crews and employment would be short-term in nature. Therefore these activities do not result in substantial population growth that could adversely impact schools, parks, or police and fire protection. Once new systems have been installed, the current employment base would continue to operate commercial facilities and lead to any increased demand on public services or new or physically altered governmental facilities.

Thus, short-term construction-related and long-term operational impacts to public services associated with the HFC reduction measures under the SLCP Strategy would be **less-than-significant**.

R. Recreation

1. Impacts Associated with Black Carbon Measures

Impact 16.1-a: Short-Term Construction-Related and Long-Term Operational Effects on Recreation

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be incorporated into the design of future development projects. This consists of minor temporary construction projects. It is expected there would be a sufficient construction employment base available to meet this demand for construction and there would be no increased demand on population such that it could affect recreation resources .

As a result, short-term construction-related and long-term operational impacts, associated with black carbon reduction measures on recreation would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 16.2-a: Short-Term Construction-Related and Long-Term Operational Effects on Recreation

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction

and operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic materials diverted from landfills into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, such as pipeline installation and methods of disposal of methane vapors, and inspection and monitoring of equipment).

These activities would likely occur within footprints of existing manufacturing facilities, or in areas with appropriate zoning. In addition, demand for these crews would be temporary (e.g., 6 – 12 months per project) and would not be anticipated to substantially increase regional population levels. Construction and operational activities associated with reasonably foreseeable compliance responses would not be anticipated to result in increased use of regional parks and other recreational facilities, such that existing neighborhood and regional parks or other recreational facilities would be substantially deteriorated. Construction crews would be temporary, but facilities would require employees to run new or modified facilities; however, increases in population would not be substantial and the demand for new (or expansion of) recreational-related facilities is not anticipated.

Although anaerobic digesters constructed in response to the methane reduction measures would vary in size, it should be noted that medium-sized digesters can be maintained by as few as two to three employees. Large-scale digesters could require up to 16 employees (Institute for Self Reliance 2010). Operation of the facilities could be automatically run with little staff involvement required. The minimal increase in employment opportunity would not create an increased demand on reactional facilities within communities containing digesters.

Therefore, short-term construction-related and long-term operational impacts on regional parks or other recreational facilities associated with the methane reduction measures would be **less-than-significant**.

3. Impacts Associated with HFC Measures

Impact 16.3-a: Short-Term Construction-Related and Long-Term Operational Effects on Recreation

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may modifications to existing facilities.

Buildings and facilities that adopt low-HFC refrigerants, foaming agents, and aerosols could be required to undergo moderate retrofitting to incorporate new technologies (e.g., compression calibration for refrigeration systems, foam expansion equipment); however, this would be expected to happen within the existing footprint of such buildings. Construction activities could be performed by relatively small crews and employment would be short term in nature. It is expected that there is a sufficient employment base to handle the short-term construction-related activities. Once new systems have been installed, it is anticipated the current employment base would be capable of supplying workers to operate commercial facilities. Thus, the communities would not experience a substantial increase in population growth that could produce strain on recreational resources that could result in the deterioration of existing recreation facilities or construction of new recreation facilities.

Thus, short-term construction-related and long-term operational impacts to recreation associated with the HFC reduction measures under the SLCP Strategy would be **less-than-significant**.

S. Transportation and Traffic

1. Impacts Associated with Black Carbon Measures

Impact 17.1-a: Short-Term Construction-Related Effects on Transportation and Traffic

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Construction associated with replacing residential wood burning stoves and fireplaces would occur within the boundaries of existing structures, or new installations would be incorporated into the design of future development projects. An increase in trips traveled could occur during the installation of these devices; however, this would occur over an extended time period and would not be anticipated to generate a substantial increase in demand on the transportation sector because these are relatively minor construction projects carried out by small crews and would be temporary in nature. This would not create a spike in transportation needs such that there would be conflict with applicable programs, plans, ordinances, or policies (e.g., performance standards, congestion management. There are no operational impacts to transportation or traffic resulting from implementation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Thus the short-term construction-related and long-term operational impacts associated with the black carbon reduction measure would be **less-than-significant**.

2. Impacts Associated with Methane Reduction Measures

Impact 17.2-a: Short-Term Construction-Related Effects on Transportation and Traffic

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: construction of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., installing scrape manure systems or using equipment such as manure vacuums, storage silos and tanks, and facilities to support pasturing of cattle or a hybrid of both pasture and conventional systems); the development of organic material composting facilities that would convert organic wastes diverted from landfills (e.g., yard waste, green wastes, food) into composted materials; and the collection and reduction of methane emissions from oil and gas facilities (which may include modifications to existing facilities, pipeline replacement or reconstruction activities, inspection and monitoring, and disposal of methane vapors).

Although detailed information about potential specific construction activities is not currently available, it would be anticipated to result in short-term construction traffic (primarily motorized) from worker commute- and material delivery-related trips. The amount of construction activity would vary depending on the particular type, number, and duration of usage for the varying equipment, and the phase of construction. These variations would affect the amount of project-generated traffic for both worker commute trips and material deliveries. Depending on the amount of trips generated and the location of new facilities, implementation could conflict with applicable programs, plans, ordinances, or policies (e.g., performance standards, congestion management); and/or result in hazardous design features and emergency access issues from road closures, detours, and obstruction of emergency vehicle movement, especially due to project-generated heavy-duty truck trips.

Thus, short-term construction-related impacts on transportation and traffic associated with methane reduction measures could be potentially significant.

This impact on transportation and traffic could be reduced to a less-than-significant level by mitigation that can and should be implemented by local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 17.2-a:

The Regulatory Setting in Attachment A includes applicable laws and regulations in regards to transportation. ARB does not have the authority to require implementation of mitigation related to new or modified facilities that would be approved by local jurisdictions. The ability to require such measures is under the purview of jurisdictions with local or State land use approval and/or permitting authority. New or modified facilities in California would qualify as a "project" under CEQA. The jurisdiction with primary approval authority over a proposed action is the Lead Agency, which is required to review the proposed action for compliance with CEQA statutes. Project-specific impacts and mitigation would be identified during the environmental review by agencies with project-approval authority. Recognized practices that are routinely required to avoid and/or minimize construction traffic impacts include:

- Proponents of new facilities constructed would coordinate with local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA). The local or State land use agency or governing body must comply with applicable regulations and would approve the project for development.

- Based on the results of project level environmental review, project proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the environmental impacts of the project. The definition of actions required to mitigate potentially significant traffic impacts may include the following; however, any mitigation specifically required for a new or modified facility would be determined by the local lead agency.

- Minimize the number and length of access, internal, service and maintenance roads and use existing roads when feasible.

- Provide for safe ingress and egress to/from the proposed project site. Identify road design requirements for any proposed roads, and related road improvements.

- If new roads are necessary, prepare a road siting plan and consult standards contained in federal, State, or local requirements. The plans should include design and construction protocols to meet the appropriate roadway standards and be no larger than necessary to accommodate their intended functions (e.g., traffic volume and weight of vehicles). Access roads should be located to avoid or minimize impacts to washes and stream crossings, follow natural contours and minimize side-hill cuts. Roads internal to a project site should be designed to minimize ground disturbance. Excessive grades on roads, road embankments, ditches, and drainages should be avoided, especially in areas with erodible soils.

- Prepare a Construction Traffic Control Plan and a Traffic Management Plan.

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and that the programmatic analysis does not allow project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation ultimately implemented to reduce the potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that the potentially significant impact regarding traffic resulting from the construction of new facilities or modification of existing facilities associated with the methane reduction measures would be **potentially significant and unavoidable**.

Impact 17.2-b: Long-Term Operational Effects on Transportation and Traffic

Reasonably foreseeable compliance responses that could result from implementation of the methane reduction measures under the SLCP Strategy could include: operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors).

Solid manure collection systems could be operated by dairy employees and would not require supplemental delivery trips during operation. No substantial changes to traffic patterns would result from scraping activities; however, the operation of centralized anaerobic digesters could potentially generate traffic impacts due to movement of manure and organic waste from point of origin to the receiving facility. New fueling stations associated with digesters may increase traffic flows on local roads for on- and off-site fleets. In addition, monitoring of oil and gas facilities for the purpose of reducing escaped methane emissions would also generate an increase in miles traveled. Additionally, commute routes of future employees could generate increased daily trips. At this programmatic level of analysis, the location of these facilities cannot be determined; therefore impacts to applicable traffic plans cannot be accurately predicted at present.

Thus, long-term operational impacts on transportation and traffic, associated with methane reduction measures, could be potentially significant.

This impact on transportation and traffic could be reduced to a less-than-significant level by mitigation that can and should be implemented by local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 17.2-b: Implement Mitigation Measure 17.2-a

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and that the programmatic analysis does not allow project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation ultimately implemented to reduce the potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that the potentially significant impact regarding traffic resulting from the operation of new facilities or modification of existing facilities and implementation of oil and gas monitoring associated with the methane reduction measures would be **potentially significant and unavoidable**.

3. Impacts Associated with HFC Measures

Impact 17.3-a: Short-Term Construction-Related and Long-Term Operational Effects on Transportation and Traffic

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Existing residences, commercial buildings, and facilities that incorporate low-GWP refrigerant replacements could require minor modifications. An increase in trips traveled could occur during the installation of these devices; however, this would occur over an extended time period and would not be anticipated to generate a substantial increase in demand on the transportation sector. In addition, although construction-related activities associated with the physical alteration of existing buildings and facilities for the adoption of low-GWP compounds could generate construction worker-related miles traveled, this would be temporary and would create minimal demand on the transportation sector. Impacts associated with the incorporation of low-GWP refrigerants, foam expanding agents, and aerosols to transportation and traffic would be less-than-significant.

Following the installation of the low-GWP powered appliances and technologies, routine maintenance (e.g., refills) would be required, but such operational activity would not create strain on transportation because it would be similar to the existing need for routine maintenance.

Therefore, the short-term construction related and long-term operational impacts to transportation and traffic associated with the phase out of high-GWP HFCs would be **less-than-significant**.

T. Utilities and Service Systems

Impacts on utilities and service systems are of a long-term nature, thus, short-term effects are not addressed below.

1. Impacts Associated with Black Carbon Measures

Impact 18.1-a: Long-Term Operational Effects on Utilities and Service Systems

Reasonably foreseeable compliance responses that could result from implementation of the proposed black carbon reduction measures include increased installation of gas fireplaces, electric heaters, gas heaters, and U.S. EPA-certified devices.

Replacement of wood-burning stoves and fireplaces with electric heaters, gas heaters, U.S. EPA-certified and gas fireplaces would not include installation of supporting infrastructure related to wastewater or stormwater management. Disposal would not be substantial compared to typical household needs, which could be serviced by existing landfills and recycling facilities and would not produce strain on these services such that new facilities would be required.

Thus, long-term operational impacts on utilities and services systems, associated with the black carbon reduction measures under the SLCP Strategy would be **less-than-significant.**

2. Impacts Associated with Methane Reduction Measures

Impact 18.2-a: Long-Term Operational Impacts to Utilities and Service Systems

The methane reduction measures under the SLCP Strategy could include: operation of new or modified digesters, either on-site or centralized, for dairies, landfills and wastewater treatments plants to convert manure, organic wastes, and solid wastes to biogas (which may include electricity generator sets, biogas storage tanks and compression and cleaning equipment, above ground pipeline systems, transmission poles and wires, and vehicle fueling stations); changes to manure management systems and practices at dairies (e.g., scrape manure systems or equipment such as manure vacuums, storage silos and tanks, and pasturing of cattle or a hybrid of both pasture and conventional systems); the operation of organic material composting facilities that would convert organic materials diverted from landfills into compostable materials; and, the collection and reduction of methane emissions from oil and gas facilities (which may include inspection and monitoring of infrastructure and disposal of methane vapors).

Reasonably foreseeable compliance responses associated with the methane reduction measures could result in new demand for water, wastewater, electricity, and gas services. Generally, facilities would be citied in areas with existing utility infrastructure—or areas where existing utility infrastructure is easily assessable. New or modified utility installation, connections, and expansion would be subject to the requirements of the applicable utility providers.

The improved maintenance and monitoring of oil and gas facilities would not result in any impacts to utilities and service systems in that exceedance of local RWQCB standards for wastewater would not occur. Also, implementation of this compliance response would not result in the construction of new or expanded wastewater treatment or storm water drainage facilities, landfill servicing, or the generation of solid waste.

Lagoon-based systems use a substantial amount of water, primarily related to dilution requirements for land application. Conversion to non-lagoon systems scrape based systems, irrigation of pastures, and use of digesters, etc. would demand water; however, it would be expected to be substantially less than the demand associated with lagoons combined with flood irrigation of cropland.

Thus, implementation of the SLCP Strategy could reduce water demands related to dairies in California.

Methods to reduce fugitive methane emissions include the operation of anaerobic digesters across a number of sectors. Animal, organic, and human waste can be anaerobically digested to produce controlled methane, which can then be captured and used as a renewable energy source. It should be noted that the water demands of digesters vary depending on size, scale, capacity, and feedstock (product to be digested); therefore, water demand is not consistent as varying combinations of facility size and feedstock dryness dictate water needs. Further, anaerobic digesters produce digestate, which can be managed in several ways: compost, land applications, fertilizer, and landfill cover. Therefore, it can be assumed that a digester could potentially need landfill servicing.

Dairy, organic waste, and wastewater treatment anaerobic digesters are discussed with respect to utilities and service systems independently below. As a compliance response to the methane reduction measures, dairies could construct on-site digesters as a method of manure management. As the current flush-water method of manure management requires a large amount of water, dairies that adopt on-site digestion would have sufficient water supplies for operation, and would not require the construction or expansion of wastewater treatment facilities. On-site digesters would result in new impermeable surfaces; however, this area would be small in comparison to the dairy as a whole and would not affect stormwater flow. Stormwater facilities would not need to be constructed.

Development of off-site centralized dairy digester facilities could require new water and wastewater treatment facilities or connection to a municipal system. Water would be required to increase the liquid content of manure feedstock as well as water down the resulting effluent; however, this water could be non-potable. Digesters located near dairy facilities could be supplied by groundwater or irrigation districts; digesters within urban areas would be supplied by a municipal source. Domestic water use (e.g., restrooms for employees) could be serviced by septic systems, or, for digesters near urban areas, could connect to a municipal system. Additionally, compliance with WDRs, NPDES and SWPPP permitting, and additional local permits as discussed in Section 10, "Hydrology and Water Quality," would ensure that exceedance of local RWQCB wastewater treatment requirements would not occur (RWQCB 2010). Construction of new or expanded storm water drainage facilities could result from the development of off-site digesters, but as the location of these facilities is uncertain, the conditions under which a facility may require supplemental storm water management cannot be predicted nor adequately analyzed.

Anaerobic digesters constructed for the management of organic waste could create additional strains on utilities and service systems. Organic waste digesters constructed within the vicinity of an existing solid waste disposal facility would likely not require supplemental water, but those constructed independently would need to connect to a municipal source or use a groundwater well. Organic waste digesters may dispose of resulting digestate by distributing it amongst various agricultural areas or convey it to a wastewater treatment facility. The latter would put additional pressure on wastewater facilities to comply with the treatment and disposal requirements of the SWRCB and the local RWQCB (CalRecycle 2011). The locations of these facilities is, at this time, uncertain, and therefore supplemental storm water drainage facilities could be required with project implementation depending on the characteristics of future project sites.

A potential compliance response would be the expansion of wastewater treatment facilities to adopt the process of anaerobic digestion, expand existing anaerobic digesters, and potentially dispose of digestates originating from other facilities. Unlike the digesters discussed above, no new wastewater treatment plants would need to be constructed to comply with the methane reduction measures. These facilities would be modified to increase capacity of anaerobic digestion. Wastewater treatment plants inherently receive a stable source of water; therefore, increased levels of digestion would not exceed water supplies available. Further, plants cannot operate without complying with the wastewater treatment requirements established by the governing RWQCB and SWRCB. Digestate could be disposed of on-site. It would not be expected that construction or expansion of storm water drainage facilities would be required.

The operation of digester systems at dairies, organic compost facilities, and wastewater treatment plants designed to export electricity or biogas for off-site use or consumption could potentially create impacts for electric and gas utilities and their service systems. Exported electricity generated by digesters would necessitate interconnection with the local electricity distribution grid and may require safety equipment and engineering upgrades to local distribution systems owned and operated by electric utilities. The export or injection of digester-derived biogas into natural gas pipeline systems would require interconnection infrastructure with local utility-owned pipeline systems and may require biogas upgrading to meet the constituency standards and heating values of their pipeline systems. (Note that CEC and CPUC are currently involved in proceedings for biomethane under AB 1900; see Attachment A).

Any new or modified facilities, no matter their size and location would be required to seek local or State land use approvals prior to their development. In addition, part of the land use entitlement process for facilities proposed in California requires that each of these projects undergo environmental review consistent with the requirements of CEQA and the CEQA Guidelines. Through the environmental review process, utility and service demands would be calculated; agencies would provide input on available service capacity and the potential need for service-related infrastructure including expansions to wastewater treatment plants, new water supply entitlements and infrastructure, storm water infrastructure, and solid waste handling capacity (e.g., landfills). Resulting environmental impacts would also be determined through this process.

Thus, long-term operational impacts on utilities and services systems, associated with the methane reduction measures could be potentially significant.

This impact could be reduced to a less-than-significant level by mitigation that can and should be implemented by local lead agencies, but is beyond the authority of the ARB and not within its purview.

Mitigation Measure 18.2-a:

ARB does not have the authority to require implementation of mitigation related to new or modified facilities that would be approved by local jurisdictions. The ability to require such measures is under the purview of jurisdictions with local or the corresponding state land use approval and/or permitting authority. There is uncertainty surrounding the location of construction activities, and therefore the applicable local or state laws adopted to reduce construction-related impacts to utilities and service systems will vary by state, or possibly country. The measures discussed below are based on recognized practices used in California that are routinely required to avoid and/or mitigate utilities and service systems-related impacts, and could be implemented regardless of location:

- Proponents of new facilities constructed as a result of reasonably foreseeable compliance responses would coordinate with the corresponding local or State land use agencies to seek entitlements for development including the completion of all necessary environmental review requirements (e.g., CEQA, NEPA). The local or State land use agency or governing body must comply with applicable regulations and would approve the project for development.

- Based on the results of project level environmental review, project proponents would implement all feasible mitigation identified in the environmental document to reduce or substantially lessen the environmental impacts of the project. The definition of actions required to mitigate potentially significant utility or service-related impacts may include the following; however, any mitigation specifically required for a new or modified facility would be determined by the local lead agency.

- Comply with local plans and policies regarding the provision of water supply, wastewater treatment, and storm water drainage utilities, and solid waste services.

- Where an on-site wastewater system is proposed, submit a permit application to the appropriate local jurisdiction.

- Comply with local plans and policies regarding the provision of wastewater treatment services.

Because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects, and the programmatic analysis does not allow project-specific details of mitigation, there is inherent uncertainty in the degree of mitigation ultimately implemented to reduce the potentially significant impacts.

Consequently, while impacts could be reduced to a less-than-significant level by land use and/or permitting agency conditions of approval, this Revised Draft EA takes the conservative approach in its post-mitigation significance conclusion and discloses, for CEQA compliance purposes, that the potentially significant impact to utilities and service systems resulting from the operation of new facilities associated with the methane reduction measures would be **potentially significant and unavoidable**.

3. Impacts Associated with HFC Measures

Impact 18.3-a: Long-Term Operational Effects on Utilities and Service Systems

The HFC reduction measures under the SLCP Strategy contain actions to reduce HFC emissions within the State through replacing high-GWP HFCs, used as refrigerants, foam expansion agents, aerosol propellants, and to a lesser extent, as solvents and fire suppressants, with low-GWP compounds such as ammonia, CO_2, hydrocarbons, lower-GWP HFCs, and HFOs. This may require modifications to existing facilities.

Installation of low-GWP compound-powered appliances and technology would be inherently minor or moderate and would create similar demand on utilities and service systems. Additional wastewater treatment or stormwater drainage infrastructure would not be a result of operation of low-GWP devices. Solid waste would not be generated.

Thus, long-term operational impacts on utilities and services systems, associated with the phase out of high-GWP HFCs would be **less-than-significant**.

5.0 CUMULATIVE AND GROWTH-INDUCING IMPACTS

A. Approach to the Cumulative Analysis

This section satisfies requirements of the California Environmental Quality Act (CEQA) to discuss how the project being analyzed would contribute to cumulative impacts. The California Air Resources Board's (ARB or Board) certified regulatory program (Cal. Code Regs., tit.17, § 60000-60008) does not provide specific direction on a cumulative impacts analysis, and while ARB by virtue of its certified program is exempt from Chapters 3 and 4 of CEQA and corresponding sections of the CEQA Guidelines, the Guidelines nevertheless contain useful information for preparation of a thorough and meaningful cumulative analysis for the Short-Lived Climate Pollutant Reduction Strategy (SLCP Strategy).

CEQA requires a lead agency to discuss a cumulative impact if the project's incremental effect combined with the effects of other projects is "cumulatively considerable." (Cal. Code Regs., tit. 14 § 15130, subd. (a).) The discussion of cumulative impacts need not provide as much detail as the discussion of effects attributable to the project alone. (Cal. Code Regs., tit. 14 § 15130, subd. (a).) Where a lead agency is examining a project with an incremental effect that is not "cumulatively considerable," a lead agency need not consider that effect significant, but must briefly describe its basis for concluding that the incremental effect is not cumulatively considerable.

In considering cumulative impacts, an agency may prepare a list of past, present, and probable future projects that will produce related or cumulative impacts, or rely on a summary of projections contained in an adopted planning document or an adopted or certified environmental document for the planning document. (Cal. Code Regs., tit. 14 § 15130, subd. (b).) The pertinent discussion of cumulative impacts contained in one or more previously certified environmental impact reports (EIRs) may be incorporated by reference pursuant to provisions for tiering and program EIRs, and no further cumulative analysis is required when the lead agency determines the regional and area wide impacts have already been addressed in the prior certified EIR. (Cal. Code Regs., tit. 14 § 15130, subd. (d).)

The SLCP Strategy is a later activity that was described in the First Update to the Scoping Plan (Scoping Plan Update), which was evaluated in a programmatic Environmental Analysis (EA) and certified in May 2014. While ARB could have relied on the cumulative analysis from the Scoping Plan Update and do no further cumulative analysis, ARB chose to summarize any additional information about cumulative and growth-inducing impacts associated with the recommended actions in the SLCP Strategy identified for each resource topic evaluated in Chapter 4 of this Revised Draft EA in combination with the cumulative impacts described in the Scoping Plan Update EA, as described in more detail in section C below.

B. Significance Determinations and Mitigation

Implementation of the SLCP Strategy is determined to potentially result in cumulatively considerable contributions to significant cumulative impacts to certain resource areas, as discussed below. While suggested mitigation is provided for each potential cumulatively considerable contribution to a significant impact, some of the mitigation needs to be implemented by other agencies. Where impacts cannot be feasibly mitigated to less-than-significant, the Revised Draft EA recognizes the impact as significant and unavoidable, and the Board will need to make the appropriate findings for any significant and unavoidable environmental impacts of the SLCP Strategy as part of the approval process.

C. Cumulative Impact Analyzed in the Scoping Plan Update EA

For purposes of this analysis, ARB is relying on the summary of projections contained in the EA prepared for the 2014 Scoping Plan Update. The Scoping Plan Update EA, certified by the Board in 2014, was prepared as a program environmental document for the entire statewide plan of greenhouse gas (GHG) reductions strategies, which included the SLCP Strategy. The Scoping Plan Update EA provided a program level review of significant adverse impacts associated with the reasonably foreseeable compliance responses that appeared most likely to occur as a result of implementing the recommended actions identified in each of the nine sectors discussed in the Scoping Plan Update. The impact discussion includes, where relevant, construction-related effects, operational effects of new or modified facilities, and influences of the recommended actions on GHG and air pollutant emissions. The Scoping Plan Update EA considered cumulative impacts of a full range of reasonably foreseeable compliance responses to all the recommendations in all nine sectors, including the SLCP Strategy, along with the expected background growth in California in its impacts conclusions for each resource topic area. That EA considered the cumulative effect of both other "closely related" past, present, and future reasonably foreseeable activities undertaken to reduce GHGs in response to statewide programs and policies, as well other activities with "related impacts." (Cal. Code Regs., tit. 14 § 15355, subd. (b); 15130, subd. (a)(1).)

A previously approved plan may be used in a cumulative impacts analysis, the pertinent discussion of cumulative impacts contained in one or more previously certified EIRs may be incorporated by reference, and in certain circumstances, no further cumulative impact analysis is required for a project that is consistent with a plan that has a certified EIR. (Cal. Code Regs., tit. 14 § 15130, subd. (d).)

Consistent with these provisions, ARB has determined that for the cumulative analysis of the SLCP Strategy, which was considered in and is consistent with the Scoping Plan Update EA, it is appropriate to rely on the cumulative analysis contained in the Scoping Plan Update EA. The Scoping Plan Update EA is incorporated by reference into this document for the purpose of relying on cumulative analysis and the geographic extent of impact analyses that have already been prepared and presented in the certified EA.

(Cal. Code Regs., tit. 14, § 15168.) ARB has also determined it would be appropriate to provide a summary of that information along with a summary of any additional information about cumulative and growth-inducing impacts associated with the recommended actions analyzed in Chapter 4. Because of the statewide reach of the SLCP Strategy and the longer-term future horizon for achievement of short-lived climate emission reductions, the impact analyses in this programmatic EA for the resource topics in Chapter 4 are inherently cumulative in nature, rather than site or project specific, in that they address the impacts of the reasonably foreseeable compliance responses to the recommended actions in the statewide context. The impact conclusions and mitigation measures in the resource-oriented sections of Chapter 4 are cumulative because they describe the potential impacts associated collectively of the full range of reasonably foreseeable compliance responses, along with expected background growth in California, as appropriate. Therefore, the analysis of cumulative impacts below includes:

- A summary of the cumulative impacts found for each resource area in the Scoping Plan Update EA in May 2014.
- A summary of information about impacts associated with the recommended actions in the SLCP Strategy identified for each resource topic evaluated in Chapter 4 of this Revised Draft EA, which are inherently cumulative in nature.
- A significance conclusion that determines if the SLCP Strategy's contribution to this significant impact would be cumulatively considerable, given the conclusion in Chapter 4 about whether the proposed measures may themselves result in a significant adverse impact on the resource area.

This approach to cumulative impacts analysis is "guided by the standards of practicality and reasonableness" (Cal. Code Regs., tit. 14 § 15130 (b)) and serves the purpose of providing "a context for considering whether the incremental effects of the project at issue are considerable" when judged "against the backdrop of the environmental effects of other projects." (*CBE v. Cal. Res. Agency* (2002) 103 Cal.App.4th 98, 119.)

D. Cumulative Impacts by Resource Area

1. Aesthetics

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result in a significant cumulative impact to aesthetic resources resulting from new or modified facilities. As discussed in the Scoping Plan Update EA, there is uncertainty as to the specific location of new facilities or the modification of existing facilities. Construction and operation of these facilities (although likely to occur in areas zoned or used for manufacturing or industrial purposes), could conceivably introduce or increase the presence of artificial landscape elements (e.g., heavy-duty equipment, removal of existing vegetation, buildings) in areas of scenic importance, such as visibility from a State scenic highways.

Construction and operation of these facilities (although likely to occur in areas zoned or used for manufacturing or industrial purposes), could conceivably introduce or increase the presence of artificial landscape elements (e.g., heavy-duty equipment, removal of existing vegetation, buildings) in areas of scenic importance, such as visibility from a State scenic highway. The visual impact of such development would depend on several variables, including the type and size of facilities, distance and angle of view, visual absorption and placement in the landscape. In addition, facility operation may introduce substantial sources of glare, exhaust plumes, and nighttime glare from lighting for safety and security purposes. Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, it was determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a significant cumulative aesthetics-related impact.

Under the SLCP Strategy, construction activities could include the presence of heavy-duty equipment, vegetation removal, and grading. Long-term visual impacts could result from operation of new facilities that could introduce or increase the presence of visible artificial elements in areas of scenic importance, such as visibility from State scenic highways. The impact analysis in Chapter 4 determined the short- term construction-related and long-term operational aesthetic impacts resulting from the development of new facilities or modification of existing facilities and the operation of projects associated with implementation of the SLCP Strategy would be potentially significant and unavoidable.

Based on the conclusions in Chapter 4, the SLCP Strategy’s contribution to this significant impact would be cumulatively considerable. Implementation of the project-level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in **cumulatively considerable contribution to a significant cumulative impact** on aesthetic resources.

2. Agricultural and Forest Resources

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which included the recommendation for the SLCP Strategy, could result in a significant cumulative impact to agricultural and forest resources. As discussed in the Scoping Plan Update EA, there is uncertainty as to the specific location of these new facilities or the modification of existing facilities. Construction of new facilities could result in the conversion of Prime Farmland, Unique Farmland, or

Farmland of Statewide Importance, Williamson Act conservation contracts, or forest land or timberland, resulting in the loss of these resources. Because ARB has no land use authority, mitigation is not within its purview to reduce potentially significant impacts to less-than-significant levels. Compliance with existing land use policies, ordinances, and regulations would serve to minimize this impact. Land use impacts would be further addressed for individual projects through the local development review process.

Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, it was determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a significant cumulative impact to agricultural and forest resources.

Under the SLCP Strategy, new facilities could be located on agricultural or forest lands, which could result in the conversion of Important Farmland, forest land or timber land to other uses. The impact analysis in Chapter 4 determined the short-term construction-related and long-term operational impacts on agricultural and forest resources resulting from the development of new facilities associated with implementation of the SLCP Strategy would be potentially significant and unavoidable.

Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to this significant impact would be cumulatively considerable. Implementation of the project-level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in a **cumulatively considerable contribution to a significant cumulative impact** on agricultural and forest resources.

3. Air Quality

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which included the recommendation for the SLCP Strategy, could result in a significant cumulative impact to air quality. As discussed in the Scoping Plan Update EA, reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update could result in an increase in criteria air pollutants and TACs, as well as generate unpleasant odors that could affect sensitive receptors. These would be generated by the use of heavy-duty construction equipment on a short-term basis, as well as longer-term operational impacts associated with anaerobic digestion and composting facilities. Therefore, the Scoping Plan Update could generate emission levels that conflict with applicable air quality plans, violate or contribute substantially to an existing or projected ambient air quality standard violation, result in a cumulatively considerable net increase in non-attainment areas, or expose sensitive receptors to substantial pollutant concentrations or odors.

However, all projects, no matter their size or type, would be required to seek local or State land use approvals prior to their implementation. Part of the land use entitlement process requires that each of these projects undergo environmental review consistent with California environmental law (e.g., CEQA) and other applicable local requirements (e.g., local air district rules and regulations). This environmental review process would assess whether project implementation would result in short-term construction and long-term operational air quality impacts.

Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, it was determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a cumulative impact to air quality.

Reasonably foreseeable compliance responses associated with the SLCP Strategy could result in a short-term increase in criteria air pollutants and TACs from construction on a short-term basis and possibly long-term operationally from the methane sector depending on the design of future incentive and regulatory programs.

Therefore, the SLCP Strategy could generate emission levels that conflict with applicable air quality plans, violate or contribute substantially to an existing or projected ambient air quality standard violation, result in a cumulatively considerable net increase in non-attainment areas, or expose sensitive receptors to substantial pollutant concentrations or odors. However, all projects, no matter their size or type would be required to seek local or State land use approvals prior to their implementation. Part of the land use entitlement process in California requires that each of these projects undergo environmental review consistent with California environmental law (e.g., CEQA) and other applicable local requirements (e.g., local air district rules and regulations). This environmental review process would assess whether project implementation would result in short-term construction-related and long-term operational air quality impacts.

The impact analysis in Chapter 4 determined the short-term construction-related and long-term operational air quality impacts resulting from the development of new facilities or modification of existing facilities associated with implementation of the SLCP Strategy would be potentially significant and unavoidable.

Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to this significant impact would be cumulatively considerable. Implementation of the project-level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in a **cumulatively considerable contribution to a significant cumulative impact** on air quality.

Implementation of the SLCP Strategy would encourage the collection of natural gas from dairies, landfills, and wastewater treatment plants. Generally, odor is a perceived nuisance and an environmental impact. Factors that would affect odor impacts include the design of collection facilities and exposure duration. In general, odors associated with dairies, landfills, and wastewater treatment plants are part of the existing conditions baseline, and are likely to be reduced through the use of a closed system (e.g., digester facilities). In addition, odor impacts are site-specific and the gaseous compounds released during operations would be distributed into the atmosphere in a way that would not allow for combined effects. Thus, implementation of the SLCP Strategy **would not result in a cumulatively considerable contribution to a significant cumulative impact** on odor.

4. Biological Resources

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result in a significant cumulative impacts to biological resources. Implementation of reasonably foreseeable compliance responses associated with recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction and operational activities associated with new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. Construction could require disturbance of undeveloped area, such as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways. These activities would have the potential to adversely affect biological resources (e.g., species, habitat) that may reside or be present in those areas. Because there are biological species that occur, or even thrive, in developed settings, resources could also be adversely affected by construction and operations within disturbed areas at existing manufacturing facilities or at other sites in areas with zoning that would permit the development of manufacturing or industrial uses.

The biological resources that could be affected by construction and operation associated with implementation of new regulations and/or incentive measures under the Scoping Plan Update would depend on the specific location of any necessary construction and its environmental setting. Harmful impacts could include modifications to existing habitat; including removal, degradation, and fragmentation of riparian systems, wetlands, or other sensitive natural wildlife habitat and plan communities; interference with wildlife movement or wildlife nursery sites; loss of special-status species; and/or conflicts with the provisions of adopted habitat conservation plans, natural community conservation plans, or other conservation plans or policies to protect natural resources Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, it was determined implementation of the recommended actions in the Scoping Plan

Update, which includes the SLCP Strategy, could result in a significant cumulative impact on biological resources.

Implementation of reasonably foreseeable compliance responses associated with the SLCP Strategy could also require construction and operational activities associated with new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. Construction might result in disturbance of undeveloped areas through such activities as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways.

The biological resources that could be affected by construction and operation associated with implementation of new regulations and/or incentive measures, would depend on the specific location of any necessary construction and its environmental setting. Harmful impacts could include modifications to existing habitat; including removal, degradation, and fragmentation of riparian systems, wetlands, or other sensitive natural wildlife habitat and plan communities; interference with wildlife movement or wildlife nursery sites; loss of special-status species; and/or conflicts with the provisions of adopted habitat conservation plans, natural community conservation plans, or other conservation plans or policies to protect natural resources.

The impact analysis in Chapter 4 determined the short-term construction-related and long-term operational impacts on biological resources, would be potentially significant and unavoidable.

Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to this significant impact would be cumulatively considerable. Implementation of the project-level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in a **cumulatively considerable contribution to a significant cumulative impact** on biological resources.

5. Cultural Resources

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result in a significant cumulative impacts to cultural resources. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction activities associated with new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. Construction activities could require disturbance of undeveloped area, such as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways. Demolition of existing structures may also occur before the construction of new buildings and structures. The cultural resources that could potentially be affected by ground disturbance activities could include, but are not limited to, prehistoric and historical archaeological sites, paleontological resources, historic buildings, structures, or archaeological sites associated with agriculture and mining, and heritage landscapes. Properties important to Native American communities and other ethnic groups, including tangible properties possessing intangible traditional cultural values, also may exist. Historic buildings and structures may also be adversely affected by demolition-related activities. Such resources may occur individually, in groupings of modest size, or in districts. Because culturally sensitive resources can also be located in developed settings, historic, archeological, and paleontological resources, and places important to Native American communities, could also be adversely affected by construction of new facilities. Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, it was determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a significant cumulative impact on cultural resources.

Implementation of the SLCP Strategy could result in earth-moving activities that could affect cultural resources. Implementation of reasonably foreseeable compliance responses associated with the SLCP Strategy could also require construction activities associated with new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. Construction activities could require disturbance of undeveloped area, such as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways. Demolition of existing structures may also occur before the construction of new buildings and structures. The cultural resources that could potentially be affected by ground disturbance activities could include, but are not limited to, prehistoric and historical archaeological sites, paleontological resources, historic buildings, structures, or archaeological sites associated with agriculture and mining, and heritage landscapes. Properties important to Native American communities and other ethnic groups, including tangible properties possessing intangible traditional cultural values, also may exist. Historic buildings and structures may also be adversely affected by demolition-related activities. Such resources may occur individually, in groupings of modest size, or in districts. Because culturally sensitive resources can also be located in developed settings, historic, archeological, and paleontological resources, and places important to Native American communities, could also be adversely affected by construction of new facilities.

The impact analysis in Chapter 4 determined the short-term construction-related and long-term operational impacts on cultural resources resulting from the development of new facilities or modification of existing facilities and operation of measures, associated with implementation of the SLCP Strategy, would be potentially significant and unavoidable.

Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to this significant impact would be cumulatively considerable. Implementation of the project-level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in a **cumulatively considerable contribution to a significant cumulative impact** on cultural resources.

6. Energy Demand

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, would not result in a significant cumulative impact to energy demand. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction and operational activities associated with new or modified facilities or infrastructure. Temporary increases in energy demand associated with new facilities would include fuels used during construction, and gas and electric operational demands. Typical earth-moving equipment that may be necessary for construction includes: graders, scrapers, backhoes, jackhammers, front-end loaders, generators, water trucks, and dump trucks. While energy would be required to complete construction for any new or modified facilities or infrastructure projects, it would be temporary and limited in magnitude and would not result in sustained increases in demand that would adversely affect energy supplies. Therefore, the Scoping Plan Update EA determined the Scoping Plan Update would not result in a cumulative impact relative to construction-related energy demand.

The Scoping Plan Update EA also determined long-term operational energy demand impacts associated with the recommended actions under the Scoping Plan Update could result in increased energy demand. For instance, transport of materials to biomass plants could increase diesel demand. These demands would not be substantial with consideration of the various projects because, in part, energy would be produced. Thus no cumulative impact on long-term operational energy demand associated with the Scoping Plan Update would occur.

Implementation of reasonably foreseeable compliance responses associated with the SLCP Strategy could also require construction and operational activities associated with new or modified facilities or infrastructure. Temporary increases in energy demand associated with new facilities would include fuels used during construction, and gas and electric operational demands. Typical earth-moving equipment that may be necessary for construction includes: graders, scrapers, backhoes, jackhammers, front-end loaders, generators, water trucks, and dump trucks. While energy would be required to complete construction for any new or modified facilities or infrastructure projects, it would be temporary and limited in magnitude and would not result in sustained increases in demand that would adversely affect energy supplies. Further, it is expected that operation of new or modified facilities would not result in a substantial demand increase on local or regional energy supplies. In addition, operation of anaerobic digesters (i.e., dairy digesters, wastewater treatment plants, and organic digesters) could supplement the State's energy grid with a source of renewable energy

Based on the conclusions in Chapter 4, the short-term construction-related and long-term operational impacts on energy demand resulting from the development of new facilities or modification of existing facilities and operation of projects, associated with implementation of the SLCP Strategy, would be less-than-significant. Energy demands from individual projects and activities would not be expected to combine such that excessive use would be required beyond what would be necessary. Generally, a shift in the types of energy would occur toward less petroleum-based fuels. Therefore, the SLCP Strategy **would not make a cumulatively considerable contribution such that a cumulative impact would occur** related to energy demand.

7. Geology and Soils

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result in a significant cumulative impact on geology and soils. Implementation of the reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction and operational activities associated with new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. Construction and operation could be located in a variety of relatively high-risk geologic and soil conditions that may be potentially hazardous. For instance, the seismic conditions at the site of a new facility may have high to extremely high seismic-related fault rupture and ground shaking potential associated with earthquake activity. New facilities could also be subject to seismic-related ground failure, including liquefaction and landslides. Construction and operational activities could be located in a variety of geologic, soil, and slope conditions with varying amounts of vegetation that would be susceptible to soil erosion. Strong ground shaking could also trigger landslides in areas where the natural slope is naturally unstable or is over-steepened by the construction of access roads and structures. Construction and operation could also occur in locations that would expose facilities and structures to expansive soil conditions. Development of new facilities could be susceptible to the presence of expansive soils particularly in areas of fine-grained sediment accumulation typically associated with playas, valley bottoms, and local low-lying areas.

The specific design details, siting locations, seismic hazards, and geologic, slope, and soil conditions for any particular facilities that could occur as a result of reasonably foreseeable compliance responses were not known and would be analyzed on a site-specific basis at the project level. Therefore, the Scoping Plan Update EA determined development of these facilities could expose people and structures to relatively high levels of risk associated with strong seismic ground shaking, including liquefaction and landslides, and instability. These geologic, seismic, and soil-related conditions could result in damage to structures, related utility lines, and access roads, blocking access and posing safety hazards to people.

Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, it was determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a significant cumulative impact on geology and soils.

Implementation of the reasonably foreseeable compliance responses associated with the SLCP Strategy could also require construction and operational activities associated with new or modified facilities or infrastructure. Although it is reasonably foreseeable that construction could occur, there is uncertainty as to the exact location of any new facilities or modification of existing facilities. Construction activities could require disturbance of undeveloped areas, such as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways. These activities would have the potential to adversely affect soil and geologic resources in construction areas.

New facilities could be located in a variety of geologic, soil, and slope conditions with varying amounts of vegetation that would be susceptible to soil compaction, soil erosion, and loss of topsoil during construction. The level of susceptibility varies by location. However, the specific design details, siting locations, and soil compaction and erosion hazards for particular manufacturing facilities are not known at this time and would be analyzed on a site-specific basis at the project level. Therefore, the impact analysis in Chapter 4 determined the short-term construction-related impacts on geology, seismicity, and soils resulting from the development of new facilities or modification of existing facilities, associated with implementation of the methane measures in the SLCP Strategy, would be potentially significant and unavoidable.

Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to the short-term construction related significant impact would be cumulatively considerable. Implementation of the project- level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in a **cumulatively considerable contribution to a significant short-term cumulative impact** on geology and soils.

Chapter 4 determined there would be less-than-significant long-term operational impacts on geology, seismicity, and soils. Thus, the SLCP Strategy **would not make a cumulatively considerable contribution to a long-term cumulative impact** on geology and soils.

8. Greenhouse Gases

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result cumulatively beneficial impact to greenhouse gases. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction activities associated with new or modified facilities or infrastructure. Specific, project-related construction activities could result in increased generation of short-term GHG emissions in limited amounts associated with the use of heavy-duty off-road equipment, materials transport, and worker commutes. The Scoping Plan Update EA determined the short-term construction related GHG emissions impacts associated with reasonably-foreseeable compliance responses for the recommended actions in the Scoping Plan Update would be less-than- significant, when considered in comparison to the overall GHG reduction associated with implementation of the Scoping Plan Update.

Implementation of reasonably foreseeable compliance responses associated with the SLCP Strategy could require construction activities associated with new or modified facilities or infrastructure. Specific, project-related construction activities could result in increased generation of short-term GHG emissions in limited amounts associated with the use of heavy-duty off-road equipment. As described in Chapter 4, the short-term construction- generated GHGs for typical construction projects occur for a finite period of time (e.g., during periods of construction) that is typically much shorter than the operational phase, and agencies generally recommended that GHG analyses focus on operational phase emissions, unless the project is of a unique nature requiring atypical (e.g., large scale, long-term) activity levels (e.g., construction of a new dam or levee) for which quantification and consideration (e.g., amortization of construction emissions over the lifetime of the project) may be recommended. The long-term operational impacts associated with the SLCP Strategy would reduce emissions of black carbon, methane, and HFCs, thereby reduce GHG emissions in the State. The short-term construction related GHG emissions impacts would be less-than-significant, when compared to the overall GHG reduction associated with implementation of the SLCP Strategy. Overall, the SLCP Strategy would result in a long-term beneficial effect and no significant cumulative adverse effect would occur. Thus, the SLCP Strategy **would not make a considerable contribution (i.e., would be beneficial) such that a significant cumulative impact would occur** on GHG emissions.

9. Hazards and Hazardous Materials

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result in a significant cumulative impact to hazards and hazardous materials. Reasonably foreseeable compliance responses to the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could include construction and operation of new or modified facilities or infrastructure. There is uncertainty as to the specific locations where construction and operations of new facilities or the modification of existing facilities would occur.

Construction activities may require the transport, use, and disposal of hazardous materials. Construction activities generally use heavy-duty equipment requiring periodic refueling and lubricating. Large pieces of construction equipment (e.g., backhoes, graders) are typically fueled and maintained at the construction site. However, the transport, use, and disposal of hazardous materials would be required to comply with all applicable federal, State and local laws. In addition, although there is uncertainty as to the specific locations where new facilities could be constructed or where existing facilities could be reconstructed. Therefore, the Scoping Plan Update EA found potentially significant impacts to hazards or hazardous materials impacts. Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, it was determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a significant cumulative aesthetics-related impact.

Reasonably foreseeable compliance responses to the SLCP Strategy could include construction and operation of new or modified facilities or infrastructure. There is uncertainty as to the specific locations where construction and operations of new facilities or the modification of existing facilities would occur. These construction activities may require the transport, use, and disposal of hazardous materials. Construction activities generally use heavy-duty equipment requiring periodic refueling and lubricating fluids. Large pieces of construction equipment (e.g., backhoes, graders) are typically fueled and maintained at the construction site as they are not designed for use on public roadways. Thus, such maintenance uses a service vehicle that mobilizes to the location of the construction equipment. It is during the transfer of fuel that the potential for an accidental release is most likely. Although precautions would be taken to ensure that any spilled fuel is properly contained and disposed, and such spills are typically minor and localized to the immediate area of the fueling (or maintenance), the potential still remains for a significant release of hazardous materials into the environment. Consequently, the construction activities could create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment.

The impact analysis in Chapter 4 determined the short-term construction-related impacts resulting from the development of new facilities or modification of existing facilities, associated with implementation of the SLCP Strategy, would be potentially significant and unavoidable. Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to this significant impact would be cumulatively considerable. Implementation of the project- level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in **cumulatively considerable contribution to a significant cumulative short-term impact** to hazards and hazardous materials.

The impact analysis in Chapter 4 determined the long-term operational impacts resulting from operation of new facilities or modified facilities and other compliance actions associated with implementation of the SLCP Strategy would be less than significant. As a result, operational impacts associated with the SLCP Strategy **would not make a considerable contribution to a significant long-term cumulative impact** related to hazards and hazardous materials impact.

10. Hydrology and Water Quality

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result in a significant cumulative impact to hydrology and water quality. Construction activities and long-term operations associated with reasonably foreseeable compliance responses to the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could be located in a variety of conditions with regards to altering drainage patterns, flooding, and inundation by seiche, tsunami, or mudflow. The level of susceptibility varies by location. The specific design details, siting locations, and associated hydrology and water quality issues are not known at this time and would be analyzed on a site-specific basis at the project level. Therefore, for purposes of CEQA disclosure, these potential hydrology and water quality-related impacts were determined to be significant. Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, it was determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a significant cumulative impact to hydrology and water quality.

Construction activities associated with implementation of the SLCP Strategy could require disturbance of undeveloped areas, such as clearing of vegetation, earth movement and grading, trenching for utility lines, erection of new buildings, and paving of parking lots, delivery areas, and roadways. Specific construction projects would be required to comply with applicable erosion, water quality standards, and waste discharge requirements (e.g., NPDES, SWPPP). However, construction project may add impervious surfaces that could increase runoff on an on- going basis, encounter groundwater resources during excavation activities, and cause erosion that could degrade water quality. In addition, depending on the location of a proposed project, people or structures could be located in a floodplain. Therefore, the impact analysis in Chapter 4 determined the short-term construction-related impacts on hydrology and water quality resulting from the development of new facilities or modification of existing facilities, associated with implementation of the SLCP Strategy, would be potentially significant and unavoidable.

Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to this significant impact would be cumulatively considerable. Implementation of the project-level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in a **cumulatively considerable contribution to a significant short-term cumulative impact** on hydrology and water quality.

The impact analysis in Chapter 4 determined the long-term operational impacts resulting from operation of new facilities or modified facilities and other compliance actions associated with implementation of the SLCP Strategy would be less than significant. As a result, operational impacts associated with the SLCP Strategy **would not make a considerable contribution to a significant long-term cumulative impact** related to hydrology and water quality.

11. Land Use and Planning

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, would not result in a significant cumulative land use planning-related impact. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require both construction and long-term operation of new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. However, facilities would likely occur within the footprint of existing manufacturing facilities, or in areas with zoning that would permit the development of these facilities. Thus, implementation of the recommended actions would not be anticipated to divide an established community or conflict with a land use or conservation plan.

Short-term construction-related and long-term operational impacts on land use and planning associated with implementation of the SLCP Strategy may not be consistent with existing and planned land uses (e.g., vehicle fueling stations within lands zoned for agricultural uses). The environmental consequences of land use changes related to land use planning consistency can result in effects on the environment associated with agriculture and forestry, biology, geology and soils, and hydrology. Cumulative impacts associated with the topic areas are described within this chapter in Sections 2, 4, 7, and 10. While project-specific construction-related and operational impacts from the SLCP Strategy may not be consistent with existing and planned land uses, they would be site-specific and would not combine with other projects under the Scoping Plan Update. Therefore, short-term construction, and long-term land use impact **would not make a considerable contribution such that a significant cumulative impact would occur related to land use and planning.**

12. Mineral Resources

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could not result in a significant cumulative impact to mineral resources. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require both the construction and operation of new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. New facilities would likely occur within existing footprints or in areas with consistent zoning, where original permitting and analyses considered these issues, and thus impacts to the availability of a known mineral resource or recovery site would be less-than-significant.

In addition, some of the recommended actions and associated compliance responses could require the extraction of minerals (i.e., lithium or platinum) used to manufacture fuel cell and battery technologies. However, implementation of these measures would not substantially deplete the supply of lithium or platinum and both are currently used in auto manufacturing processes. Therefore, the Scoping Plan update EA determined that implementation of recommended actions in the Scoping Plan Update would not result in a significant cumulative impact to mineral resources.

Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the SLCP Strategy could require both the construction and operation of new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. New facilities would likely occur within existing footprints or in areas with consistent zoning, where original permitting and analyses considered these issues, and thus impacts to the availability of a known mineral resource or recovery site would be less-than-significant. Furthermore, compliance responses associated with the SLCP Strategy would not include extraction of minerals used to manufacture fuel cell and battery cell technologies.

Based on the conclusions in Chapter 4, the short-term construction-related and long-term operational impacts on mineral resources resulting from the development of new facilities or modification of existing facilities and operation of projects, associated with implementation of the SLCP Strategy, would be less-than-significant. New facilities would likely occur in areas with consistency zoning, where original permitting and analyses considered the availability of mineral resources within specific jurisdictions.

Therefore, the SLCP Strategy **would not make a considerable contribution such that a significant cumulative impact would occur** related to mineral resources.

13. Noise

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result in a significant cumulative impact to noise. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction and operation of new or modified facilities or infrastructure. These activities could result in the generation of short-term construction noise in excess of applicable standards or that result in a substantial increase in ambient levels at nearby sensitive receptors, and exposure to excessive vibration levels, which would be potentially significant. The Scoping Plan Update EA also determined that operational effects of implementation of recommended actions associated with the Scoping Plan Update could result in potentially significant impacts. Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project- level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, it was determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a significant cumulative construction-related and operational noise impacts.

Implementation of reasonably foreseeable compliance responses associated with the SLCP Strategy could require construction and operation of new or modified facilities or infrastructure. These activities could result in the generation of short-term construction and long-term operational noise in excess of applicable standards or that result in a substantial increase in ambient levels at nearby sensitive receptors, and exposure to excessive vibration levels. Thus, the impact analysis in Chapter 4 determined the short-term construction-related and long-term operational-related noise impacts resulting from the development of new facilities, associated with implementation of the SLCP Strategy, would be potentially significant and unavoidable.

Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to this significant impact would be cumulatively considerable. Implementation of the project-level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in a **cumulatively considerable contribution to a significant cumulative construction-related impact** on noise.

14. Population and Housing

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, would not result in a significant cumulative impact to population and housing. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction and operation of new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. The Scoping Plan Update EA determined that a substantial amount of construction worker migration would not be likely to occur, and a sufficient construction employment base would likely be available. Construction activities would not require new additional housing or generate changes in land use. Therefore, the Scoping Plan Update EA determined that implementation of the recommended actions in the Scoping Plan Update would not result in a significant cumulative impact related to population and housing growth.

Implementation of reasonably foreseeable compliance responses associated with the SLCP Strategy could require construction and operation of new or modified facilities or infrastructure. Construction activities would be anticipated to require relatively small crews, and demand for these crews would be temporary (e.g., 6 – 12 months per project). Therefore, a substantial amount of construction worker migration would not be likely to occur, and a sufficient construction employment base would likely be available. Operation of these new facilities would not be expected to require new additional housing or generate changes in land use that could conflict with adopted plans. The implementation of the SLCP Strategy would not lead to job losses or large-scale worker displacement. Based on the conclusions in Chapter 4 the short-term construction-related and long-term operational impacts to population and housing associated with implementation of the SLCP Strategy would be less-than-significant. Job opportunities would be widespread, limited in the level of staffing needs at specific locations, and generally occur on a seasonal basis. Therefore, the SLCP Strategy **would not make a cumulatively considerable contribution such that a significant cumulative impact would occur** related to population and housing growth.

15. Public Services

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, would not result in a cumulative impact to public services. Reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could include construction and operation of new or modified facilities or infrastructure. There is uncertainty as to the specific location of these new facilities or the modification of existing facilities. These would likely occur within the footprint of existing facilities, or in areas with zoning that would permit the development of these facilities. The Scoping Plan determined that a substantial amount of construction worker migration would not occur and that a sufficient construction employment base would likely be available. Construction activities would not require new additional housing to accommodate or generate changes in land use and, therefore, would not significantly affect public services. Therefore, the Scoping Plan Update EA determined that the Scoping Plan Update would not result in a significant cumulative impact related to public services.

Implementation of the SLCP Strategy could provide a range of employment opportunities; however construction and operational activities would not require additional housing or generate changes in land use, and would not substantially affect the provisions of public services.

Based on the conclusions in Chapter 4, the short-term construction-related and long-term operational impacts on public services resulting from the development of new facilities or modification of existing facilities and operation of projects, associated with implementation of the SLCP Strategy, would be less-than-significant. Demands on public services would not be substantially increased in individual jurisdictions and would not be expected to combine with other related projects to result in a need for new or physically altered governmental facilities. Therefore, the SLCP Strategy **would not make a cumulatively considerable contribution such that a significant cumulative impact would occur** related to public services.

16. Recreation

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, would not result in a significant cumulative impact to recreational facilities. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction and operations of new or modified facilities or infrastructure. There is uncertainty as to the specific locations of potential new or modified facilities. The Scoping Plan Update EA that the need for a substantial amount of construction worker migration would not occur and that a sufficient construction employment base would likely be available. Thus, construction activities associated with reasonably foreseeable compliance responses would not be anticipated to increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration would occur. In addition, the demand for new (or expansion of) recreational-related facilities would not occur as a result of construction activities. Therefore, the Scoping Plan Update would not result in a significant cumulative impact related to recreational facilities.

Implementation of the SLCP Strategy could provide a range of employment opportunities; however construction and operational activities would not require additional housing or generate changes in land use, and would not substantially affect existing, or require the construction of new, recreation resources.

Based on the conclusions in Chapter 4, the short-term construction-related and long-term operational impacts on recreation resulting from the development of new facilities or modification of existing facilities and operation of projects, associated with implementation of the SLCP Strategy, would be less-than-significant. Demands on recreation resources would not be substantially increased in individual jurisdictions and would not be expected to combine with other related projects to result in a need for new or physically altered recreation facilities. Therefore, the SLCP Strategy **would not make a cumulatively considerable contribution such that a significant cumulative impact would occur** related to recreation.

17. Transportation and Traffic

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result in a significant cumulative impact to transportation or traffic. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction and operations of new or modified facilities or infrastructure. Although detailed information about potential specific construction activities were not available, it was determined that some of the potential compliance responses could result in short-term construction traffic (primarily motorized) from worker commute- and material delivery-related trips. The amount of construction activity would vary depending on the particular type, number, and duration of usage for the varying equipment, and the phase of construction. These variations would affect the amount of project-generated traffic for both worker commute trips and material deliveries. Depending on the amount of trip generation and the location of new facilities, implementation could conflict with applicable programs, plans, ordinances, or policies (e.g., performance standards, congestion management); and/or result in hazardous design features and emergency access issues from road closures, detours, and obstruction of emergency vehicle movement, especially due to project-generated heavy-duty truck trips.

Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, Scoping Plan Update EA determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a cumulative short-term and long-term significant transportation and traffic-related impact.

Implementation of reasonably foreseeable compliance responses associated with the SLCP Strategy could require construction and operations of new or modified facilities or infrastructure. Although detailed information about potential specific construction activities is not currently available, some of the potential compliance responses could result in short-term construction traffic (primarily motorized) from worker commute- and material delivery-related trips. The amount of construction activity would vary depending on the particular type, number, and duration of usage for the varying equipment, and the phase of construction. In addition, demand for different types of feedstocks, processing needs, and fueling stations could affect the existing traffic patterns. These variations would affect the amount of traffic for both worker commute trips and material deliveries. Depending on the amount of trip generation and the location of new facilities, implementation could conflict with applicable programs, plans, ordinances, or policies (e.g., performance standards, congestion management); and/or result in hazardous design features and emergency access issues from road closures, detours, and obstruction of emergency vehicle movement, especially due to project-generated heavy-duty truck trips. Further, the operation of centralized anaerobic digesters could potentially generate traffic impacts due to movement of manure and organic waste from point of origin to the receiving facility. New fueling stations associated with digesters may increase traffic flows on local roads for on- and off-site fleets. In addition, monitoring of oil and gas facilities for the purpose of reducing escaped methane emissions would also generate an increase in miles traveled. Additionally, commute routes of future employees could generate increased daily trips. At the programmatic level of the analysis of this Revised Draft EA, the location of these facilities cannot be determined; therefore impacts to applicable traffic plans cannot be accurately predicted at present. Thus, it was determined that both the short-term construction related and long-term operational impacts on transportation and traffic, associated with methane reduction measures in the SLCP Strategy, could be potentially significant.

Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to this significant impact would be cumulatively considerable. Implementation of the project-level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in a **cumulatively considerable contribution to a significant cumulative impact** on transportation and traffic.

18. Utility Service Systems

The Scoping Plan Update EA found that implementation of the recommended actions discussed in the plan, which includes the recommendation for the SLCP Strategy under the Short-Lived Climate Pollutant Sector, could result in a significant cumulative impact to utility services. Implementation of reasonably foreseeable compliance responses associated with the recommended actions in the Scoping Plan Update, which included the SLCP Strategy, could require construction and operations of new or modified facilities or infrastructure. Newly constructed or modified facilities could generate substantial increases in the demand for water supply, wastewater treatment, storm water drainage, and solid waste services in their local areas. Any new or modified facilities, no matter their size and location would be required to seek local or State land use approvals prior to their development. Part of the land use entitlement process for facilities proposed in California requires that each of these projects undergo environmental review consistent with the requirements of CEQA and the CEQA Guidelines. It is assumed that facilities proposed in other states would be subject to comparable federal, state, and/or local environmental review requirements (e.g., CEQA) and that the environmental review process would assess whether adequate utilities and services (i.e., wastewater services, water supply services, solid waste facilities) would be available and whether the project would result in the need to expand or construct new facilities to serve the project.

Implementation of mitigation measures identified in the Scoping Plan Update EA were determined to not reduce these impacts to a less-than-significant level because the authority to determine project-level impacts and require project-level mitigation lies with land use and/or permitting agencies for individual projects. Thus, the Scoping Plan update EA determined implementation of the recommended actions in the Scoping Plan Update, which includes the SLCP Strategy, could result in a significant cumulative impact with respect to utilities and service systems.

Implementation of reasonably foreseeable compliance responses associated with the SLCP Strategy could also require construction and operations of new or modified facilities or infrastructure which could result in long-term operational impacts on utilities and services systems. Based on the conclusions in Chapter 4, the SLCP Strategy's contribution to this significant impact would be cumulatively considerable. Implementation of the project- level mitigation identified in Chapter 4 could effectively reduce the incremental contribution from the SLCP Strategy to a less-than-considerable level, but authority to require that mitigation will rest with other agencies that will be authorizing site-specific projects, and not with ARB. Thus, the SLCP Strategy could result in a **cumulatively considerable contribution to a significant cumulative impact** on utilities and service systems.

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6.0 MANDATORY FINDINGS OF SIGNIFICANCE

Consistent with the requirements of the California Environmental Quality Act (CEQA) Guidelines section 15065 and section 18 of the Environmental Checklist, this Environmental Analysis (EA) addresses the mandatory findings of significance for the proposed Short-Lived Climate Pollutant Reduction Strategy (SLCP Strategy).

A. Mandatory Findings of Significance

1. Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat for a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal, or eliminate important examples of the major periods of California history or prehistory?

CEQA requires a finding of significance if a project "has the potential to substantially degrade the quality of the environment." (Cal. Code Regs., tit 14, § 15065, subd. (a).) In practice, this is the same standard as a significant impact on the environment, defined as "a substantial or potentially substantial adverse change in any of the physical conditions within the area affected by the project including land, air, water, minerals, flora, fauna, ambient noise, and objects of historic or aesthetic significance." (Cal. Code Regs., tit 14, § 15382.)

As with all of the environmental impacts and issue areas, the precise nature, location and magnitude of impacts would be highly variable, and would depend on a range of reasonably foreseeable compliance responses that could occur with implementation of the SLCP Strategy. Location, extent, and a variety of other site-specific factors are not known at this time but would be addressed by environmental reviews to be conducted by local or regional agencies with regulatory authority at the project-specific level.

This Revised Draft EA, in its entirety, addresses and discloses potential environmental impacts associated with the recommended actions with the proposed regulations, including direct, indirect, and cumulative impacts in the following resource areas:

Aesthetics
Agriculture and Forest Resources
Air Quality
Biological Resources
Cultural Resources
Energy Demand
Geology and Soils
Greenhouse Gases
Hazards and Hazardous Materials
Hydrology and Water Quality
Land Use and Planning
Mineral Resources
Noise
Population and Housing
Public Services
Recreation
Transportation/Traffic
Utilities and Service Systems

As described in Chapter 4, this Revised Draft EA discloses potential environmental impacts, the level of significance prior to mitigation, proposed mitigation measures, and the level of significance after the incorporation of mitigation measures.

a) Impacts on Species

CEQA requires a lead agency to find that a project may have a significant impact on the environment where there is substantial evidence that the project has the potential to (1) substantially reduce the habitat of a fish or wildlife species; (2) cause a fish or wildlife population to drop below self-sustaining levels; or (3) substantially reduce the number or restrict the range of an endangered, rare, or threatened species. (Cal. Code Regs., tit. 14, §15065, subd. (a)(1).) Chapter 4 of this Revised Draft EA addresses impacts that could occur to biological resources, including the reduction of fish or wildlife habitat, the reduction of fish or wildlife populations, and the reduction or restriction of the range of special-status species.

b) Impacts on Historical Resources

CEQA states that a lead agency shall find that a project may have a significant impact on the environment where there is substantial evidence that the project has the potential to eliminate important examples of a major period of California history or prehistory. (Cal. Code Regs., tit. 14, § 15065, subd. (a)(1).) This incorporates the requirement that major periods of California history are preserved for future generations and a finding of significance for substantial adverse changes to historical resources. (Pub. Resources Code §§ 21001, subd. (c), 21084.1.) CEQA establishes standards for determining the significance of impacts to historical resources and archaeological sites that are a historical resource. (Cal. Code Regs., tit. 14, § 15064.5.) Chapter 4 of this Revised Draft EA addresses impacts that could occur related to California history and prehistory, historic resources, archaeological resources, and paleontological resources.

2. Does the project have impacts that are individually limited, but cumulatively considerable?

CEQA Guidelines requires a lead agency shall find that a project may have a significant impact on the environment where there is substantial evidence that the project has potential environmental impacts that are individually limited, but cumulatively considerable. (Cal. Code Regs., tit. 14, § 15065.) Cumulatively considerable means "that the incremental effects of an individual project are significant when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects." (Cal. Code Regs., tit. 14, § 15065, subd. (a)(3).) Cumulative impacts are addressed for each of the environmental topics listed above and are provided in Chapter 5, "Cumulative and Growth-Inducing Impacts," in this Revised Draft EA.

3. Does the project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?

CEQA requires a lead agency to find that a project may have a significant impact on the environment where there is substantial evidence that the project has the potential to cause substantial adverse impacts on human beings, either directly or indirectly. (Cal. Code Regs., tit. 14, § 15065, subd. (a)(4).) Under this standard, a change to the physical environment that might otherwise be minor must be treated as significant if people would be significantly affected. This factor relates to adverse changes to the environment of human beings generally, and not to impacts on particular individuals. While changes to the environment that could indirectly affect human beings would be represented by all of the designated CEQA issue areas, those that could directly affect human beings include air quality, geology and soils, hazards and hazardous materials, hydrology and water quality, noise, population and housing, public services, transportation/traffic, and utilities, which are addressed in Chapter 4 of this Revised Draft EA.

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7.0 ALTERNATIVES ANALYSIS

This section satisfies the requirement of California Environmental Quality Act (CEQA) to addresses alternatives to the proposed project. (Cal. Code Regs., tit. 14, § 15126.6.) The following discussion provides an overview of the steps taken to develop alternatives to the proposed action (i.e., approval of the Proposed Short-Lived Climate Pollutant Reduction Strategy [SLCP Strategy]), the project objectives associated with the proposed action, and an analysis of the alternatives' environmental effects and ability to meet the project objectives.

A. Approach to Alternatives Analysis

The California Air Resources Board's (ARB or Board) certified regulatory program (Cal. Code Regs., tit. 17 § 60000-60008) requires that where a contemplated action may have a significant effect on the environment, a document shall be prepared in a manner consistent with the environmental protection purposes of ARB's regulatory program and with the goals and policies of CEQA. Among other things, the document must address feasible alternatives to the proposed action that would substantially reduce any significant adverse impact identified.

The certified regulatory program provides general guidance that any action or proposal for which significant adverse environmental impacts have been identified during the review process shall not be approved or adopted as proposed if there are feasible mitigation measures or feasible alternatives available that would substantially reduce such adverse impact. For purposes of this section, "feasible" means capable of being accomplished in a successful manner within a reasonable period of time, taking into account economic, environmental, social, and technological factors, and consistent with the Board's legislatively mandated responsibilities and duties. (Cal. Code Regs., tit. 17 § 60006.)

While ARB, by virtue of its certified program, is exempt from Chapters 3 and 4 of CEQA, CEQA nevertheless provides useful information for preparing thorough and meaningful alternatives analysis. CEQA speaks to an evaluation of "a range of reasonable alternatives to the project, or the location of the project, which would feasibly attain most of the basic project objectives but would avoid or substantially lessen any of the significant effects, and evaluate the comparative merits of the alternatives." (Cal. Code Regs., tit. 14, § 15126.6, subd. (a).) The purpose of the alternatives analysis is to determine whether or not different approaches to or variations of the project would reduce or eliminate significant project impacts, within the basic framework of the objectives, a principle that is consistent with ARB's regulatory requirements.

The range of alternatives is governed by the "rule of reason," which requires evaluation of only those alternatives "necessary to permit a reasoned choice" (Cal. Code Regs., tit. 14 § 15126.6 (f).) Further, an agency "need not consider an alternative whose effect cannot be reasonably ascertained and whose implementation is remote and speculative." (Cal. Code Regs., tit. 14 § 15126.6 (f)(3).) The analysis should focus on alternatives that are feasible and that take economic, environmental, social, and technological factors into account. Alternatives that are remote or speculative need not be discussed. Furthermore, the alternatives analyzed for a project should focus on reducing or avoiding significant environmental impacts associated with the project as proposed.

This section evaluates a range of alternatives to the SLCP Strategy that could reduce or eliminate the project's significant effects on the environment, while meeting most of the basic project objectives. (Cal. Code. Regs., tit 14, § 15216.6 (a).) This section contains an analysis of each alternative's ability to meet the project objectives while reducing the severity, or eliminating, significant adverse environmental impacts identified earlier in this Revised Draft EA.

The alternatives identified for the SLCP Strategy reflect the broad-based nature of the Strategy as a whole. Consistent with Senate Bill (SB) 605 and SB 1383, the SLCP Strategy considers a wide range of measures that can reduce short-lived climate pollutants (SLCPs) across the California economy, and recommends many for further review and implementation. The SLCP Strategy itself, however, does not implement any of these measures. Rather measures identified in the Strategy that would be carried out by ARB would be more fully developed through a more focused public processes, with an accompanying CEQA analyses as appropriate. For regulatory measures, this would include a full Administrative Procedure Act public review process, as well as meeting the specific requirements outlined in SB 1383. Recognizing this ongoing review and development process, and the inherently programmatic nature of the SLCP Strategy, staff has developed alternatives at the same programmatic level of detail. The alternatives are intended to explore different broad approaches to achieving the objectives of the SLCP Strategy, rather than to investigate each possible alternative to each possible proposed measure. Reasonable alternatives to specific measures can be further investigated as the SLCP Strategy is more fully implemented and these measures are formally considered.

In developing the alternatives, ARB made a good-faith effort to account for alternatives suggested by the public. This included reviewing public comments received at several public workshops, including a workshop on an initial "concept paper" for the SLCP Strategy in May 2015, and comments received at three regional public workshops and scoping meetings held across the State on the Draft Strategy in October 2015. ARB staff has also met repeatedly with stakeholders representing a diverse range of constituencies and solicited expert feedback from academic experts and other state agencies. A formal legal petition from the Animal Legal Defense Foundation, proposing adding certain agricultural emissions to California's Cap-and-Trade Regulation, was also considered in developing these alternatives. The comments and materials reviewed generally suggested specific approaches to particular sectors or SLCPs; ARB staff did not find comments suggesting a wholesale alternative comprehensive approach that could satisfy the objectives of SB 605 and SB 1383.

B. Project Objectives

SLCPs include methane, black carbon, and short-lived hydrofluorocarbons (HFCs). They are powerful greenhouse gases (GHGs) that remain in the atmosphere for a much shorter period of time than longer-lived climate pollutants, such as carbon dioxide (CO_2) and nitrous oxide (N_2O). Despite their relatively shorter atmospheric lifespan, their relative potency in terms of how they heat the atmosphere (i.e., global warming potential [GWP]) can be tens, hundreds, or even thousands of times greater than that of CO_2.

Methane contributes to background tropospheric ozone formation and black carbon is a part of particulate matter and diesel exhaust. Exposure to ozone and particulate matter causes adverse health effects and mortality, and diesel exhaust is a recognized carcinogen.

The Legislature and Governor Brown solidified the state's commitment to address SLCPs by passing and signing Senate Bill (SB) 605 (Lara, Chapter 523, Statutes of 2014) and subsequently Senate Bill 1383 ((Lara, Chapter 395, Statutes of 2016). Pursuant to the requirement of these bills, ARB is developing the SLCP Strategy for consideration of approval in early 2017.

The primary objectives of the SLCP Strategy are listed below. These objectives are derived from the SLCP concepts contained within the 2014 Scoping Plan Update, prepared under the requirements of Assembly Bill (AB) 32 (Health & Saf. Code, § 38561), and from the requirements of SB 605 and SB 1383, which require ARB to develop, approve, and begin implementing "a comprehensive strategy to reduce emissions of short-lived climate pollutants in the state" by January 1, 2018.

The scope of the SLCP Strategy includes actions to reduce emissions from all major sources of methane, HFCs, and anthropogenic black carbon, as well as reviewing the status of another fluorinated gas, sulfuryl fluoride. The major administrative and program implementation objectives of the SLCP Strategy include the following:

1. Complete an inventory of sources and emissions of SLCPs in the State based on available data;
2. Identify research needs to address any data gaps;
3. Identify and implement existing and potential new control measures to reduce emissions of methane and hydrofluorocarbon gases by 40 percent and anthropogenic black carbon by 50 percent below 2013 levels by 2030 and;
4. Coordinate with other state agencies and districts to develop measures identified as part of the SLCP Strategy.
5. Provide consultation to California's Department of Resources Recycling and Recovery (CalRecycle) during the development of regulations to reduce the level of the statewide disposal of organic waste by 50 percent by 2020 and 75 percent by 2025. These regulations:

- May require local jurisdictions to impose requirements on generators and authorize jurisdictions to impose penalties on generators for noncompliance;
- Shall include requirements intended to meet the goal that not less than 20 percent of edible food that is currently disposed of is recovered for human consumption by 2025;
- Shall not establish numerical organic waste limits on individual landfills;
- May include different levels of requirements for local jurisdictions and phased timelines based upon their progress in meeting the organic waste reduction goals for 2020 and 2025; and
- May include penalties imposed by CalRecycle for noncompliance;
- Shall take effect on or after January 1, 2022;

6. Provide consultation to CalRecycle to evaluate progress towards meeting the 2020 and 2025 organics waste reduction goals by July 1, 2020. This analysis will evaluate:
   - The status of new organics infrastructure development;
   - The status of efforts to reduce regulatory barriers to the siting of organics recycling facilities;
   - The effectiveness of policies aimed at facilitating the permitting of organics recycling infrastructure; and
   - The status of markets for products generated by organics recycling facilities.
7. ARB, in consultation with California Department of Food and Agriculture (CDFA), develop and adopt regulations to reduce methane emissions from livestock manure management operations and dairy manure management operations consistent with an up to 40 percent reduction in the dairy sector's and livestock sector's 2013 sector-wide levels by 2030 on or after January 1, 2024. In considering adoption of these regulations, ARB must determine:
   - The regulations are technologically feasible.
   - The regulations are economically feasible considering milk and live cattle prices and the commitment of state, federal, and private funding, among other things, and that markets exist for the products generated by dairy manure management and livestock manure management methane emissions reduction projects, including composting, biomethane, and other products. The analysis shall include consideration of both of the following:
   - Electrical interconnection of onsite electrical generation facilities using biomethane;
   - Access to common carrier pipelines available for the injection of digester biomethane;
   - The regulations are cost effective;
   - The regulations include provisions to minimize and mitigate potential leakage to other states or countries, as appropriate;

- o And the regulations include an evaluation of the achievements made by incentive-based programs.

8. Prior to implementing a regulation to reduce methane emissions from livestock and dairy manure management operations, ARB publish a report on the ARB website evaluating progress toward eliminating barriers, engaging stakeholders, considering and conducting research, and considering development and adoption of additional methane reduction protocols;
9. ARB, in consultation with California Public Utilities Commission (CPUC) and California Energy Commission (CEC), develop policies to encourage development of infrastructure and biomethane projects at dairy and livestock operations;
10. ARB develop a pilot financial mechanism to reduce Low Carbon Fuel Standard (LCFS) credit value uncertainty from dairy-related projects and make recommendation to the Legislature to expand the mechanism to other biogas sources;
11. ARB provide guidance on the impact of regulations on LCFS credits and compliance offsets;
12. CPUC, in consultation with ARB and CDFA, direct utilities to develop at least 5 dairy biomethane pipeline injection projects;
13. ARB, in consultation with CDFA, analyze and report on the methane reduction progress of the dairy and livestock sector;
14. ARB, in consultation with CDFA, evaluate the feasibility of achieving enteric methane reduction through incentive-based mechanisms and develop regulation if it determines is cost-effective, considers impact to animal productivity, is scientifically proven, and would not damage animal health, public health, or consumer acceptance.
15. Incorporate and prioritize, as appropriate, measures for SLCPs that offer the following co-benefits: improving water quality or reducing other air pollutants to reduce effects on community health and provide benefits to disadvantaged communities, as identified in Health and Safety Code Section 39711, job growth and local economic benefits in the state; public health benefits; potential for new innovation in technology, energy, and resource management practices; and
16. Evaluate the best-available scientific, technological, and economic information to ensure the strategy is cost effective and technologically feasible.

C. Description of Alternatives

Detailed descriptions of each alternative are presented below. The analysis that follows the descriptions of the alternatives includes a discussion of the degree to which each alternative meets the basic project objectives, and the degree to which each alternative avoids potentially significant impacts identified in Chapter 4.

1. Alternative 1: No-Project Alternative

a) Alternative 1 Description

ARB is including Alternative 1, the No-Project Alternative, to provide a good faith effort to disclose environmental information that is important for considering the SLCP Strategy. ARB's certified regulatory program does not mandate consideration of a "No-Project Alternative." (Cal. Code Regs., tit. 17, § 60006.) Under ARB's certified program, the alternatives considered, among other things, must be "consistent with the state board's legislatively mandated responsibilities and duties." (Cal. Code Regs., tit. 17, § 60006.) It is not clear that ARB would have legal authority to pursue the No-Project Alternative because ARB is legislatively mandated to develop, approve, and begin implementing by January 1, 2018, a comprehensive strategy to reduce emissions of SLCPs in the State per SB 605 (Lara, Chapter 523, Statutes of 2014) and subsequently, SB 1383 (Lara, Chapter 395, Statutes of 2016). Moreover, ARB is required under SB 32 (Pavley, Chapter 249, Statutes of 2016) to ensure that statewide greenhouse gas emissions are reduced to 40 percent below the 1990 level by 2030. Failing to control SLCPs, including failure to approve the SLCP Strategy, would undermine continued support of GHG limits and of further reductions, and result in conflicts with ARB's mandates under AB 32, SB 32, SB 605, and SB 1383.

Nonetheless, the No-Project Alternative is included to assist in the analysis and consideration of this portion of the SLCP Strategy and the action alternatives. It is useful to include a "No-Project Alternative" in this analysis for the same reasons that this type of alternative is called for in CEQA. As noted in CEQA, "the purpose of describing and analyzing a no-project alternative is to allow decision-makers to compare the impacts of approving the proposed project with the impacts of not approving the proposed project." (Cal. Code Regs., tit. 14, § 15126.6, subd. (e)(1).) The No-Project Alternative also provides an important point of comparison to understand the potential environmental benefits and impacts of the other alternatives.

Alternative 1 in this analysis describes a reasonably foreseeable scenario if ARB did not approve the SLCP Strategy. Under this No-Project Alternative, those measures included in the initial Scoping Plan and the First Update to the Scoping Plan that are already being implemented, as well as those measures enacted under authority outside of AB 32 and SB 32, such as the Sustainable Freight Strategy, and 2016 Mobile Source Strategy in progress, would continue to be implemented.

The No-Project Alternative does not contemplate that there would be no further action by ARB or other state agencies related to the reduction of GHG emissions. Some of the recommended actions contained in the SLCP Strategy may occur as a result of subsequent regulatory actions by ARB or other agencies under separate statutory authority regardless of their inclusion in the SLCP Strategy.

b) Alternative 1 Impact Discussion

a. Objectives

The No-Project Alternative would not meet any the project objectives listed in Chapter 2 (and reiterated above). The No-Project Alternative would not provide a completed inventory of SLCPs in the State and identify research needs or identify new potential control measures to meet the targeted reductions (Objectives 1, 2, and 3). The No-Project Alternative is also not consistent with the remaining Objectives. because, by maintaining the status quo rather than advancing SLCP controls consistent with statute, it would fail to fulfill legislative direction to ARB to fulfill those Objectives.

Although there has already been substantial progress towards reducing emissions of some pollutants, such as black carbon, California still has some of the nation's highest levels of air pollution, and much of the state will need to virtually eliminate black carbon emissions and other pollutants to meet health-based federal air quality standards over the next 20 years. California has already taken steps to reduce methane emissions from the agricultural, oil and gas, and waste treatment sectors. HFCs are the fastest growing source of GHG emissions in California and globally, and must be further controlled to keep the state on track to meet its 2020 and 2050 GHG limits. California previously developed an inventory of HFCs, and has rules in place to cut their emissions by 25 percent below business-as-usual emissions levels by 2020. The SLCP Strategy is identified in the First Update to the Climate Change Scoping Plan as one of the recommended actions to achieve additional GHG emission reductions and, as stated in the SLCP Strategy, there is a need to reduce SLCPs such as black carbon, methane, and HFCs. Thus, the No-Project Alternative would fail to make needed progress toward state GHG reduction goals.

b. Environmental Impacts

The No-Project Alternative includes GHG emission reduction actions that are ongoing or already implemented as part of the initial Scoping Plan, First Update to the Scoping Plan, or would be developed under authorities additional to AB 32. The direct and indirect environmental impacts associated with implementation of the ongoing actions were analyzed in the 2008 Functional Equivalent Document (FED), the 2011 FED Supplement, and the 2014 EA, incorporated here by reference. It is also reasonable to expect that other measures would developed in the absence of the SLCP Strategy measures to achieve the targets in SB 32. These measures are being analyzed in the EA being prepared for the 2030 Scoping Plan and are not fully known at this time, but we can reasonably assume that these would still result in potentially significant adverse environmental impacts similar to those analyzed in for ongoing actions in the previously listed documents.

The No-Project Alternative would avoid the particular site-specific environmental impacts identified in Chapter 4 of this document. These include short-term construction and long-term operational impacts that may occur as a result of activities carried out in response to regulations or programs carried out to implement the proposed measures. The resource areas affected include aesthetics, agricultural and forest resources, air quality, biological resources, cultural resources, geology and soils, hazards and hazardous materials, hydrology and water quality, land use and planning, noise, transportation/traffic, and utilities and service systems, as described in Chapter 4. As described in the cumulative impacts section in Chapter 5, there are cumulatively considerable impacts found for most of these resource areas resulting from implementation of the Scoping Plan and its 2014 Update from recommended measures in the Scoping Plan that would still be expected to occur under the No-Project Alternative.

Further, the No-Project Alternative would allow the continued emissions of SLCPs in California at business as usual levels, and would not support efforts to reduce these emissions. As noted under Objective 15, reducing SLCP emissions provides co-benefits of improving water quality and reducing other air pollutants to reduce adverse effects on community health and provide benefits to disadvantaged communities. (Health § Saf. Code, § 39711.) Moreover, SLCP emissions would continue to threaten public health and welfare in California, with attendant negative impacts on many environmental resource areas. The No-Project Alternative would not decrease potential adverse effects associated with existing SLCP emissions and would not realize the co-benefits.

2. Alternative 2: Reduced Intensity Project Alternative

Under Alternative 2, the Reduced-Intensity Alternative, only some of the measures in the SLCP Strategy would be approved, based on the goal of reducing or avoiding specific measure impacts. These alternatives could potentially result in equal- or reduced-intensity impacts.

As described in Chapter 4, and shown in the impact summary table in Attachment A, proposed measures for black carbon, methane, and HFC result in a number of potentially significant and unavoidable impacts after mitigation. The impact analysis in Chapter 4 does not focus on impacts of individual actions for each reduction measure, but rather the impacts from a range of reasonably foreseeable compliance responses likely to occur in response to measures identified for reductions for each pollutant.

Furthermore, there is variation among the reduction measures in terms of potentially significant and unavoidable impacts within each resource, compared to beneficial or less-than-significant impacts. Therefore, Alternative 2 includes a reduction in measures by pollutant, with the intent of reducing the primary impacts from the likely compliance responses from those measures. Although these alternatives, for the sake of brevity, are discussed together, the Board could, select some combination or subset of them across the pollutant types (e.g., solely the reduced intensity black carbon alternative, while retaining the project as proposed for methane).

a) Black Carbon Alternative

i. Description of the Black Carbon Alternative

Under this alternative, no incentives would be provided for replacement of polluting wood-fueled heating devices with cleaner alternatives, and instead, only education and outreach programs would be pursued. Education and outreach programs provide information about the health and environmental impacts of residential wood smoke. These programs may cause homeowners to install cleaner heating devices or burn less, especially those that burn for aesthetic and not heating purposes. Over time, these programs may change public preference and cause more rapid adoption of cleaner burning alternatives. This would likely reduce the need for replacement devices and any potential impacts associated with their installation and operation. Although Chapter 4 determined these impacts are less-than-significant, this alternative has been included to provide an alternate, potentially lower-impact, approach to realizing black carbon reduction objectives.

ii. Impact Discussion

a. Objectives

The black carbon alternative described above would provide fewer black carbon and GHG emission reductions, would be less effective in achieving and maintaining the statewide 2020 and 2030 GHG emission limits, and would be less effective at providing black carbon emission reductions to meet the requirements of SB 1383. Therefore, this alternative is considerably less effective at meeting objectives related to reducing SLCP emissions.

Even with education and outreach programs, there may be little perceived benefit to a homeowner to replace a wood-fueled heating device with a cleaner alternative in the absence of monetary incentives. In addition to failing to fulfill Objective 3 (identifying effective control measures to reduce SLCP emissions), failing to replace these devices could also fail to fulfill Objective 15 (prioritizing measures that impact community health and impact disadvantaged communities). Wood-burning devices emit criteria air pollutants and toxic air contaminants (TACs). Allowing them to continue operating would fail to reduce these emissions, including in disadvantaged and rural communities that often rely on wood-burning as a primary heat source and may not have the means to install a cleaner alternative.

b. Environmental Impacts

As described above, the black carbon alternative could eliminate the short-term construction impacts identified in Chapter 4. By softening measures to reduce black carbon emissions there would likely be fewer construction projects. Although the impacts were determined to be less than significant, these could be reduced further. The benefits of reduced emissions reductions, however, would be fewer and the goal for reduced short-lived climate emissions would very likely not be met.

b) Methane Alternative: Dairy Pasturage

i. Description of Dairy Pasturage Alternative

Under the Dairy Pasturage Alternative, rather than supporting the use of digesters to manage manure, pasturing of cattle would be further prioritized. Although staff expects a range of compliance responses to the SLCP Strategy, including expansion of pasturage in some circumstances, as described in Chapter VIII and Appendix D to the SLCP Strategy, this alternative would channel additional incentives to pasturage measures. This could reduce the number of digesters constructed and operated. It would reduce cumulative revenues from digester projects to dairy farmers and could reduce cost effectiveness of emissions reductions from the sector, which could lead to emissions leakage outside of California, where enteric fermentation emissions from dairy operations tend to be higher.

ii. Impact Discussion

a. Objectives

The alternative described above would provide fewer GHG emission reductions in furtherance of achieving and maintaining the statewide 2020 GHG emissions limit and continuing reductions in emissions of GHG emissions beyond 2020, including the legislatively mandated 40 percent economy-wide methane reduction required by SB 1383. As staff describes in detail in Chapter VIII and Appendix D of the SLCP Strategy, a relatively small number of dairies are likely to find pasturage systems economically and environmentally sound, meaning that a wholesale conversion to this system is unlikely and would not succeed in reducing methane emissions to a large degree. The amount and location of grazing land available in the State to pasture cattle may not be economically feasible for many dairy owners. That is, herd sizes would need to be substantially reduced or dairy footprint size substantially increased to accommodate pasture-only dairies. Thus, focusing on pasturage would be more likely to limit overall methane reductions, or (if such a measure were enforced by regulation) might simply displace dairies to other states without such requirements. Accordingly, Objective 3 identifying effective control measures to reduce SLCP emissions would not likely be satisfied by this alternative. Objective 15 may also not be satisfied, because the decreased focus on digesters would forego some investments in disadvantaged communities, and could also result in continued use of diesel fuel or natural gas, rather than biogas from digester projects, resulting in potentially elevated levels of criteria air pollutants and TACs from combustion and production of these fuels. Further, if dairy footprint size were increased, potentially elevated levels of criteria air pollutants and TACs could result from increased distances travelled by on-farm equipment and support systems like engine-driven irrigation pumps. Potential animal feed nutrient deficits arising from pasture forage may also require importation of supplemental feed, potentially increasing mobile source emissions resulting from increased transportation.
Environmental Impacts

Therefore, this alternative is considerably less effective at meeting objectives related to reducing SLCP emissions, and likely would result in failing to meet the legislative requirements of SB 1383 to reduce methane and prioritize biogas recovery from dairy and livestock operations (objectives 9 - 12).

b. Environmental Impacts

As described above, the dairy pasturage alternative could eliminate some of the reasonably foreseeable compliance responses identified in the SLCP Strategy for which potentially significant and unavoidable impacts were identified in Chapter 4.

By reducing measures to reduce methane emissions, there would be fewer construction projects. Emissions reductions could occur but there would be fewer, if any, modifications and construction on dairies to change manure management practices. However, the goal and the SB 1383 legislatively mandated reduction target for reduced short-lived climate emissions would very likely not be met.

c) Methane Alternative: Incentives for Dairies

i. Description of Incentives for Dairies Alternative

Under the Incentives for Dairies Alternative, rather than supporting the use of digesters to manage manure, solid manure collection and management systems would be incentivized. Although staff expects a range of compliance responses to the SLCP Strategy, including expansion scrape management in some circumstances, as described in Chapter VIII and Appendix D to the SLCP Strategy, this alternative would channel additional incentives to solid manure management measures. This could reduce the number of digesters constructed and operated. It would reduce cumulative revenues from digester projects to dairy farmers and could reduce cost effectiveness of emissions reductions from the sector, which could lead to emissions leakage outside of California, where enteric fermentation emissions from dairy operations tend to be higher.

ii. Impact Discussion

a. Objectives

The alternative described above would provide fewer GHG emission reductions in furtherance of achieving and maintaining the statewide 2020 GHG emissions limit and continuing reductions in emissions of GHG emissions beyond 2020. Therefore, this alternative is considerably less effective at meeting objectives related to reducing SLCP emissions.

If incentives for solid manure management reduced the installation of digesters and production of biogas, Objective 3 (identifying effective control measures to reduce SLCP emissions) would not be satisfied, likely foregoing a significant portion of the expected methane emission reductions (commensurate with objective 7, the 40 percent economy-wide reduction mandated by SB 1383). As staff describes in Chapter VIII and Appendix D of the SLCP Strategy, solid manure and management would be used only on a limited array of dairies without pipeline connections or other ability to use biogas. Installing such systems in locations where pipeline connections are available would be less economically efficient (because it would forego the opportunity to market biogas) and so would be less likely to be successful. Additionally, this would not satisfy biogas development intent of SB 1383 for dairy biogas (objectives 9 – 12). Accordingly, Objective 3 would not likely be satisfied by this alternative. Objective 15 may also not be satisfied, because the decreased focus on digesters would forego some investments in disadvantaged communities, and could also result in continued use of diesel fuel or natural gas, rather than biogas from digester projects, resulting in potentially elevated levels of criteria air pollutants and TACs from combustion and production of these fuels.

b. Environmental Impacts

As described above, incentives for dairies could eliminate some of the reasonably foreseeable compliance responses identified in the SLCP Strategy for which potentially significant and unavoidable impacts were identified in Chapter 4.

By reducing measures to reduce methane emissions, there would be fewer construction projects. Emission reductions could occur but there would be fewer, if any, new modifications and construction on dairies to change manure management practices. However, the SB 1383 legislatively mandated reduction target for reduced short-lived climate emissions would very likely not be met.

d) Methane Alternative: Waste Diversion

i. Description of the Waste Diversion Alternative

Under the Waste Diversion Alternative, regulations to divert organics from landfills would not be developed, and instead organic landfill waste would be addressed only under existing mandates, with some incentive funding for further diversion but no additional regulatory mandates. This would potentially reduce the rate of development of new or expanded infrastructure for composting, anaerobic digestion, or energy and fuels production. This alternative was initially considered, but ultimately dismissed given that SB 1383 specifically requires the adoption of regulations to achieve specific organic diversion targets (objectives 5 – 6). Therefore this alternative was rejected as not even potentially feasible and is not be analyzed further.

e) HFC Alternative: No Incentives for Manufactured Refrigerants

i. Description of the HFC Alternative

Under the No Incentives for Manufactured Refrigerants Alternative, no manufactured synthetic refrigerants would be incentivized. Rather, incentives would be provided for the use of ammonia, CO_2 and hydrocarbons, which are all very-low GWP refrigerants, and are often referred to as “natural refrigerants.” Not incentivizing synthetic refrigerants would reduce the demand for new replacement refrigerants that are emerging such as hydrofluoro-olefins (HFOs). Because of significant industrial production already existing for non-refrigerant uses of CO_2, ammonia, and hydrocarbons, it is also not likely that these natural refrigerants will require increased production facilities to meet increased demand. HFOs are the main class of synthetic refrigerants that are expected to replace the current high-GWP HFCs used. HFOs are manufactured from the same fluorinated feedstock chemicals used to make HFCs, and are chemically similar to HFCs, but HFOs have unsaturated bonds that result in a short atmospheric lifetime of less than three weeks, and therefore, low-GWP values. HFO production requires new chemical manufacturing plants that do not already exist. But world-wide demand for HFOs under the global high-GWP phase down would likely lead to increased production of these compounds regardless of incentives from California toward natural refrigerants only. The construction of new chemical manufacturing plants cannot be attributed to the SLCP Strategy alone. Incentives away from HFOs could however be warranted because they are a brand new class of chemicals with future impacts that have yet to be determined. Specifically, HFOs break down when inadvertently released to the atmosphere through refrigerant leaks, forming trifluoroacetic acid (TFA) as one of its breakdown products. TFA is a toxin to aquatic life and accumulates in surface waters with no known path of decomposition. Although several studies indicate that increased use of HFOs would not lead to harmful amounts of TFA in surface waters, environmental groups have questioned the impact of TFA on the environment if HFOs were to largely replace HFCs. This alternative could instead incentivize use of CO_2, ammonia, and hydrocarbons that have been used as refrigerants since 1880, and their safety, performance, and effects on the environment are well-documented. It would do so recognizing that there is some uncertainty as to the scale of HFO production necessary, as well as the ultimate impact of TFA on aquatic system. ARB has therefore included this alternative to provide consideration of a less-HFO-focused approach to meeting HFC reduction goals. Although the impacts of using HFOs are less-than-significant, this alternative provides fuller public information, consistent with the purposes of CEQA.

ii. Impact Discussion

a. Objectives

Elimination of incentives to use refrigerants other than ammonia, CO_2, and hydrocarbons could stifle innovation for developing additional alternatives to high-GWP HFCs. Using ammonia, CO_2, and hydrocarbon refrigerants as replacements in existing refrigeration equipment designed to use HFCs requires substantial and costly upgrades to existing systems. Whereas, lower-GWP HFO-HFC blends can be used in existing HFC equipment (with minor changes to the system), in a process known as a “retrofit”, where the existing high-GWP refrigerant is removed, and replaced by a lower-GWP refrigerant still compatible with the equipment. Therefore, limiting incentives to only the natural refrigerants would lead to fewer facilities opting for a retrofit of existing high-GWP HFC systems, and reduced use of high-GWP HFCs would be less likely to occur as rapidly so objective 3 (identifying effective control measures to reduce SLCP emissions) would not be satisfied. Further it would not meet objective 15 (priority on new innovations) or objective 16 (to ensure the strategy is cost effective and technologically feasible) since converting existing equipment to ammonia, CO_2, and hydrocarbon refrigerants is more costly.

b. Environmental Impacts

This alternative could reduce concerns about unknown issues related to widespread use of new chemicals, such as the potential for an impact from the break-down of HFOs to TFA in surface waters. Although Chapter 4 determined this risk to be less-than-significant, it would be further reduced under this alternative. However, using ammonia, CO_2, and hydrocarbon refrigerants as replacements in existing refrigeration equipment designed to use HFCs requires substantial upgrades to existing systems. This would lead to more intensive construction impacts than use of lower-GWP HFO-HFC blends, which can be used in existing HFC equipment. Further, to the degree that this alternative foregoes lower-cost replacement systems for existing HFC equipment, it might slow the replacement of these systems, and so forego some HFC reductions or lessen their pace in California, potentially failing to fulfill Objectives 3 and 16.

f) Alternative 2 Conclusion

As described above, Alternative 2 could eliminate specific impacts identified in Chapter 4 or some concerns raised by commenters during public outreach. Reducing support to use of digesters to manage methane emissions from dairies, livestock, landfills and wastewater treatment plants could result in fewer construction projects and impacts associated with that construction as described in Chapter 4. By foregoing some more aggressive measures to address black carbon from fireplaces, some potential construction activities could be reduced (though these activities would result in less-than-significant impacts anyway). And by declining to focus on HFOs, potential residual risks associated with those compounds (including from TFA pollution) might be addressed. However, with regard to each pollutant, reductions might be reduced, less certain, or more costly. Despite the presence of mandates for reductions, it might well be more difficult to achieve those mandates in the real world. This would potentially compromise the objectives of this project, as well as the policy objectives of governing legislation, with regard to relevant impacts and these alternatives: These construction-related impacts include impacts related to aesthetics, agricultural and forest resources, air quality, biological resources, cultural resources, geology and soils, hazards and hazardous materials, hydrology and water quality, land use and planning, noise, transportation/traffic, and utilities and service systems. Other long-term environmental impacts could also be reduced including impacts on aesthetics (from new digesters), agricultural and forest resources (especially from digester operations), air quality (especially from the long-term operation of digesters and the use of biogas to the extent combustion would increases from business as usual), geology and soils, hazards and hazardous materials, and transportation/traffic.

The HFC alternative, however, could lead to more intensive construction impacts than the current proposed SLCP HFC strategy. Under this alternative, emission reductions would still be intended to occur but there is some potential for a slower pace of reduction, or missed goals, in light of these increased costs or potential difficulties with systems conversions solely to natural refrigerants.

Overall, this alternative is less effective at reducing emissions of methane and hydrofluorocarbon gases by 40 percent and anthropogenic black carbon by 50 percent below 2013 levels by 2030 and prioritization of specific co-benefits, especially related to the methane measures, as required by SB 1383. These measures are also likely to provide fewer GHG emission reductions in furtherance of achieving and maintaining the statewide 2020 GHG emissions limit. Therefore, this alternative is considerably less effective at meeting objectives related to reducing SLCP emissions. Accordingly, objectives 3, 5, 6, 9, 10, 11, 12 and 15 would not be fully satisfied.

Alternative 2 would achieve parts of the remaining project objectives, but would achieve the outcomes desired under those objectives to a lesser extent than the SLCP Strategy. Without a full suite of incentives, regulations, and other actions to reduce short-lived climate pollutant emissions, it is much less likely that steps would be made to reduce black carbon, methane, and HFC emissions. Thus, this alternative may not feasibly meet objectives related to the purpose and need of the SLCP Strategy.

3. Alternative 3: Extend the Cap-and-Trade Regulation to Other Economic Sectors

a) Alternative 3 Description

Under Alternative 3, Extend the Cap-and-Trade Regulation to Other Economic Sectors and include Black Carbon and HFCs as a regulated pollutant, ARB would broaden the reach of the State’s market-based Cap-and-Trade Regulation to include regulation of other economic sectors under the emissions cap that include sources of SLCPs, rather than the focused application to specific covered entities that is the basis for the existing program. ARB staff believes this alternative would be very difficult to implement because there are generally not methods available to measure fugitive emissions accurately enough to include them in the market, among other difficulties discussed below, but it is included for analysis in response to public requests to evaluate the issue.

Under Alternative 3, methane from dairy and waste sources, and emissions from HFCs would be added to the ARB Cap-and-Trade Regulation. Any GHG reductions that would have otherwise occurred through implementation of specific actions or regulations in the “uncapped sectors” under the SLCP Strategy would become covered under the declining emissions cap, along with those in the capped sectors. The current “uncapped sectors” include sources of SLCPs (e.g., black carbon, methane, and HFCs).

This approach is inconsistent with that taken in initial Scoping Plan and First Update to the Scoping Plan, which identified appropriate sectors to be covered by the Cap-and-Trade Regulation. The regulation applies a firm and declining emission reduction cap on a focused set of covered entities that represent approximately 85 percent of total statewide GHG emissions, while identifying other recommended actions to reduce GHG emissions across uncapped sectors. The essential difference between the SLCP Strategy and Alternative 3 is that the Cap-and-Trade Regulation would be implemented across other economic sectors that contain SLCPs, and not just the entities covered under the current program, and would include black carbon and HFCs as a new capped pollutant.

Sources of SLCPs, under this Alternative, would generally be regulated upstream in each production chain. For instance, dairies and other agricultural producers would be responsible for the emissions from their facilities,[5] as would landfills. Importers and producers of HFCs would similarly be responsible for emissions from their products.

Under this alternative, existing Cap-and-Trade Regulation thresholds are assumed to apply, meaning that only very large dairies and HFC importers and producers would be included in the regulation. Commensurate reporting and verification requirements under the Mandatory Reporting Regulation would also be applied to support Cap-and-Trade Regulation compliance.

The exception is black carbon. There is no readily-identifiable responsible entity for these emissions for Cap-and-Trade regulation purposes. The emissions from individual fireplaces and other wood-fueled devices would not be sufficient to trigger Cap-and-Trade Regulation thresholds. Nor would it be appropriate or effective to include individual homeowners in the regulation. Accordingly, under this alternative, the black carbon measures identified in the SLCP Strategy would be pursued instead.

As under the existing Cap-and-Trade Regulation, under Alternative 3 regulated entities would face a steadily declining emissions cap on all sectors to meet the State's emission goals. Under this Alternative, the cap is assumed to be adjusted (despite substantial data challenges discussed below) to ensure continued compliance, by all covered sectors, with the 2020 statewide GHG emissions limit and the 2030 target in SB 32.

ARB, or other lead agencies, could still pursue any of the recommended measures under the SLCP Strategy, in addition to implementing the broader Cap-and-Trade Regulation under this Alternative, because changes to the Cap-and-Trade Regulation would not necessarily replace the proposed measures, which could be pursued as complementary measures. However, for purposes of analysis and disclosure under Alternative 3, staff assumed that these measures are generally not pursued, and the focus is on the effects of relying on the Cap-and-Trade Regulation as the primary control strategy for the newly-covered sectors.

Reasonably foreseeable compliance responses for sectors covered by the Cap-and-Trade Regulation would generally be similar to those under the current Cap-and-Trade

[5] This Alternative therefore addresses options proposed by the Animal Legal Defense Foundation in a petition to ARB.

Regulation and addressed in the FED prepared for the Cap-and-Trade Regulation in 2010. This would likely include continued implementation of projects under currently adopted compliance offset protocols (i.e., U.S. Forest Projects, Urban Forest Projects, and Ozone-Depleting Substance Compliance), as well as the development of additional compliance offset protocols and associated offset projects consistent with the goals and procedures of the existing Cap-and-Trade Regulation. Livestock project offsets, however, would not be issued for new projects after the sector was included in the Cap-and-Trade Regulation. More broadly, because the program would be extended to other economic sectors in the State, the supply of available offsets from currently-uncapped SLCP sectors now included in the Regulation would be virtually eliminated, as the only projects eligible for offsets would be in sectors not regulated or capped in the State. Staff would endeavor to identify appropriate sources of offsets to maintain liquidity and price control benefits in the market.

Compliance responses in the newly covered sectors, in addition to tracking those generally described in the 2010 FED, would likely involve decreased sector-specific reductions of SLCPs, and implementation of SLCP-reducing projects, except where these projects were more economically efficient than purchasing compliance instruments in the market.

Regarding methane sources, staff anticipates that far fewer digester projects would be installed in the dairy sector because the sector would both lose offset funding streams and receive no additional incentives or regulatory requirements specifically to control agricultural methane. Instead, depending on allowance prices (which are generally expected to be too low to incentivize digester projects in most locations), dairy operations might either relocate operations out of the State to avoid carbon costs or purchase compliance instruments. A limited number of operators might move towards dry manure management or pasturage but, as described in Chapter VIII and Appendix D of the SLCP Strategy, available land area (with regard to pasturage) and foregone opportunities to produce biogas (with regard to both pasturage and dry manure management) are likely to limit these responses. With regard to waste methane, staff anticipates a similar decrease in the amount of landfill and waste-diversion specific projects, and instead a focus on compliance instrument purchases.

Regarding HFCs, staff expects that inclusion in the Cap-and-Trade Regulation would decrease the scope and speed of efforts to move away from high-GWP HFCs. Although in some cases the costs of switching to lower-GWP systems may be less than the cost of procuring compliance instruments in the Cap-and-Trade market, the market alternative will likely out-compete certain projects. The absence of specific regulations disfavoring high-GWP refrigerants will also limit efforts to deter their long-term use. The Ozone-Depleting Substance compliance offset protocol would also likely cease to function once these gases were included in the cap, further limiting reduction efforts in the sector.

Compliance responses for black carbon sources would be the same as described in the SLCP Strategy, because these sources would not be included in the Cap-and-Trade Regulation.

b) Alternative 3 Impact Discussion

a. Objectives

Extending the Cap-and-Trade Regulation to other economic sectors that include SLCP sources and including black carbon and HFCs in the cap would not be consistent with several of the project objectives. The State would still pursue GHG emission reductions through this program in applicable economic sectors to maintain and continue reductions beyond 2020 and the objectives of the SLCP Strategy, but specific reductions of SLCPs could not be guaranteed.

As staff explains in the SLCP Strategy, the Cap-and-Trade Regulation creates a declining aggregate cap on overall emission levels, not individual emissions reduction targets for particular gases or for facilities at the entity or sector level. Securing SLCP-specific reductions for specific pollutants and sectors, therefore requires discrete regulations focused on specific pollutants and sectors.

Conversely, ARB determined that combustion and process emissions are the emissions sources with a compliance obligation under the Cap-and-Trade Regulation. These emissions can be measured according to the accuracy requirements of the Mandatory Greenhouse Gas Emissions Reporting Regulation (MRR), accurate quantification methodologies are available, consistent carbon costs can be applied, and the sources accord with those covered by federal reporting programs (ARB 2011). In contrast, most fugitive emissions[6] (a category into which SLCP emissions generally fall) do not meet these criteria.[7] They are frequently difficult to measure and measurements have high uncertainties (WCI 2010); measurement methods are often expensive, labor intensive, and imprecise; and carbon costs are hard to reliably assign (ARB 2011). Specific to these sectors, quantifying and managing agricultural methane under the cap would be difficult, as would be appropriately defining points of regulation for compliance across the diverse sector. On the HFC side there are also substantial implementation difficulties because HFC leaks and releases occur over a long time-scale, making calculating compliance obligations in any particular year difficult. Refrigerants are not expected or meant to be emitted under normal use, unlike producing CO_2 from burning

[6] Fugitives from certain oil and gas sources are an exception because they are unusually possible to quantify with rigor.

[7] ARB's responses to comments in the 2011 Final Statement of Reasons for the Regulation and Western Climate Initiative design documentation provide detailed rationale for the treatment of fugitive emissions in specific sectors. For example, the quantification methods that are often used to quantify fugitive emissions, including calibrated bagging, high volume sampling, and a default emissions factor, only provide a snapshot of emissions rather than actual measurements of emissions from the source. See also Western Climate Initiative, Inc. (2010) WCI Comments on the Proposed Mandatory Reporting of GHG Emissions from Proposed Reporting for Oil and Gas Operations (Subpart W), at pg. 44.

fossil fuels. One facility might lose its entire refrigerant this year, whereas another stays essentially leak-tight (but may lose a large amount the following year). For Cap-and-Trade to operate successfully there generally must be direct, known emissions in the current year. Moreover, because the sector is very diverse with so many small actors, importers, it is difficult to define the point of regulation effectively.

Thus, the Cap-and-Trade Regulation would likely not operate very successfully to control SLCPs, and their inclusion in the regulation might undermine the overall effectiveness of the market by, for instance, introducing uncertainty as to the compliance obligations of SLCP market participants. For these reasons, alone, this Alternative does not satisfy Objective 3 of the SLCP Strategy

Further, even if the Cap-and-Trade Regulation operated more successfully than staff anticipates, including SLCPs as a technical matter, would not guarantee reductions of SLCPs, or implementation of control projects at particular SLCP sources. Instead, it would drive reductions across the California economy. As a result, specific SLCP reduction targets might not be achieved, further failing to achieve Objective 3.

Moreover, avoiding leakage of covered industries to other sectors would be a continuing challenge, especially for sectors (like dairy production) that might relocate to other states, rather than paying compliance costs in the absence of incentive programs that the SLCP Strategy would provide.

Objective 15 would also not be fully achieved, because Cap-and-Trade does not target particular measures to particular disadvantaged communities. Thus, the particular economic, and environmental co-benefits associated with SLCP reduction projects (such as replacing diesel fuel with biogas, and eliminating a share of TACs from the fuel in farming communities) could not be guaranteed to occur, and would likely occur (if at all) in reduced amounts.

This lack of specific projects in specific areas might also undermine Objective 4, because, though ARB would continue to collaborate with other agencies and districts where possible, ARB would not be collaborating to implement particular projects or programs within the jurisdiction or geographic areas of these agencies and districts. Instead, ARB would be implementing a statewide program that might (or might not) have particular local impacts, diminishing the efficacy and depth of collaboration on specific projects that might otherwise occur. A number of public benefits and co-benefits perhaps could still be achieved by a broadened Cap-and-Trade Regulation consistent with Objective 4 if it were to function well; however, the opportunity to align and implement specific recommended actions in the SLCP Strategy that would support or complement other statewide initiatives and maximize a broad range of benefits to the economy, environment, and public health would be diminished and compliance with SB 605 and SB 1383 may not be achieved.

Finally, this alternative could fail to achieve Objective 2 regarding identifying research needs regarding data gaps. Extending the Cap-and-Trade Regulation to the currently uncapped sectors and including methane from agriculture and landfills and from HFCs would require ongoing enforcement, monitoring and verification by ARB. This could prove difficult as both the technical methodology and resources required to ensure that GHG emission reductions in these sectors are real, permanent, quantifiable, verifiable and enforceable, are not yet well-defined. For related reasons, this alternative could fail to meet SLCP reduction goals due to potential increases in administrative burden for both implementation and compliance with the Regulation.

b. Environmental Impacts

Reasonably foreseeable compliance responses under this alternative would likely be similar to those under the current Cap-and-Trade Regulation, and therefore, any potentially significant impacts analyzed in the 2010 Cap-and-Trade FED would likely be similar under Alternative 3.

Potentially significant impacts would also be similar in some instances to those disclosed in this Revised Draft EA for the measures in the SLCP Strategy, to the extent that some entities pursue these responses in response to Cap-and-Trade Regulation price signals, along with similar or additional compliance responses under the broadened Cap-and-Trade Regulation. Any reduction in offset supply, resulting from coverage of SLCP-emitting sectors in the Cap-and-Trade Regulation, would have environmental impacts similar to those described in Chapter 4. This is because changes in offset availability from certain sectors are expected to be similar under this alternative and under the SLCP Strategy, with the notable exception that the ozone-destroying substances protocol might be phased out along with the livestock protocol, resulting in somewhat greater shifts in environmental impacts from offset-supported projects.

Because sector- and pollutant-specific projects would likely occur at a reduced frequency, however, the specific short-term and long-term environmental impacts identified in Chapter 4 of this Revised Draft EA, particularly impacts from methane specific measures on aesthetics, agricultural and forest resources, air quality, biological resources, cultural resources, geology and soils, hazards and hazardous materials, hydrology and water quality, land use and planning, noise, transportation/traffic, and utilities and service systems, would also likely occur at reduced levels. The precise degree to which these impacts could be avoided, however, turns on whether individual entities covered by the Cap-and-Trade Regulation under this alternative find it economically efficient to pursue these strategies as part of their compliance response. Some of these impacts might continue to be potentially significant and unavoidable.

8.0 REFERENCES

California Air Resources Board (ARB) 2014. Compliance Offset Protocol: Livestock Projects. Available: http://www.arb.ca.gov/regact/2014/capandtrade14/ctlivestockprotocol.pdf. Accessed: March 2016.

California Air Resources Board. 2011. Final Statement of Reasons. Cap-and- Trade Regulation. Available: http://www.arb.ca.gov/regact/2010/capandtrade10/fsor.pdf. Accessed: Accessed: March 2016.

Boutonnet J.-C., P. Bingham, D. Calamari, C. de Rooij, J. Franklin, T. Kawano, J.-M. Libre, A. McCulloch, G. Malinverno, J.M. Odom, G.M. Rusch, K. Smythe, I. Sobolev, R. Thompson and J. M. Tiedje. 1999. Environmental Risk Assessment of Trifluoroacetic Acid, Human and Ecological Risk Assessment. Available: http://www.tandfonline.com/doi/abs/10.1080/10807039991289644. Accessed: April 2016.

Cahill, Thomas M., Carmen M. Thomas, Steven E. Schwarzbach, and James N. Seiber. 2001. Accumulation of Trifluoroacetate in Seasonal Wetlands in California. Environmental Science and Technology, Volume 35(5), 820-825. Available: http://pubs.acs.org/doi/abs/10.1021/es0013982. Accessed: September 2015.

California Department of Resources Recycling and Recovery (CalRecyle). 2011 (June). Statewide Anaerobic Digester Facilities for the Treatment of Municipal Organic Sold Waste Final Program Environmental Impact Report. Available: http://www.calrecycle.ca.gov/swfacilities/compostables/ AnaerobicDig/PropFnlPEIR.pdf. Accessed: September 2015.

California Energy Commission (CEC). 2015. Anaerobic Digestion. Available: http://www.energy.ca.gov/biomass/ anaerobic.html. Accessed: September 2015.

Chen,J., Lu, J., Avise, J.C., DaMassa, J.A., Kleeman, M.J., Kaduwela, A.P., 2014, Seasonal Modeling of $PM_{2.5}$ in California's San Joaquin Valley, Atmospheric Environment, 92, pp. 182-190.

Frank H., E.H. Christoph, O. Holm-Hansen and J.L. Bullister. 2002. Trifluoroacetate in Ocean Waters, Environ. Sci. Technol., 36, pp. 12-15.

Gallagher, G.; Zhan, T.; Hsu, Y-K.; Gupta, P.; Pederson, J.; Croes, B.; Blake, D. R.; Barletta, B.; Meinardi, S.; Ashford, P.; Vetter, A.; Saba, S.; Slim, R.; Palandre, L.; Clodic, D.; Mathis, P.; Wagner, M.; Forgie, J.; Dwyer, H.; Wolf, K. 2014. High-global Warming Potential F-gas Emissions in California: Comparison of Ambient-based versus Inventory-based Emission Estimates, and Implications of Refined Estimates. Environ Sci. Technol., 2014, 48, pp. 1084-1093.

Henne, Stephan, Dudley E. Shallcross, Stefan Reimann, Ping Xiao, Dominik Brunner, Simon O'Doherty, and Brigitte Buchmann. 2012. Future Emissions and Atmospheric Fate of HFC-1234yf from Mobile Air Conditioners in Europe. Environmental Science & Technology, 2012, 46, pp. 1650-1658.

Honeywell. 2015a (October). Safety Data Sheet: Solstice yf Refrigerant (R- 1234yf). Available: http://msds-resource.honeywell.com/ehswww/hon/result/result_single.jsp?P_LANGU=E&P_SYS=1&C001=MSDS&C997=C100;E%2BC101;SDS_US%2BC102;US%2B1000&C100=*&C101=*&C102=*&C005=000000011078&C008&C006=HON&C013. Accessed: October 2015.

Honeywell. 2015b (October). Safety Data Sheet: Solstice ze Refrigerant (R- 1234ze). Available: http://msds-resource.honeywell.com/ehswww/hon/result/result_single_main.jsp?P_LANGU=E&P_SYS=1&C001=MSDS&C997=C100;E%2BC101;SDS_US%2BC102;US%2B1000&C100=E&C101=SDS_US&C102=US&C005=000000012546%20&C008=&C006=HON&C013=&. Accessed: October 2015.

Hurley, T.J. Wallington, Mehrdad Javadi, and Ole John Nielsen. 2008. Atmospheric chemistry of CF_3CFCH_2: Products and mechanisms of Cl atom and OH radical initiated oxidation. Chemical Physics Letters, 450(4-6), pp. 263-267.

Institute for Local Self-Reliance. 2010 (October). Update on Anaerobic Digester Projects Using Food Wastes in North America. Prepared for Division of Sustainability. City of Atlanta, George. Available: http://ilsr.org/wp-content/uploads/2012/03/atlanta-adreport.pdf. Accessed: November 2015.

Kelly, J. T., et al. 2014. Fine-scale simulation of ammonium and nitrate over the South Coast Air Basin and San Joaquin Valley of California during CalNex-2010,

J. Geophys. Res. Atmos., 119, 3600–3614. Available: http://authors.library.caltech.edu/46301/1/jgrd51267.pdf. Accessed: April 2016.

Kirschke, S. et. al. 2013. Three Decades of Global Methane Sources and Sinks. Nature Geosciences. Volume 6, 813-823.

Kleeman, M.J., Ying, Q., and Kaduwela, A. 2005. Control strategies for the reduction of airborne particulate nitrate in California's San Joaquin Valley, Atmospheric Environment, 2005, 39, pp. 5325-5341. http://www.sciencedirect.com/science/article/pii/S1352231005004917.

Krauter, Charles and Dave Goorahu. 2002. Ammonia Emissions and Fertilizer Applications in California's Central Valley." Charles Krauter and Dave Goorahu of Center for Irrigation Technology, College of Agricultural Sciences & Technology, California State University Fresno, CA; and Christopher Potter and Steven Klooster of NASA - Ames Research Center, Ecosystem Science and Technology Branch Moffett Field, CA. Paper presented at 11th International Emission Inventory Conference - Emission Inventories - Partnering for the Future. Atlanta, GA, April 15-18, 2002 Available at: http://www.epa.gov/ttnchie1/conference/ei11/ammonia/krauter.pdf. Accessed: April 2016.

National Emissions Inventory (NEI). 2015. Air Pollutant Emissions Trends Data 1990-2014 on the U.S. EPA website at: http://www.epa.gov/ttn/chief/trends/index.html#tables. Accessed: April 2016.

Luecken, Deborah J., Robert L. Waterland, Stella Papasavva, Kristen N. Taddonio, William T. Hutzell, John P. Rugh, and Stephen O. Andersen. 2010. Ozone and TFA Impacts in North American from Degradation of 2,3,3,3- Tetrafluropropene (HFO-1234yf), A Potential Greenhouse Gas Replacement. *Environmental Science and Technology*, Volume 44(1), 343-348.

National Park Service (NPS). 2015. Yosemite National Park. Available: http://www.nps.gov/yose/blogs/fireinfo.htm. Accessed: November 2015.

Parker, D.B. 2011 (January). Effectiveness of manure scraper system for odor control in tunnel-ventilated swine finisher barns. Transactions of the American Society of Agricultural and Biological Engineers. Vol. 54 (1): 315-324.

Pedersen, H. 2012. Low GWP Alternatives to HFCs in Refrigeration. Available: http://www.unep.org/ozonaction/ecanetwork/Portals/138/ECA%202012/Announcements/Low%20GWP%20Alternatives%20to%20HFCs%20in%20Refrigeration.pdf. Accessed: November 2015.

Regional Water Quality Control Board (RWQCB). 2010 (June) Dairy Manure Digester and Co-Digester Facilities Draft Program Environmental Impact Report. Available: http://www.calrecycle.ca.gov/swfacilities/compostables/AnaerobicDig/DairyDigDEIR.pdf. Accessed: September 2015.

Russell, Mark H., Gerco Hoogeweg, Eva M. Webster, David A. Ellis, Robert L. Waterland, and Robert A. Hoke. 2012. TFA from HFO-1234yf: Accumulation and Aquatic Risk in Terminal Bodies. *Environmental Toxicology and Chemistry*, Volume 31(9), 1957-1965.

Schweizer, Don and Ricardo Cisneros. 2015. Wildland fire management and air quality in the southern Sierra Nevada: Using the Lion Fire as a case study with a multi-year perspective on PM 2.5 impacts and fire policy. Available: http://www.sierraforestlegacy.org/Resources/Community/PrescribedFire/Schweiz er&Cisneros_2014_JEnvMan_WildlandFireAirQualityLionFire.pdf. Accessed: April 2016.

Society of Vertebrate Paleontology. 2010. Standard Procedures for the Assessment and Mitigation of Adverse Impacts to Paleontological Resources. Available: https://vertpaleo.org/PDFS/68/68c554bb-86f1-442f-a0dc- 25299762d36c.pdf. Accessed: November 2015.

U.S. EPA. 2010. Transitioning to Low-GWP Alternatives in Commercial Refrigeration. Available: https://www.epa.gov/sites/production/files/2015-07/documents/transitioning_to_low-gwp_alternatives_in_commercial_refrigeration.pdf. Accessed: October 2015.

U.S. EPA. 2014. Assessment of the Potential Impact of Hydrocarbon Refrigerants on Ground Level Ozone Concentrations (EPA Contract Number EP- W-10-031 Task Order 305, Task 01). Technical memorandum from ICF International to U.S. EPA Stratospheric Protection Division, February 24, 2014. Available: https://www.regulations.gov/#!documentDetail;D=EPA-HQ-OAR-2013- 0748-0003. Accessed: April 2016.

Western Climate Initiative, Inc. 2010. WCI Comments on the Proposed Mandatory Reporting of GHG Emissions from Proposed Reporting for Oil and Gas Operations (Subpart W) at pg. 39. available at http://www.westernclimateinitiative.org/component/remository/general/WCI-Comments-on-the-Proposed-Mandatory-Reporting-of-GHG-Emissions-from--Proposed-Reporting-for-Oil-and-Gas-Operations-%28Subpart-W%29. Accessed: April 2016

ATTACHMENT A: ENVIRONMENTAL AND REGULATORY SETTING

1. AESTHETICS

A. Existing Conditions

Similar to the U.S., the visual character of California varies greatly related to topography and climate. The foothills form a transitional landform from the valley floor to the higher Sierra Nevada, Cascade, and Coast Ranges. The valley floor is cut by two rivers that flow west out of the Sierra Nevada and east out of the Coast Ranges. Irrigated agriculture land is the primary landscape in the Sacramento and San Joaquin Valleys, and the foothill landscape has been altered by grazing, mining, reservoir development, and residential and commercial development. The visual character of the state also varies dramatically from the north, which is dominated by forest lands, and the south, which is primarily residential and commercial development.

B. Regulatory Setting

Applicable laws and regulations associated with aesthetics and scenic resources are discussed in Table 1.

Table 1: Applicable Laws and Regulations for Aesthetic Resources	
Applicable Regulations	**Description**
Federal	
Federal Land Policy and Management Act of 1976 (FLPMA)	FLPMA is the enabling legislation establishing the Bureau of Land Management's (BLM's) responsibilities for lands under its jurisdiction. Section 102 (a) of the FLPMA states that "…the public lands be managed in a manner that will protect the quality of scientific, scenic, historical, ecological, environmental, air and atmospheric, water resources, and archeological values…" Section 103(c) identifies "scenic values" as one of the resources for which public land should be managed.
BLM Contrast Rating System	The contrast rating system is a systematic process used by BLM to analyze visual impacts of proposed projects and activities. It is primarily intended to assist BLM personnel in the resolution of visual impact assessment.
Natural Historic Preservation Act (NHPA)	Under regulations of the NHPA, visual impacts to a listed or eligible National Register property that may diminish the integrity of the property's "setting … [or] … feeling" in a way that affects the property's eligibility for listing may result in a potentially significant adverse effect. "Examples of adverse effects … include…: Introduction of visual, atmospheric, or audible elements that diminish the

Table 1: Applicable Laws and Regulations for Aesthetic Resources	
Applicable Regulations	**Description**
	integrity of the property's significant historic features." (Title 36 Code of Federal Regulations CFR (CFR) Part 800.5)
National Scenic Byways Program	Title 23, Sec 162 outlines the National Scenic Byways Program. This program is used to recognize roads having outstanding scenic, historic, cultural, natural, recreational, and archaeological qualities through designation of road as: National Scenic Byways; All-American Roads; or America's Byways. Designation of the byways provides eligibility for Federal assistance for safety improvement, corridor management plans, recreation access, or other project that protect scenic, historical, recreational, cultural, natural, and archaeological resources.
State	
Ambient Air Quality Standard for Visibility-Reducing Particles	Extinction coefficient (measure of absorption of light in a medium) of 0.23 per kilometer — visibility of 10 miles or more (0.07 — 30 miles or more for Lake Tahoe) due to particles when relative humidity is less than 70 percent.
California Streets and Highway Code, Section 260 through 263 – Scenic Highways	The State Scenic Highway Program promotes protection of designated State scenic highways through certification and adoption of local scenic corridor protection programs that conform to requirements of the California Scenic Highway Program.
Local	
County and City Controls	Most local planning guidelines to preserve and enhance the visual quality and aesthetic resources of urban and natural areas are established in the jurisdiction's general plan. The value attributed to a visual resource generally is based on the characteristics and distinctiveness of the resource and the number of persons who view it. Vistas of undisturbed natural areas, unique or unusual features forming an important or dominant portion of a viewshed, and distant vistas offering relief from less attractive nearby features are frequently considered to be scenic resources. In some instances, a case-by-case determination of scenic value may be needed, but often there is agreement within the relevant community about which features are valued as scenic resources. In addition to federal and State designations, counties and cities have their own scenic highway designations, which are intended to preserve and enhance existing scenic resources. Criteria for designation are commonly included in the conservation/open space element of the

Table 1: Applicable Laws and Regulations for Aesthetic Resources	
Applicable Regulations	**Description**
	city or county general plan.

2. AGRICULTURAL AND FOREST RESOURCES

A. Existing Conditions

1. Agricultural Resources

The State of California maps and classifies farmland through the California Department of Conservation Farmland Mapping and Monitoring Program (FMMP). Classifications are based on a combination of physical and chemical characteristics of the soil and climate that determine the degree of suitability of the land for crop production. The classifications under the FMMP are as follows:

1. Prime Farmland—land that has the best combination of features for the production of agricultural crops;
2. Farmland of Statewide Importance—land other than Prime Farmland that has a good combination of physical and chemical features for the production of agricultural crops, but that has more limitations than Prime Farmland, such as greater slopes or less ability to store soil moisture;
3. Unique Farmland—land of lesser quality soils used for the production of the state's leading agricultural cash crops;
4. Farmland of Local Importance—land of importance to the local agricultural economy;
5. Grazing Land—existing vegetation that is suitable for grazing;
6. Urban and Built-Up Land—land occupied by structures in density of at least one dwelling unit per 1.5 acres;
7. Land Committed to Nonagricultural Use—vacant areas; existing land that has a permanent commitment to development but has an existing land use of agricultural or grazing lands; and
8. Other Land— land not included in any other mapping category, common examples of which include low-density rural developments, brush, timber, wetland, and vacant and nonagricultural land surrounded on all sides by urban development.

CEQA Section 21095 and CEQA Guidelines Appendix G, together, define Prime, Unique, and Farmland of Statewide Importance as "Important Farmland," whose conversion may be considered significant. Local jurisdictions can further consider other classifications of farmland as important, and can also utilize an agricultural land evaluation and site assessment (LESA) model to determine farmland importance and impacts from conversion.

As of 2012, California contained 41,570 acres of Prime Farmland; 33,337 acres of Farmland of Statewide Important; 28,725 acres of Unique Farmland; 15,168 acres of Farmland of Local Importance; and 197,866 acres of grazing land (FMMP 2012).

a) Williamson Act

The California Land Conservation Act of 1965--commonly referred to as the Williamson Act--enables local governments to enter into contracts with private landowners for the purpose of restricting specific parcels of land to agricultural or related open space use. In return, landowners receive property tax assessments which are much lower than normal because they are based upon farming and open space uses as opposed to full market value. The Open Space Subvention Act of 1971 provided local governments an annual subvention of forgone property tax revenues from the state through the year 2009; these payment have been suspended in more recent years due to revenue shortfalls.

Of California's 58 counties, 52 have executed contracts under the Land Conservation Act Program. The 15.4 million acres reported as enrolled in Land Conservation Act contracts statewide in 2013, represents approximately 50 percent of California's farmland total of about 30 million acres, or about 31 percent of the State's privately owned land (California Department of Conservation 2015).

2. Forestry Resources

Forestland is defined as land that can support 10 percent native tree cover of any species, including hardwoods, under natural conditions, and that allows for management of one or more forest resources, including timber, aesthetics, fish and wildlife, biodiversity, water quality, recreation, and other public benefits (Public Resources Code [PRC] 12220[g]). There are 40,233,000 acres of forested land within California including oak woodlands and conifer forests (CDFW 2014a).

Timberland is privately-owned land, or land acquired for state forest purposes, which is devoted to and used for growing and harvesting timber, or for growing and harvesting timber and compatible uses, of, at minimum 15 cubic feet per acre (PRC 51104[g]).

Forest managed for harvest is called timberland, and includes 2,932,000 acres in private ownership, 146,000 acres in State ownership, 10,130,000 acres in federal ownership, and 4,551,000 acres of non-industrial timberland in private ownership (CDFW 2014a).

B. Regulatory Setting

Table 2 below provides a general description of applicable laws and regulations that may pertain to agriculture and forest resources.

Table 2: Applicable Laws and Regulations for Agriculture and Forest Resources	
Applicable Regulations	**Description**
Federal	
Farmland Protection Policy Act (FPPA)	FPPA directs federal agencies to consider the effects of federal programs or activities on farmland, and ensure that such programs, to the extent practicable, are compatible with

Table 2: Applicable Laws and Regulations for Agriculture and Forest Resources	
Applicable Regulations	**Description**
	state, local, and private farmland protection programs and
National Forest Management Act (NFMA) of 1976	NFMA is the primary statute governing the administration of national forests. The act requires the Secretary of Agriculture to assess forest lands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan for each unit of the National Forest System. Goal 4 of the U.S. Forest Service's National Strategic Plan for the National Forests states that the nation's forests and grasslands play a significant role in meeting America's need for producing and transmitting energy. Unless otherwise restricted, National Forest Service lands are available for energy exploration, development, and infrastructure (e.g., well sites, pipelines, and transmission lines). However, the emphasis on non-recreational special uses, such as utility corridors, is to authorize the special uses only when they cannot be reasonably accommodated on non-National Forest Service lands.
State	
The California Land Conservation Act, also known as the Williamson Act (Government Code Section 51200)	The California Department of Conservation's (DOC's) Division of Land Resource Protection administers the Williamson Act program, which permits property tax adjustments for landowners who contract with a city or county to keep their land in agricultural production or approved open space uses for at least 10 years. Lands covered by Williamson Act contracts are assessed on the basis of their agricultural value instead of their potential market value under nonagricultural uses. In return for the preferential tax rate, the landowner is required to contractually agree to not develop the land for a period of at least 10 years. Williamson Act contracts are renewed annually for 10 years unless a party to the contract files for nonrenewal. The filing of a non-renewal application by a landowner ends the automatic annual extension of a contract and starts a 9-year phase-out of the contract. During the phase-out period, the land remains restricted to agricultural and open-space uses, but property taxes gradually return to levels associated with the market value of the land. At the end of the 9-year non-renewal process, the contract expires and the owner's uses of the land are restricted only by applicable local zoning. The Williamson Act defines compatible use of contracted lands as any use determined by the county or city administering the agricultural preserve to be compatible with the agricultural, recreational, or open space use of land within the preserve and subject to contract (Government Code, Section 51202[e]). However, uses deemed compatible by a county or city government must be

Table 2: Applicable Laws and Regulations for Agriculture and Forest Resources	
Applicable Regulations	**Description**
	consistent with the principles of compatibility set forth in Government Code, Section 51238.1. Approximately 16 million acres of farmland (about 50 percent of the State's total farmland) are enrolled in the program.
California Farmland Conservancy Program (CFCP) (Public Resources Code [PRC] Section 10200)	The program provides grant funding for agricultural conservation easements. Although the easements are always written to reflect the benefits of multiple resource values, there is a provision in the CFCP statute that prevents easements funded under the program from restricting husbandry practices. This provision could prevent restricting those practices to benefit other natural resources.
Farmland Mapping and Monitoring Program (FMMP) (Government Code Section 65570, PRC Section 612)	Under the FMMP, the DOC assesses the location, quality, and quantity of agricultural lands and conversion of these lands over time. Agricultural designations include the categories of Prime Farmland, Farmland of Statewide Importance, Unique Farmland, Farmland of Local Importance, Grazing Land, Urban and Built-Up Land, and Other Land. FMMP uses the following definitions to describe farmland types. 9. Prime Farmland is defined by the DOC as "Land with the best combination of physical and chemical features able to sustain long term production of agricultural crops. This land has the soil quality, growing season, and moisture supply needed to produce sustained high yields. Land must have been used for production of irrigated crops at some time during the past four years." 10. Farmland of Statewide Importance is defined by the DOC as "Land similar to Prime Farmland that has a good combination of physical and chemical characteristics for the production of agricultural crops. This land has minor shortcomings, such as greater slopes or less ability to store soil moisture than Prime Farmland. Land must have been used for production of irrigated crops at some time during the past four years." 11. Unique Farmland is defined by the DOC as "Lesser quality soils used for the production of the State's leading agricultural crops. This land is usually irrigated, but may include non-irrigated orchards or vineyard as found in some climatic zones in California."
State Lands Commission Significant Land Inventory	The State Lands Commission is responsible for managing lands owned by the State, including lands that the State has received from the federal government. These lands total more than 4 million acres and include tide and submerged lands, swamp and overflow lands, the beds of navigable waterways,

Table 2: Applicable Laws and Regulations for Agriculture and Forest Resources	
Applicable Regulations	**Description**
	and State School Lands. The State Lands Commission has a legal responsibility for, and a strong interest in, protecting the ecological and Public Trust values associated with the State's sovereign lands, including the use of these lands for habitat preservation, open space and recreation. Scoping Plan projects located within these lands would be subject to the State Lands Commission permitting process.
Local	
Open Space Element	State law requires each city and county to adopt a general plan containing at least seven mandatory elements including an open space element. The open space element identifies open space resources in the community and strategies for protection and preservation of these resources. Agricultural and forested lands are among the land use types identified as open space in general plans.
Zoning	The city or county zoning code is the set of detailed requirements that implement the general plan policies at the level of the individual parcel. The zoning code presents standards for different land uses and identifies which land uses (e.g., agriculture, residential, commercial, industrial) are allowed in the various zoning districts of the jurisdiction. Since 1971, state law has required the city or county zoning code to be consistent with the jurisdiction's general plan, except in charter cities.

3. AIR QUALITY

A. Existing Conditions

Federal, State, and local governments all share responsibility for reducing air pollution. The California Air Resources Board (ARB or Board) is California's lead air agency and controls emissions from mobile sources, fuels, and consumer products, as well as air toxics.

ARB also coordinates local and regional emission reduction measures and plans that meet federal and State air quality limits. At the federal level, the U.S. Environmental Protection Agency (EPA) has oversight of State programs. In addition, EPA alone has jurisdiction to establish emission standards for certain mobile sources such as ships, trains, and airplanes.

1. Criteria Air Pollutants

Concentrations of emissions of criteria air pollutants are used to indicate the quality of the ambient air because these are the most prevalent air pollutants known to be deleterious to human health. A brief description of each CAP is provided below. Emission source types and health effects are summarized in Table 3.

Table 3: Sources and Health Effects of Criteria Air Pollutants

Pollutant	Sources	Acute[1] Health Effects	Chronic[2] Health Effects
Ozone	Secondary pollutant resulting from reaction of reactive organic gases (ROG) and oxides of nitrogen (NO_X) in presence of sunlight. ROG emissions result from incomplete combustion and evaporation of chemical solvents and fuels; NO_X results from the combustion of fuels	Increased respiration and pulmonary resistance; cough, pain, shortness of breath, lung inflammation	Permeability of respiratory epithelia, possibility of permanent lung impairment
Carbon monoxide (CO)	Incomplete combustion of fuels; motor vehicle exhaust	Headache, dizziness, fatigue, nausea, vomiting, death	Permanent heart and brain damage
Nitrogen dioxide (NO_2)	Combustion devices; e.g., boilers, gas turbines, and mobile and stationary reciprocating internal combustion engines	Coughing, difficulty breathing, vomiting, headache, eye irritation, chemical pneumonitis or pulmonary edema; breathing abnormalities, cough, cyanosis, chest pain, rapid heartbeat, death	Chronic bronchitis, decreased lung function
Sulfur dioxide (SO_2)	Coal and oil combustion, steel mills, refineries, and pulp and paper mills	Irritation of upper respiratory tract, increased asthma symptoms	Insufficient evidence linking SO_2 exposure to chronic health impacts
Respirable particulate matter (PM_{10}) and fine particulate matter ($PM_{2.5}$)	Fugitive dust, soot, smoke, mobile and stationary sources, construction, fires and natural windblown dust, and formation in The atmosphere by condensation and/or transformation of SO_2 and ROG	Breathing and respiratory symptoms, aggravation of existing respiratory and cardiovascular diseases, premature death	Alterations to the immune system, carcinogenesis

Table 3: Sources and Health Effects of Criteria Air Pollutants			
Pollutant	**Sources**	**Acute[1] Health Effects**	**Chronic[2] Health Effects**
Lead	Metal processing	Reproductive/ developmental effects (fetuses and children)	Numerous effects including neurological, endocrine, and cardiovascular
			effects
[1] Acute" refers to effects of short-term exposures to criteria air pollutants, usually at relatively high concentrations. [2] Chronic" refers to effects of long-term exposures to criteria air pollutants, even at relatively low concentrations. Sources: US EPA 2011.			

a) Ozone

Ozone is a photochemical oxidant (a substance whose oxygen combines chemically with another substance in the presence of sunlight) and the primary component of smog. Ozone is not directly emitted into the air but is formed through complex chemical reactions between precursor emissions of reactive organic gases (ROG) and oxides of nitrogen (NO_X) in the presence of sunlight. ROG are volatile organic compounds that are photochemically reactive. ROG emissions result primarily from incomplete combustion and the evaporation of chemical solvents and fuels. NO_X are a group of gaseous compounds of nitrogen and oxygen that result from the combustion of fuels.

Anthropogenic emissions of the ozone precursors ROG and NO_X have decreased over the past several years because of more stringent motor vehicle standards and cleaner burning fuels. During the last 20 years the maximum amount of ROG and NO_X over an 8-hour period decreased by 17 percent. However, most counties in California are still in nonattainment for ozone.

b) Nitrogen Dioxide

NO_2 is a brownish, highly-reactive gas that is present in all urban environments. The major human-made sources of NO_2 are combustion devices, such as boilers, gas turbines, and mobile and stationary reciprocating internal combustion engines.

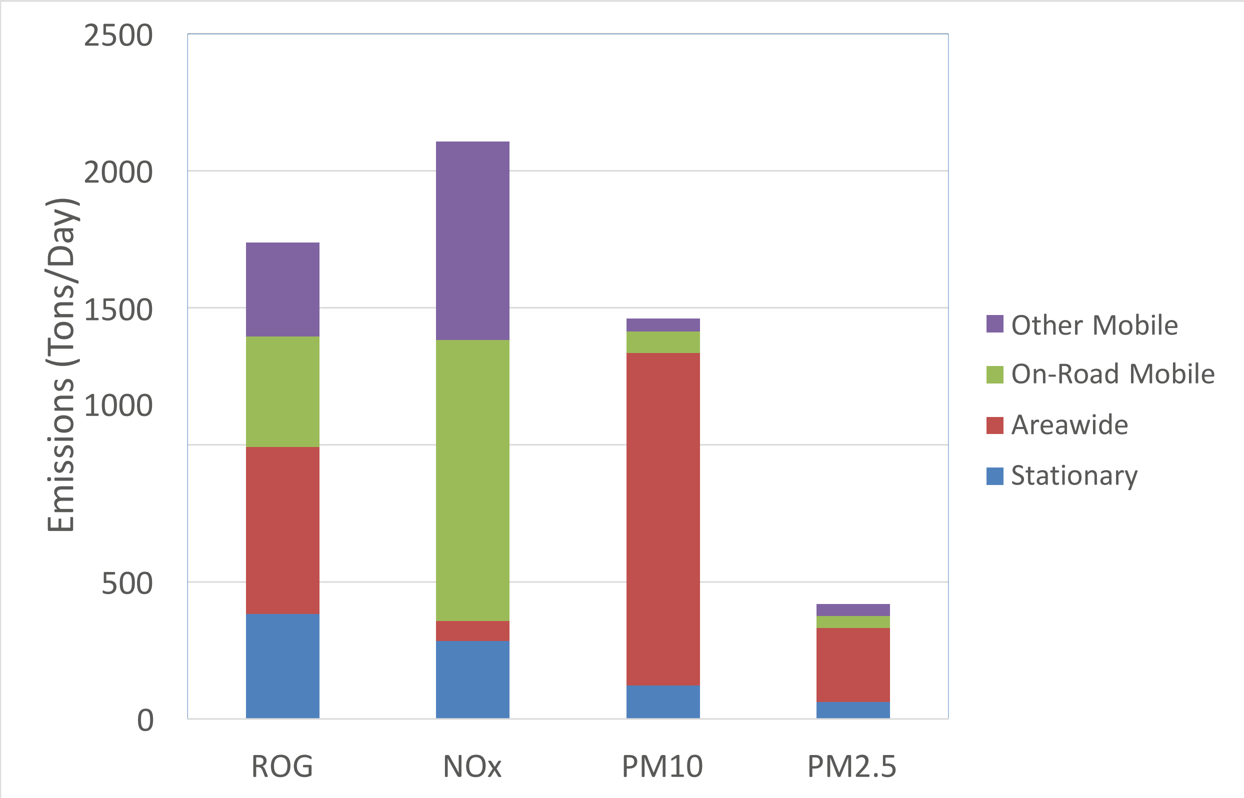
Combustion devices emit primarily nitric oxide (NO), which reacts through oxidation in the atmosphere to form NO_2. The combined emissions of NO and NO_2 are referred to as NO_X and are reported as equivalent NO_2. Because NO_2 is formed and depleted by reactions associated with photochemical smog (ozone), the NO_2 concentration in a particular geographical area may not be representative of the local sources of NO_X emissions (US EPA 2011).

c) Particulate Matter

Respirable particulate matter with an aerodynamic diameter of 10 micrometers or less is referred to as PM_{10}. PM_{10} consists of particulate matter emitted directly into the air, such as fugitive dust, soot, and smoke from mobile and stationary sources, construction equipment, fires and natural windblown dust, and particulate matter formed in the atmosphere by reaction of gaseous precursors (ARB 2009). $PM_{2.5}$ includes a subgroup of smaller particles that have an aerodynamic diameter of 2.5 micrometers or less. PM_{10} emissions in California are dominated by emissions from area sources, primarily fugitive dust from vehicle travel on unpaved and paved roads, farming operations, construction and demolition, and particles from residential fuel combustion. Direct emissions of PM_{10} have increased slightly in California over the last 20 years, and are projected to continue to increase. $PM_{2.5}$ emissions have remained relatively steady over the last 20 years and are projected to increase slightly through 2020. Emissions of $PM_{2.5}$ are dominated by the same sources as emissions of PM_{10} (ARB 2009).

Exhibit 1 summarizes emissions of CAPs within California for various source categories. According to California’s emission inventory, mobile sources are the largest contributor to the estimated annual average for air pollutant levels of ROG and NO_X accounting for approximately 43 percent and 83 percent, respectively, of the total emissions. Area wide sources account for approximately 83 percent and 65 percent of California’s PM_{10} and $PM_{2.5}$ emissions, respectively (ARB 2013).

d) Emission Inventory



Source: ARB 2013
Exhibit 1 California 2012 Emission Inventory

e) Toxic Air Contaminants

Concentrations of toxic air contaminants (TACs) are also used to indicate the quality of ambient air. A TAC is defined as an air pollutant that may cause or contribute to an increase in mortality or in serious illness, or that may pose a hazard to human health. TACs are usually present in minute quantities in the ambient air; however, their high toxicity or health risk may pose a threat to public health even at low concentrations.

According to the *California Almanac of Emissions and Air Quality* (ARB 2009), the majority of the estimated health risks from TACs can be attributed to relatively few compounds, the most predominant being particulate-exhaust emissions from diesel-fueled engines (diesel PM). Diesel PM differs from other TACs in that it is not a single substance, but rather a complex mixture of hundreds of substances. Although diesel PM is emitted by diesel-fueled internal combustion engines, the composition of the emissions varies depending on engine type, operating conditions, fuel composition, lubricating oil, and whether an emissions control system is being used. Unlike some TACs, no ambient monitoring data are available for diesel PM because no routine measurement method currently exists. However, ARB has made preliminary concentration estimates based on a PM exposure method. This method uses the ARB emissions inventory's PM_{10} database, ambient PM_{10} monitoring data, and the results from several studies to estimate concentrations of diesel PM. In addition to diesel PM, the TACs for which data are available that pose the greatest existing ambient risk in California are benzene, 1,3-butadiene, acetaldehyde, carbon tetrachloride, hexavalent chromium, paradichlorobenzene, formaldehyde, methylene chloride, and perchloroethylene.

Diesel PM poses the greatest health risk among these 10 TACs mentioned. Since 1990, the health risk associated with diesel PM has been in California has reduced by 52 percent. Overall, levels of most TACs, except paradichlorobenzene and formaldehyde, have decreased since 1990 (ARB 2009: Chapter 5).

B. Regulatory Setting

Applicable laws and regulations associated with air quality are discussed in Table 4.

Table 4: Applicable Laws and Regulations for Air Quality	
Regulation	**Description**
Federal	
Clean Air Act (CAA) (40 CFR)	CAA, which was last amended in 1990, requires the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment. CAA established two types of NAAQS: primary standards set limits to protect public health, including the health of "sensitive" populations such as asthmatics, children, and the elderly; and secondary standards set limits to protect public welfare, including protection against decreased visibility, damage to animals, crops, vegetation, and buildings. EPA Office of Air Quality Planning and Standards has set NAAQS for six principal pollutants, which are called "criteria" pollutants. Title III of the CAA directed the EPA to promulgate national emissions standards for Hazardous Air Pollutants. The CAA also required the EPA to promulgate vehicle or fuel standards containing reasonable requirements that control toxic emissions, at a minimum to benzene and formaldehyde. Performance criteria were established to limit mobile-source emissions of toxics, including benzene, formaldehyde, and 1,3-butadiene. In addition, Section 219 required the use of reformulated gasoline in selected areas with the most severe ozone nonattainment conditions to further reduce mobile-source emissions.

Table 4: Applicable Laws and Regulations for Air Quality	
Regulation	**Description**
SmartWay	SmartWay is an EPA program that reduces transportation-related emissions by creating incentives to improve supply chain fuel efficiency. It aims to increase the availability and market penetration of fuel efficient technologies and strategies that help freight companies save money while also reducing adverse environmental
Other Applicable Federal-Level Regulations	This includes all other applicable regulations at the federal level for portions of the project area that are outside of the U.S. (e.g., Canada).
State	
California Clean Air Act (CCAA) CCR (Titles 13 and 17)	ARB is the agency responsible for coordination and oversight of State and local air pollution control programs in California and for implementing the CCAA. The CCAA, which was adopted in 1988, required the ARB to establish California ambient air quality standards (CAAQS).
Waste Heat and Carbon Emissions Reduction Act	This Act is designed to encourage the development of new combined heat and power (CHP) systems in California with a generating capacity of not more than 20 megawatts. Section 2843 of the Act provides that the Energy Commission's guidelines require that CHP systems: be designed to reduce waste energy; have a minimum efficiency of 60 percent; have NO_X emissions of no more than 0.07 pounds per megawatt-hour; be sized to meet the eligible customer generation thermal load; operate continuously in a manner that meets the expected thermal load and optimizes the efficient use of waste heat; be cost effective, technologically feasible, and environmentally beneficial.
Other Applicable State-Level Regulations	This includes all other applicable regulations at the State level for portions of the project area that are outside of California (e.g., AB 1807 and AB 2588).
Local	
Air Districts	Air Districts have primary responsibility for preparation, adoption, and implementation of mobile, stationary, and area emission control measures and for the preparation of the SIP and any amendments.

4. BIOLOGICAL RESOURCES

A. Existing Conditions

The state's geography and topography have created distinct local climates ranging from high rainfall in northwestern mountains to the driest place in North America, Death

Valley. North to south, the state extends for almost 800 miles, bridging the temperate rainforests in the Pacific Northwest and the subtropical arid deserts of Mexico. Many parts of the state experience Mediterranean weather patterns, with cool, wet winters and hot, dry summers. Summer rain is indicative of the eastern mountains and deserts, driven by the western margin of the North American monsoon. Along the northern coast abundant precipitation and ocean air produces foggy, moist conditions. High mountains have cooler conditions, with a deep winter snow pack in normal climate years. Desert conditions exist in the rain shadow of the mountain ranges (CDFW 2015).

While the state is largely considered to have a Mediterranean climate, it can be further subdivided into six major climate types: Desert, Marine, Cool Interior, Highland, Steppe, and Mediterranean. California deserts, such as the Mojave, are typified by a wide range of elevation with more rain and snow in the high ranges, and hot, dry conditions in valleys. Cool Interior and Highland climates can be found on the Modoc Plateau, Klamath, Cascade, and Sierra ranges. Variations in slope, elevation, and aspect of valleys and mountains result in a range of microclimates for habitats and wildlife. For example, the San Joaquin Valley, exhibiting a Mediterranean climate, receives sufficient springtime rain to support grassland habitats, while still remaining hot and relatively dry in summer. Steppe climates include arid, shrub-dominated habitats that can be found in the Owens Valley, east of the Sierra Nevada, and San Diego, located in coastal southern California (CDFW 2015).

The marine climate has profound influence over terrestrial climates, particularly near the coast. Additionally, the state is known for variability in precipitation because of the El Niño-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO).

Oscillations are the cyclical shifting of high and low pressure systems, as evidenced by the wave pattern of the jet stream in the northern hemisphere. The ENSO is the cycle of air pressure systems influenced by the location of warm and cold sea temperatures. El Niño events occur when waters are warmer in the eastern Pacific Ocean, typically resulting in greater precipitation in southern California and less precipitation in northern California, and La Niña events occur when waters are colder in the eastern Pacific resulting in drier than normal conditions in southern California and wetter conditions in northern California during late summer and winter. The warmer ocean temperatures associated with El Niño conditions also result in decreased upwelling in the Pacific Ocean (CDFW 2015).

1. Plant Diversity

California has the highest numbers of native and endemic plant species of any state, with approximately 6,500 species, subspecies, and varieties of plants, representing 32 percent of all vascular plants in the United States. Nearly one-third of the state’s plant species are endemic, and California has been recognized as one of 34 global hotspots for plant diversity. Within the California Floristic Province, which encompasses the Mediterranean area of Oregon, California, and northwestern Baja, 2,124 of the 3,488 species are endemic, representing a 61 percent rate of endemism. Over 200 species, subspecies, and varieties of native plants are designated as rare, threatened, or endangered by state law, and over 2,000 more plant taxa are considered to be of conservation concern (CDFW 2015).

2. Wildlife Diversity

California has a large number of animal species, representing a substantial proportion of the wildlife species nationwide. The state's diverse natural communities provide a wide variety of habitat conditions for wildlife. The state's wildlife species include approximately 100 reptile species, 75 amphibian species, 650 bird species, and 220 mammal species. Additionally, 48 mammals, 64 birds, 72 amphibians and reptiles, and 20 freshwater fish live in California and nowhere else (CDFW 2015).

California exhibits a wide range of aquatic habitats from the Pacific Ocean to isolated hillside seeps, to desert oases that support both water-dependent species and provide essential seasonal habitat for terrestrial species. Perennial and ephemeral rivers and streams, riparian areas, vernal pools, and coastal wetlands support a diverse array of flora and fauna, including 150 animal and 52 plant species that are designated specialstatus species. The California Natural Diversity Database identifies 123 different aquatic habitat-types in California, based on fauna. Of these, 78 are stream habitat-types located in seven major drainage systems: Klamath, Sacramento-San Joaquin, North/Central Coast, Lahontan, Death Valley, South Coast, and Colorado River systems. These drainage systems are geologically separated and contain distinctive fishes and invertebrates. California has approximately 70 native resident and anadromous fish species, and 72 percent of the native freshwater fishes in California are either listed, or possible candidates for listing as threatened or endangered, or are extinct (CDFW 2015).

B. Regulatory Setting

Applicable laws and regulations associated with biological resources are discussed in Table 5.

Table 5: Applicable Laws and Regulations for Biological Resources

Applicable Law	Description
Federal	
Federal Endangered Species Act (ESA)	Designates and provides for protection of threatened and endangered plant and animal species, and their critical habitat. Two sections of the ESA address take of threatened and endangered species. Section 7 covers actions that would result in take of a federally-listed species and have a federal discretionary action. Section 10 regulates actions that would result in take of threatened or endangered species and a non-federal agency is the lead agency for the action. Section 10 of the ESA requires preparation of a habitat conservation plan (HCP). More than 430 HCPs have been

Table 5: Applicable Laws and Regulations for Biological Resources	
Applicable Law	**Description**
	approved nation-wide.
Migratory Bird Treaty Act	Makes it unlawful to take or possess any migratory nongame bird (or any part of such migratory nongame bird) as designated in the Migratory Bird Treaty Act.
Clean Water Act (CWA)	Requires the permitting and monitoring of all discharges to surface water bodies. Section 404 requires a permit from the U.S. Army Corps of Engineers (USACE) for a discharge from dredged or fill materials into Waters of the U.S., including wetlands. Section 401 requires a permit from a regional water quality control board (RWQCB) for the discharge of pollutants. By federal law, every applicant for a federal permit or license for an activity that may result in a discharge into a California water body, including wetlands, must request State certification that the proposed activity would not violate State and federal water quality standards.
Rivers and Harbors Act of 1899	Requires permit or letter of permission from USACE prior to any work being completed within navigable waters.
EPA Section 404 (b)(1) Guidelines	Requires USACE to analyze alternatives in a sequential approach such that USACE must first consider avoidance and minimization of impacts to the extent practicable to determine whether a proposed discharge can be authorized.
California Desert Conservation Area Plan (CDCA)	Comprises one of two national conservation areas established by Congress in 1976. FLPMA outlines how BLM would manage public lands. Congress specifically provided guidance for the management of the CDCA and directed the development of the 1980 CDCA Plan.
Federal Noxious Weed Act of 1974 (P.L. 93-629) (7 U.S.C. 2801 et seq.; 88 Stat. 2148)	Establishes a federal program to control the spread of noxious weeds. Authority is given to the Secretary of Agriculture to designate plants as noxious weeds by regulation, and the movement of all such weeds in interstate or foreign commerce was prohibited except under permit.
Executive Order 13112, “Invasive Species,” February 3, 1999	Federal agencies are mandated to take actions to prevent the introduction of invasive species, provide for their control, and minimize the economic, ecological, and human health impacts that invasive species cause.
Executive Order 11988, “Floodplain Management,” May 24, 1977	Requires federal agencies to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative.
Executive Order 11990, “Protection of Wetlands,”	Requires all federal agencies to consider wetland protection as an important part of their policies and take action to

Table 5: Applicable Laws and Regulations for Biological Resources	
Applicable Law	**Description**
May 24, 1977	minimize the destruction, loss, or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands.
Executive Order 13186, "Responsibilities of Federal Agencies to Protect Migratory Birds," January 10, 2001	Requires that each federal agency taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations develop and implement a Memorandum of Understanding (MOU) with the U.S. Fish and Wildlife Service (USFWS) that shall promote the conservation of migratory bird populations.
Bald and Golden Eagle Protection Act	Declares it is illegal to take, possess, sell, purchase, barter, offer to sell or purchase or barter, transport, export or import a bald or golden eagle, alive or dead, or any part, nest or egg of these eagles unless authorized. Active nest sites are also protected from disturbance during the breeding season.
BLM Manual 6840 — Special Status Species Management	Establishes special status species policy on BLM land for plant and animal species and the habitats on which they depend. The policy refers to species designated by the BLM State Director as sensitive.
Listed Species Recovery Plans and Ecosystem Management Strategies	Provides guidance for the conservation and management of sufficient habitat to maintain viable populations of listed species and ecosystems. Relevant examples include, but are not limited to, the Desert Tortoise Recovery Plan, Flat-tailed Horned Lizard Rangewide Management Strategy; Amargosa Vole Recovery Plan; and Recovery Plan for Upland Species of the San Joaquin Valley.
State	
California Endangered Species Act of 1984 (Fish and Game Code, sections 2050 through 2098)	Protects California's rare, threatened, and endangered species.
Natural Community Conservation Planning (NCCP) Act 1991	The primary objective of the NCCP program is to conserve natural communities at the ecosystem level while accommodating compatible land use. An NCCP identifies and provides for the regional or areawide protection of plants, animals, and their habitats, while allowing compatible and appropriate economic activity. There are currently 23 NCCPs that have been adopted or are in progress in California (CDFW 2014b).
Porter-Cologne Water Quality Control Act	Requires that each of the nine RWQCBs prepare and periodically update basin plans for water quality control. Each basin plan sets forth water quality standards for surface water

Table 5: Applicable Laws and Regulations for Biological Resources	
Applicable Law	**Description**
	and groundwater and actions to control nonpoint and point sources of pollution to achieve and maintain these standards.
Wetlands Preservation (Keene-Nejedly California Wetlands Preservation Act) (PRC, Section 5810 et seq.)	California has established a successful program of regional, cooperative efforts to protect, acquire, restore, preserve, and manage wetlands. These programs include, but are not limited to, the Central Valley Habitat Joint Venture, the San Francisco Bay Joint Venture, the Southern California Wetlands Recovery Project, and the Inter-Mountain West Joint Venture.
California Wilderness Preservation System (PRC, Section 5093.30 et seq.)	Establishes a California wilderness preservation system that consists of State-owned areas to be administered for the use and enjoyment of the people in such manner as will leave them unimpaired for future use and enjoyment as wilderness, provide for the protection of such areas, preserve their wilderness character, and provide for the gathering and dissemination of information regarding their use and enjoyment as wilderness.
Significant Natural Areas (Fish and Game Code section 1930 et seq.)	Designates certain areas such as refuges, natural sloughs, riparian areas, and vernal pools as significant wildlife habitat.
Protection of Birds and Nests (Fish and Game Code section 3503 and 3503.5)	Protects California's birds by making it unlawful to take, possess, or needlessly destroy the nest or eggs of any bird. Raptors (e.g., hawks and owls) are specifically protected.
Migratory Birds (Fish and Game Code section 3513)	Protects California's migratory birds by making it unlawful to take or possess any migratory nongame bird as designated in the Migratory Bird Treaty Act or any part of such migratory nongame birds.
Fur-bearing Mammals (Fish and Game Code sections 4000 and 4002)	Lists fur-bearing mammals which require a permit for take.
Fully Protected Species (Fish and Game Code Sections 3511,4700, 5050, and 5515)	Identifies several amphibian, reptile, fish, bird, and mammal species that are Fully Protected. The California Department of Fish and Wildlife (CDFW) cannot issue a take permit for these species, except for take related to scientific research.
California Environmental Quality Act (CEQA Guidelines 15380)	CEQA defines rare species more broadly than the definitions for species listed under the state and federal Endangered Species Acts. Under section 15830, species not protected through state or federal listing but nonetheless demonstrable as "endangered" or "rare" under CEQA should also receive consideration in environmental analyses. Included in this category are many plants considered rare by the California

Table 5: Applicable Laws and Regulations for Biological Resources	
Applicable Law	**Description**
	Native Plant Society (CNPS) and some animals on the CDFW's Special Animals List.
Oak Woodlands (California PRC Section 21083.4)	Requires counties to determine if a project within their jurisdiction may result in conversion of oak woodlands that would have a significant adverse effect on the environment. If the lead agency determines that a project would result in a significant adverse effect on oak woodlands, mitigation measures to reduce the significant adverse effect of converting oak woodlands to other land uses are required.
Lake and Streambed Alteration Agreement (Fish and Game Code sections 1600 et seq.)	Regulates activities that may divert, obstruct, or change the natural flow or the bed, channel, or bank of any river, stream, or lake in California designated by CDFW in which there is at any time an existing fish or wildlife resource or from which these resources derive benefit. Impacts to vegetation and wildlife resulting from disturbances to waterways are also reviewed and regulated during the permitting process.
California Desert Native Plants Act of 1981 (Food and Agricultural Code section 80001 et seq. and California Fish and Game Code sections 1925-1926)	Protects non-listed California desert native plants from unlawful harvesting on both public and private lands in Imperial, Inyo, Kern, Los Angeles, Mono, Riverside, San Bernardino, and San Diego counties. Unless issued a valid permit, wood receipt, tag, and seal by the commissioner or sheriff, harvesting, transporting, selling, or possessing specific desert plants is prohibited.
Food and Agriculture Code, Section 403	The California Department of Food and Agriculture is designated to prevent the introduction and spread of injurious insect or animal pests, plant diseases, and noxious weeds.
Noxious Weeds (Title 3, California Code of Regulations, Section 4500)	List of plant species that are considered noxious weeds.
Local	
Various City and County General Plans	General plans typically designate areas for land uses, guiding where new growth and development should occur while providing a plan for the comprehensive and long-range management, preservation, and conservation of and natural resources and open-space lands.
Various Local Ordinances	Local ordinances provide regulations for proposed projects for activities such as grading plans, erosion control, tree removal, protection of sensitive biological resources and open space.

5. CULTURAL RESOURCES

A. Existing Conditions

3. United States

Cultural resources include archaeological sites of prehistoric or historic origin, built or architectural resources older than 50 years, traditional or ethnographic resources, and fossil deposits of paleontological importance. America has a cultural heritage that dates back to some 25,000-60,000 years ago, when the first known inhabitants of the land that would eventually become the U.S. crossed the Bering land bridge into Alaska.

All areas within the U.S. have the potential for yielding as yet undiscovered archaeological and paleontological resources and undocumented human remains not interred in cemeteries or marked formal burials. These resources have the potential to contribute to our knowledge of the fossil record or local, regional, or national prehistory or history.

Archaeological resources include both prehistoric and historic remains of human activity. Built environment resources include an array of historic buildings, structures, and objects serving as a physical connection to America's past. Traditional or ethnographic cultural resources may include Native American sacred sites and traditional resources of any ethnic community that are important for maintaining the cultural traditions of any group. "Historical resources" is a term with defined statutory meaning and includes any prehistoric or historic archaeological site, district, built environment resource, or traditional cultural resource recognized as historically or culturally significant (PRC Section 21084.1; CEQA Guidelines Section 15064.5(a)). Paleontological resources, including mineralized, partially mineralized, or unmineralized bones and teeth, soft tissues, shells, wood, leaf impressions, footprints, burrows, and microscopic remains, are more than 5,000 years old and occur mainly in Pleistocene or older sedimentary rock units.

2. California

a) Prehistoric Overview

California was occupied by different prehistoric cultures dating to at least 12,000 to 13,000 years ago. Evidence for the presence of humans during the Paleoindian Period prior to about 8,000 years ago is relatively sparse and scattered throughout the State; most surface finds of fluted Clovis or Folsom projectile points or archaeological sites left by these highly mobile hunter-gatherers are associated with Pleistocene lakeshores, the Channel Islands, or the central and southern California coast (Rondeau et al 2007).

Archaeological evidence from two of the Northern Channel Islands located off the coast from Santa Barbara indicates the islands were colonized by Paleoindian peoples at least 12,000 years ago, likely via seaworthy boats (Erlandson et al 2007). By 10,000 years ago, inhabitants of this coastal area were using fishhooks, weaving cordage and basketry, hunting marine mammals and sea birds, and producing ornamental shell beads for exchange with people living in the interior of the State (Erlandson et al 2007). This is the best record of early maritime activity in the Americas, and combined with the fluted points, indicates California was colonized by both land and sea during the Paleoindian period (Jones and Klar 2007).

With climate changes between 10,000 and 7,000 years ago at the end of the Pleistocene and into the early Holocene, Lower Archaic peoples adjusted to the drying of pluvial lakes, rise in sea level, and substantial alterations in vegetation communities. Approximately 6,000 years ago, vegetation communities similar to those of the present were established in the majority of the state, while the changes in sea level also affected the availability of estuarine resources (Jones and Klar 2007). The archaeological record indicates subsistence patterns during the Lower Archaic and subsequent Middle Archaic Period shifted to an increased emphasis on plant resources, as evidenced by an abundance of milling implements in archaeological sites dating between 8,000 and 3,000 years ago.

Approximately 3,000 years ago, during the Upper Archaic and Late Prehistoric Periods, the complexity of the prehistoric archaeological record reflects increases in specialized adaptations to locally available resources such as acorns and salmon, in permanently occupied settlements, and in the expansion of regional populations and trade networks (Moratto 1984; Jones and Klar 2007). During the Upper Archaic, marine shell beads and obsidian continue to be the hallmark of long-distance trade and exchange networks developed during the preceding period (Hughes and Milliken 2007). Large shell midden/mounds at coastal and inland sites in central and southern California, for example, attest to the regular reuse of these locales over hundreds of years or more from the Upper Archaic into the Late Prehistoric period. In the San Francisco Bay region alone, over 500 shell mounds were documented in the early 1900s (Moratto 1984).

Changes in the technology used to pursue and process resources are some of the hallmarks of the Late Prehistoric period. These include an increase in the prevalence of mortars and pestles, a diversification in types of watercraft and fishhooks, and the earliest record for the bow and arrow in the State that occurs in both the Mojave Desert and northeast California nearly 2,000 years ago (Jones and Klar 2007). The period also witnessed the beginning of ceramic manufacture in the southeast desert region, southwest Great Basin, and parts of the Central Valley.

During the Late Prehistoric period, the development of social stratification and craft specialization accompanied the increase in sedentism, as indicated by the variety of artifacts, including bone tools, coiled and twined basketry, obsidian tools, marine shell beads, personal ornaments, pipes, and rattles, by the use of clamshell disk beads and strings of dentalium shell as a form of currency, and by variation in burial types and associated grave goods (Moratto 1984; Jones and Klar 2007). Pictographs, painted designs that are likely less than 1,000 years old, and other non-portable rock art created during this period likely had a religious or ceremonial function (Gilreath 2007).

Osteological evidence points to intergroup conflict and warfare in some regions during this period (Jones and Klar 2007), and there also appears to have been a decline or disruption in the long-distance trade of obsidian and shell beads approximately 1,200 years ago in parts of the State (Hughes and Milliken 2007).

b) Ethnographic Overview

At the time of European contact, California was the home of approximately 310,000 indigenous peoples with a complex of cultures distinguished by linguistic affiliation and territorial boundaries (Kroeber 1925, Cook 1978, Heizer 1978, Ortiz 1983, d'Azevedo 1986). At least 70 distinct native Californian cultural groups, with even more subgroups, inhabited the vast lands within the State. The groups and subgroups spoke between 74 and 90 languages, plus a large number of dialects (Shipley 1978: p. 80, University of California at Berkeley 2009-2010).

In general, these mainly sedentary, complex hunter-gatherer groups of indigenous Californians shared similar subsistence practices (hunting, fishing, and collecting plant foods), settlement patterns, technology, material culture, social organization, and religious beliefs (Kroeber 1925, Heizer 1978, Ortiz 1983, d'Azevedo 1986). Permanent villages were situated along the coast, interior waterways, and near lakes and wetlands. Population density among these groups varied, depending mainly on availability and dependability of local resources, with the highest density of people in the northwest coast and Santa Barbara Channel areas and the least in the State's desert region (Cook 1976). Networks of foot trails were used to connect groups to hunting or plant gathering areas, rock quarries, springs or other water sources, villages, ceremonial places, or distant trade networks (Heizer 1978).

The social organization of California's native peoples varied throughout the State, with villages or political units generally organized under a headman who was also the head of a lineage or extended family or achieved the position through wealth (Bean 1978). For some groups, the headman also functioned as the religious ceremonial leader.

Influenced by their Northwest Coast neighbors, the differential wealth and power of individuals was the basis of social stratification and prestige between elites and commoners for the Chilula, Hupa, Karok, Tolowa, Wiyot, and Yurok in the northwest corner of the State. Socially complex groups were also located along the southern California coast where differential wealth resulted in hierarchical classes and hereditary village chiefs among the Chumash, Gabrielino, Juaneño, and Luiseño (Bean and Smith 1978, Arnold and Graesch 2004).

At the time of Spanish contact, religious practices among native Californian groups varied, but ethnographers have recognized several major religious systems (Bean and Vane 1978). Many of the groups in the north-central part of the State practiced the *Kuksu* cult, primarily a ceremonial and dance organization, with a powerful shaman as the leader. Log drums, flutes, rattles, and whistles accompanied the elaborate ceremonial dances. The World Renewal cult in the northwestern corner of the State extended as far north as Alaska, entailed a variety of annual rites to prevent natural disasters, maintain natural resources and individual health, and were funded by the wealthy class. The *Toloache* cult was widespread in central and southern California and involved the use of narcotic plant (commonly known as datura or jimsonweed) materials to facilitate the acquisition of power. On the southern coast among Takic-speaking groups, the basis of Gabrielino, Juaneño, and Luiseño religious life was the *Chinigchinich* cult, which appeared to have developed from the Toloache cult.

Chinigchinich, the last of a series of heroic mythological figures, gave instruction on laws and institutions, taught people how to dance, and later withdrew into heaven where he rewarded the faithful and punished those who disobeyed his laws. The Chinigchinich religion seems to have been relatively new when the Spanish arrived, and could have been influenced by Christianity.

Trade and exchange networks were a significant part of the economy and social organization among California's Native American groups (Heizer 1978). Obsidian, steatite, beads, acorns, baskets, animal skins, and dried fish were among the variety of traded commodities. Inland groups supplied obsidian from sources along the Sierra Nevada Mountains, in Napa Valley, and in the northeast corner of the State. Coastal groups supplied marine shell beads, ornaments, and marine mammal skins. In addition to trading specific items, clamshell disk beads made from two clam species available on the Pacific coast were widely used as a form of currency (Kroeber 1922). In northwestern California, groups used strings of dentalium shell as currency.

The effect of Spanish settlement and missionization in California marks the beginning of a devastating disruption of native culture and life ways, with forced population movements, loss of land and territory (including traditional hunting and gathering locales), enslavement, and decline in population numbers from disease, malnutrition, starvation, and violence during the historic period (Castillo 1978). In the 1830s, foreign disease epidemics swept through the densely populated Central Valley, adjacent foothills, and North Coast Ranges decimating indigenous population numbers (Cook 1978). By 1850, with their lands, resources and way of life being overrun by the steady influx of non-native people during the Gold Rush, California's native population was reduced to about 100,000; by 1900, there were only 20,000 or less than seven percent of the pre-contact number. Existing reservations were created in California by the federal government beginning in 1858 but encompass only a fraction of native lands.

In 2004, the Native American population in California was estimated at over 383,000 (OPR 2005). Although acknowledged as non-federally recognized California Native American tribes on the contact list maintained by the Native American Heritage Commission (NAHC), many groups continue to await federal tribal status recognition. As of 2005, there were 109 federally recognized tribes within the state, along with dozens of non-federally recognized tribes. Members of these tribes have specific cultural beliefs and traditions with unique connections to areas of California that are their ancestral homelands.

c) Historic Overview

Post-contact history for the State is generally divided into the Spanish period (1769–1822), Mexican period (1822–1848), and American period (1848–present). The establishment of Fort Ross by Alaska-based Russian traders also influenced post-contact history for a short period (1809–1841) in the region north of San Francisco Bay. Although there were brief visits along the Pacific coast by European explorers (Spanish, Russian, and British) between 1529 and 1769 of the territory claimed by Spain, the expeditions did not journey inland.

i) Spanish Period (1769–1822)

Spain's colonization of California began in 1769 with the overland expeditions from San Diego to San Francisco Bay by Lt. Colonel Gaspar de Portolá, and the establishment of a mission and settlement at San Diego. Between 1769 and 1823, the Spanish and the Franciscan Order established a series of 21 missions paralleling the coast along El Camino Real between San Diego and Sonoma (Rolle 1969). Between 1769 and 1782, Spain built four presidios (San Diego, Monterey, San Francisco, and Santa Barbara) to protect the missions, and by 1871 had established two additional pueblos at Los Angeles and San José.

Under Spanish law, large tracts of land, including cattle ranches and farms, fell under the jurisdiction of the missions. Native Americans were removed from their traditional lands, converted to Christianity, concentrated at the missions, and used as labor on the mission farms and ranches (Castillo 1978). Since the mission friars had civil as well as religious authority over their converts, they held title to lands in trust for indigenous groups. The lands were to be repatriated once the native peoples learned Spanish laws and culture.

ii) Russian Period (1809–1841)

In 1809, Alaska-based Russians started exploring the northern California coast with the goal of hunting otter and seal and feeding their Alaskan colonies. The first Russian settlement was established in 1811–1812 by the Russian–American Fur Company to protect the lucrative marine fur trade and to grow produce for their Alaskan colonies. In 1841, as a result of the decline in local sea otter population and the failure of their agricultural colony, combined with a change in international politics, the Russians withdrew from California (Schuyler 1978).

iii) Mexican Period (1822–1848)

Following independence from Spain in 1822, the economy during the Mexican period depended on the extensive rancho system, carved from the former Franciscan missions and at least 500 land grants awarded in the State's interior to Mexican citizens (Beck and Haase 1974; Staniford 1975). Captain John Sutter, who became a Mexican citizen, received the two largest land grants in the Sacramento Valley. In 1839, Sutter founded the trading and agricultural empire named New Helvetia that was headquartered at Sutter's Fort, near the confluence of the Sacramento and American Rivers in today's City of Sacramento (Hoover et al 2002).

Following adoption of the Secularization Act of 1833, the Mexican government privatized most Franciscan lands, including holdings of their California missions. Although secularization schemes had called for redistribution of lands to Native American neophytes who were responsible for construction of the mission empire, the vast mission lands and livestock holdings were instead redistributed by the Mexican government through several hundred land grants to private, non-indigenous ranchers (Castillo 1978, Hoover et al 2002). Most Native American converts returned to traditional lands that had not yet been colonized or found work with the large cattle ranchos being carved out of the mission lands.

iv) American Period (1848–present)

In 1848, shortly after California became a territory of the U.S. with the signing of the Treaty of Guadalupe Hidalgo ending Mexican rule, gold was discovered on the American River at Sutter's Mill in Coloma. The resulting Gold Rush era influenced the history of the State, the nation, and the world. Thousands of people flocked to the gold fields in the Mother Lode region that stretches along the western foothills of the Sierra Nevada Mountains, and to the areas where gold was also discovered in other parts of the State, such as the Klamath and Trinity River basins (Caltrans 2008). In 1850, California became the 31st state, largely as a result of the Gold Rush.

a) Paleontological Setting

California's fossil record is exceptionally prolific with abundant specimens representing a diverse range of marine, lacustrine, and terrestrial organisms recovered from Precambrian rocks as old as 1 billion years to as recent as 6,000 year-old Holocene deposits (refer to geologic timescale in Table 6). These fossils provide key data for charting the course of the evolution or extinction of a variety of life on the planet, both locally and internationally. Paleontological specimens also provide key evidence for interpreting paleoenvironmental conditions, sequences and timing of sedimentary deposition, and other critical components of the earth's geologic history. Fossils are considered our most significant link to the biological prehistory of the earth (Jefferson 2004).

Table 6: Divisions of Geologic Time

Era	Period	Time in Millions of Years Ago (approximately)	Epoch
Cenozoic	Quaternary	< 0.01	Holocene
		2.6	Pleistocene
	Tertiary	5.3	Pliocene
		23	Miocene
		34	Oligocene
		56	Eocene
		65	Paleocene
Mesozoic	Cretaceous	145	
	Jurassic	200	

	Triassic	251	
Paleozoic	Permian	299	
	Carboniferous	359	
	Devonian	416	
	Silurian	444	
	Ordovician	488	
	Cambrian	542	
Precambrian		2,500	
Source: USGS Geologic Names Committee 2010			

Because the majority of the State was underwater until the Tertiary period, marine fossils older than 65 million years are not common and are exposed mainly in the mountains along the border with Nevada and the Klamath Mountains, and Jurassic shales, sandstones, and limestones are exposed along the edges of the Central Valley, portions of the Coast, Transverse, and Peninsular Ranges, and the Mojave and Colorado Deserts. Some of the oldest fossils in the State, extinct marine vertebrates called conodonts, have been identified at Anza-Borrego Desert SP in Ordovician sediments dating to circa 450 million years ago. Limestone outcrops of Pennsylvanian and Permian in the Providence Mountains SRA contain a variety of marine life, including brachiopods, fusulinids, crinoids, that lived some 300 to 250 million years ago.

Fossils from the Jurassic sedimentary layers in San Joaquin, San Luis Obispo, and Stanislaus counties include ammonites, bivalves, echinoderms and marine reptiles, all of which were common in the coastal waters. Gymnosperms (seed-bearing plants) such as cycads, conifers, and ginkgoes are preserved in terrestrial sediments from this period, evidence that the Jurassic climate was warm and moderately wet. In the great Central Valley, marine rocks record the position of the Cretaceous shoreline as the eroded ancestral Sierra Nevada sediments were deposited east of the rising Coast Ranges and became the rock layers of the Sacramento and San Joaquin valleys. These Cretaceous sedimentary deposits have yielded abundant fossilized remains of plants, bivalves, ammonites, and marine reptiles (Paleontology Portal 2003).

Along coastal southern California where steep coastal mountains plunged into the warm Pacific Ocean an abundance of fossil marine invertebrates, such as ammonites, nautilus, tropical snails and sea stars, have been found in today's coastal and near-coastal deposits from the Cretaceous Period. A rare armored dinosaur fossil dated to about 75 million years ago during the Cretaceous was discovered in San Diego County during a highway project. It is the most complete dinosaur skeleton ever found in California (San Diego Natural History Museum 2010). The lack of fossil remains of the majority of earth's large vertebrates, particularly terrestrial, marine, and flying reptiles (dinosaurs, ichthyosaurs, mosasaurs, pleisosaurs, and pterosaurs), as well as many species of terrestrial plants, after the end of the Cretaceous and the start of the Tertiary periods 65 million years ago (the K-T boundary) attests to their abrupt extinction.

B. Regulatory Setting

Applicable laws and regulations associated with cultural resources are discussed in Table 7.

Table 7: Applicable Laws and Regulations for Cultural Resources	
Applicable Regulation	**Description**
Federal	
NHPA of 1966	The NHPA requires federal agencies to consider the preservation of historic and prehistoric resources. The Act authorizes the Secretary of the Interior to expand and maintain a National Register of Historic Places (NRHP), and it establishes an Advisory Council on Historic Preservation (ACHP) as an independent federal entity. Section 106 of the Act requires federal agencies to take into account the effects of their undertakings on historic properties and afford the ACHP a reasonable opportunity to comment on the undertaking prior to licensing or approving the expenditure of funds on any undertaking that may affect properties listed, or eligible for listing, in the NRHP.
National Environmental Policy Act (NEPA) of 1969	NEPA requires federal agencies to foster environmental quality and preservation. Section 101(b)(4) declares that one objective of the national environmental policy is to “preserve important historic, cultural, and natural aspects of our national heritage.” For major federal actions significantly affecting environmental quality, federal agencies must prepare, and make available for public comment, an environmental impact statement.
Archaeological Resources Protection Act of 1979 (NRPA)(16 USC 470aa-470II)	NRPA requires a permit for any excavation or removal of archaeological resources from public lands or Indian lands. The statute provides both civil and criminal penalties for violation of permit requirements and for excavation or removal of protected resources without a permit.
Native American Graves Protection and Repatriation Act of 1990 (NAGPRA) (PL 101–601)	NAGPRA vests ownership or control of certain human remains and cultural items excavated or discovered on federal or tribal lands, in designated Native American tribes, organizations, or groups. The Act further requires notification of the appropriate Secretary or other head of any federal agency upon the discovery of Native American cultural items on federal or tribal lands; proscribes trafficking in Native American human remains and cultural items; requires federal agencies and museums to compile an inventory of Native American human remains and associated funerary objects, and to notify affected Indian tribes of this inventory; and provides for the repatriation of Native American human remains and specified objects possessed or controlled by federal agencies or museums.

Table 7: Applicable Laws and Regulations for Cultural Resources	
Advisory Council Regulation, Protection of Historic Properties (SHPO) (36 CFR 800)	Establishes procedures for compliance with Section 106 of the NHPA. These regulations define the Criteria of Adverse Effect, define the role of State Historic Preservation Officer (SHPO) in the Section 106 review process, set forth documentation requirements, and describe procedures to be followed if significant historic properties are discovered during implementation of an undertaking. Prehistoric and historic resources deemed significant (i.e., eligible for listing in the NRHP, per 36 CFR 60.4) must be considered in project planning and construction. The responsible federal agency must submit any proposed undertaking that may affect NRHP-eligible properties to the SHPO for review and comment prior to project approval.
National Park Service Regulations, National Register of Historic Places (NRHP) (36 CFR 60)	Sets forth procedures for nominating properties to the NRHP, and present the criteria to be applied in evaluating the eligibility of historic and prehistoric resources for listing in the NRHP.
Archaeology and Historic Preservation; Secretary of the Interior's Standards and Guidelines (FR 190:44716–44742)	Non-regulatory technical advice about the identification, evaluation, documentation, study, and other treatment of cultural resources. Notable in these Guidelines are the "Standards for Archaeological Documentation" (p. 44734) and "Professional Qualifications Standards for Archaeology" (pp. 44740–44741).
American Indian Religious Freedom Act of 1978	The American Indian Religious Freedom Act pledges to protect and preserve the traditional religious rights of American Indians, Aleuts, Eskimos, and Native Hawaiians. Before the act was passed, certain federal laws interfered with the traditional religious practices of many American Indians. The Act establishes a national policy that traditional Native American practices and beliefs, sites (and right of access to those sites), and the use of sacred objects shall be protected and preserved.
Department of Transportation Act of 1966, Section 4(f)	Section 4(f) of the Act requires a comprehensive evaluation of all environmental impacts resulting from federal-aid transportation projects administered by the FHA, FTA, and FAA that involve the use—or interference with use—of several types of land: public park lands, recreation areas, and publicly or privately owned historic properties of federal, state, or local significance. The Section 4(f) evaluation must be sufficiently detailed to permit the U.S. Secretary of Transportation to determine that there is no feasible and prudent alternative to the use of such land, in which case the project must include all possible planning to minimize harm to any park, recreation, wildlife and waterfowl refuge, or historic site that would result

Table 7: Applicable Laws and Regulations for Cultural Resources	
	from the use of such lands. If there is a feasible and prudent alternative, a proposed project using Section 4(f) lands cannot be approved by the Secretary. Detailed inventories of the locations and likely impacts on resources that fall into the Section 4(f) category are required in project-level environmental assessments.
State	
California Health and Safety Code Section and California PRC, Section	Disturbance of human remains without the authority of law is a felony (California Health and Safety Code, Section 7052). According to State law (California Health and Safety Code, Section 7050.5, California PRC, Section 5097.98), if human remains are discovered or recognized in any location other than a dedicated cemetery, there shall be no further excavation or disturbance of the site or any nearby area reasonably suspected to overlie adjacent human remains until 1) the coroner of the county has been informed and has determined that no investigation of the cause of death is required; 2) and if the remains are of Native American origin, and if the descendants from the deceased Native Americans have made a recommendation to the landowner or the person responsible for the excavation work for means of treating or disposing of with appropriate dignity the human remains and any associated grave goods as provided in PRC Section 5097.98; or the Native American Heritage Commission was unable to identify a descendent or the descendent failed to make a recommendation within 24 hours after being notified by the Commission. According to the California Health and Safety Code, six or more human burials at one location constitute a cemetery (Section 8100), and disturbance of Native American cemeteries is a felony (Section 7052). Section 7050.5 requires that construction or excavation be stopped in the vicinity of discovered human remains until the coroner can determine whether the remains are those of a Native American. If the remains are determined to be Native American, the coroner must contact the Native American Heritage Commission, who has jurisdiction over Native American remains (California Health and Safety Code, 7052.5c; PRC, Section 5097.98).
California Environmental Quality Act (Guidelines Section 15380)	CEQA requires that public agencies financing or approving public or private projects must assess the effects of the project on cultural resources. Furthermore, it requires that, if a project results in significant impacts on important cultural resources, alternative plans or mitigation measures must be considered; only significant cultural resources, however, need to be addressed. Thus, prior to the development of mitigation

Table 7: Applicable Laws and Regulations for Cultural Resources	
	measures, the importance of cultural resources must be determined.
AB 52 (Statutes of 2014)	AB 52 recognizes that tribal sovereignty and the unique relationship of California local governments and public agencies with California Native American tribal governments, while respecting the interests and roles of project proponents. This requires specific consultation processes for project review and approval.
Local	
City/County General Plans	Policies, goals, and implementation measures in county or city general plans may contain measures applicable to cultural and paleontological resources. In addition to the enactment of local and regional preservation ordinances, CEQA requires that resources included in local registers be considered (pursuant to section 5020.1(k) of the PRC). Therefore, local county and municipal policies, procedures, and zoning ordinances must be considered in the context of project-specific undertakings. Cultural resources are generally discussed in either the open space element or the conservation element of the general plan. Many local municipalities include cultural resources preservation elements in their general plans that include some mechanism pertaining to cultural resources in those communities. In general, the sections pertaining to archaeological and historical properties are put in place to afford the cultural resources a measure of local protection. The policies outlined in the individual general plans should be consulted prior to any undertaking or project.
Cooperative Agreements Among Agencies	Cooperative agreements among land managing agencies (BLM, National Park Service, U.S. Forest Services, California State Parks, Bureau of Indian Affairs, Department of Defense, to name a few) the SHPO and ACHP may exist and will need to be complied with on specific projects. In addition, certain agencies have existing Programmatic Agreements requiring permits (California Public Utilities Commission [CPUC], BLM) to complete archaeological investigations and employ the Secretary of Interior's Professional Qualification Standards and Guidelines (36 CFR 61).

6. ENERGY DEMAND

A. Existing Conditions

1. United States

The major energy sources consumed in the U.S. are petroleum (oil), natural gas, coal, nuclear, and renewable energy. The major users are residential and commercial buildings, industry, transportation, and electric power generators. The pattern of fuel use varies widely by sector. For example, oil provides 93 percent of the energy used for transportation, but only about 1 percent of the energy used to generate electric power (U.S. EIA 2013a).

2. California

Excluding Federal offshore areas, California ranks third in the Nation in crude oil production in 2014. California ranks third in the Nation in conventional hydroelectric generation, second in net electricity generation from other renewable energy resources, and first as a producer of electricity from geothermal energy (in 2012). In 2012, California, left with one remaining nuclear power plant after the San Onofre Nuclear Generating Station was permanently shut down in 2012, ranked fourteenth in net electricity generation from nuclear power plants and eighth in nuclear net summer capacity. Average site electricity consumption in California homes is among the lowest in the nation (6.9 megawatt hours per year), according to the Energy Information Administration's (U.S. EIA's) Residential Energy Consumption Survey last conducted in 2009. In 2012, California's per capita energy consumption ranked 49th in the Nation, due in part to its mild climate and energy efficiency programs (U.S. EIA 2013b).

In 2013, California's in-state electricity generation sources consisted of: 44.3 percent natural gas, 18.8 percent renewable sources, 8.8 percent nuclear, 7.8 percent large hydropower, and 7.8 percent from coal. Approximately 63 percent of total electricity generation was from in-state sources, with the remaining electricity coming from out-of-state imports from the Pacific Northwest (12 percent) and the Southwest (21 percent) (CEC 2014a).

In 2012, Californians consumed 274,449 gigawatt hours (GWh) of electricity and 12,897 million therms of natural gas, primarily in the commercial, residential, and industrial sectors. A California Energy Commission (CEC) staff forecast of future energy demand shows that electricity consumption will grow by between 0.79 and 1.56 percent per year between 2014 and 2024; and natural gas consumption is expected to reach up to 12,801 million therms by 2024 for an annual average growth rate of up to 0.02 percent (CEC 2014b).

The CEC is the State's primary energy policy and planning agency. Created by the Legislature in 1974, and located in Sacramento, six basic responsibilities guide the CEC as it sets state energy policy: forecasting future energy needs; promoting energy efficiency and conservation by setting the State's appliance and building efficiency standards; supporting public interest energy research that advances energy science and technology through research, development and demonstration programs; developing renewable energy resources and alternative renewable energy technologies for buildings, industry and transportation; licensing thermal power plants 50 megawatts or larger; and planning for and directing state response to energy emergencies.

The CPUC also plays a key role in regulating investor-owned electric, natural gas, telecommunications, water, railroad, rail transit, and passenger transportation companies. The CPUC regulates investor-owned electric and natural gas utilities operating in California, including Pacific Gas and Electric Company, Southern California Edison, San Diego Gas and Electric Company, and Southern California Gas Company.

B. Regulatory Setting

Applicable laws and regulations associated with energy resources are discussed in Table 8.

Table 8: Applicable Laws and Regulations for Energy Resources

Regulation	Description
Federal	
Energy Policy and Conservation Act	The Energy Policy and Conservation Act of 1975 sought to ensure that all vehicles sold in the U.S. would meet certain fuel economy goals. Through this Act, Congress established the first fuel economy standards for on-road motor vehicles in the U.S. Pursuant to the Act, the National Highway Traffic and Safety Administration, which is part of the U.S. Department of Transportation (USDOT), is responsible for establishing additional vehicle standards and for revising existing standards. From 1986 to 2012, fuel economy standards for passenger vehicles remained nearly stagnant at between 20.7 mpg for trucks and 27.5 mpg for light duty cars. In 2010, EPA adopted new passenger vehicle standards starting with the 2012 model year that incorporates GHG emissions standards on a vehicle-footprint basis and to accommodate the efficiencies of electric and other alternatively fueled vehicles. Additional standards for models years through 2025 were adopted in 2012. Translating the GHG standards to miles per gallon equivalents, the projected fuel economy standard for new passenger cars and light trucks combined would increase from 30.1 to 54.5 between 2012 and 2025 model years. Until 2010, heavy-duty vehicles (i.e., vehicles and trucks over 8,500 pounds gross vehicle weight) were not subject to fuel economy standards. In 2011, NHTSA and EPA released fuel economy standards for medium and heavy-duty vehicles (over 8,500 pounds gross vehicle weight) for 2014 through 2018

Table 8: Applicable Laws and Regulations for Energy Resources	
Regulation	**Description**
	model years. Fuel economy standards for these vehicles vary by vehicle profession and include explicit mpg goals as well as percent reduction targets. Stricter fuel economy standards for medium and heavy-duty vehicles are expected in 2015. Compliance with federal fuel economy standards is determined on the basis of each manufacturer's average fuel economy for the portion of its vehicles produced for sale in the U.S. The Corporate Average Fuel Economy (CAFE) program, administered by the EPA, was created to determine vehicle manufacturers' compliance with the fuel economy standards. The EPA calculates a CAFE value for each manufacturer based on city and highway fuel economy test results and vehicle sales. Based on the information generated under the CAFE program, the USDOT is authorized to assess penalties for noncompliance.
Energy Policy Act (EPAct) of 1992	EPAct was passed to reduce the country's dependence on foreign petroleum and improve air quality. EPAct includes several parts intended to build an inventory of alternative fuel vehicles (AFVs) in large, centrally fueled fleets in metropolitan areas. EPAct requires certain federal, state, and local government and private fleets to purchase a percentage of light duty AFVs capable of running on alternative fuels each year. In addition, financial incentives are included in EPAct. Federal tax deductions will be allowed for businesses and individuals to cover the incremental cost of AFVs. States are also required by the act to consider a variety of incentive programs to help promote AFVs.
Energy Policy Act of 2005	The Energy Policy Act of 2005 was signed into law on August 8, 2005. Generally, the act provides for renewed and expanded tax credits for electricity generated by qualified energy sources, such as landfill gas; provides bond financing, tax incentives, grants, and loan guarantees for a clean renewable energy and rural community electrification; and establishes a federal purchase requirement for renewable energy.
State	
Warren-Alquist State Energy Resources Conservation and Development Act of 1974	The Warren-Alquist Act is the legislation that created and gives statutory authority to the CEC (formally called the State Energy Resources Conservation and Development Commission).
Integrated Energy	Senate Bill 1389 (Bowen, Chapter 568, Statutes of 2002)

Table 8: Applicable Laws and Regulations for Energy Resources	
Regulation	**Description**
Policy Reports (SB 1389)	requires the CEC to prepare a biennial integrated energy policy report that contains an assessment of major energy trends and issues facing the State's electricity, natural gas, and transportation fuel sectors and provides policy recommendations to conserve resources; protect the environment; ensure reliable, secure, and diverse energy supplies; enhance the State's economy; and protect public health and safety (PRC Section 25301[a]). The CEC prepares these assessments and associated policy recommendations every 2 years, with updates in alternate years, as part of the Integrated Energy Policy Report (IEPR). Preparation of the IEPR involves close collaboration with federal, state, and local agencies and a wide variety of stakeholders in an extensive public process to identify critical energy issues and develop strategies to address those issues (CEC 2012).
California Long-Term Energy Efficiency Strategic Plan	On September 18, 2008, the CPUC adopted California's first Long Term Energy Efficiency Strategic Plan, presenting a single roadmap to achieve maximum energy savings across all major groups and sectors in California. This comprehensive plan for 2009 to 2020 is the State's first integrated framework of goals and strategies for saving energy, covering government, utility, and private sector actions, and holds energy efficiency to its role as the highest priority resource in meeting California's energy needs. The plan was updated in January 2011 to include a lighting chapter.
California Building Energy Efficiency Standards (24 CCR Part 6)	California's Building Energy Efficiency Standards conserve electricity and natural gas in new building construction and are administered by the CEC. Local governments enforce the standards through local building permitting and inspections. The CEC has updated these standards on a periodic basis. The new 2013 Building Energy Efficiency Standards, which take effect on January 1, 2014, are approximately 25 percent more efficient than previous standards for residential construction and 30 percent more efficient for nonresidential construction.
Comprehensive Energy Efficiency Plan for Existing Buildings (AB 758)	Assembly Bill 758 (Skinner, Chapter 470, Statutes 2009) requires the CEC, in collaboration with the CPUC and stakeholders, to develop a comprehensive program to achieve greater energy efficiency in the State's existing buildings.
California Renewable Energy Portfolio Standard (RPS) (SB X1-2)	In 2011, Governor Brown signed SB X1-2, which requires retail sellers of electricity, including investor-owned utilities and community choice aggregators, to provide at least 33 percent of their electricity supply (portfolio) from renewable sources by 2020. The CPUC and the CEC jointly implement the Statewide

Table 8: Applicable Laws and Regulations for Energy Resources	
Regulation	**Description**
	RPS program through rulemakings and monitoring the activities of electric energy utilities in the state.
California Qualifying Facility and Combined Heat and Power Program Settlement	In December 2010, the CPUC approved California's Qualifying Facility and Combined Heat and Power Program Settlement, which established a CHP framework for the State's investor-owned utilities. The settlement established a near-term target of 3,000 megawatts (MW) of CHP for entities under the jurisdiction of the CPUC, although this target includes not just new CHP, but capacity from renewal of contracts due to expire in the next 3 years. The CPUC has also adopted a settlement agreement that includes reforms to the Rule 21 interconnection process to provide a clear, predictable path to interconnection of distributed generation while maintaining the safety and reliability of the grid (CEC 2012).
California Strategy to Reduce Petroleum Dependence (AB 2076)	Assembly Bill 2076 (Chapter 936, Statutes of 2000) requires the CEC and the ARB to develop and submit to the Legislature a strategy to reduce petroleum dependence in California. The statute requires the strategy to include goals for reducing the rate of growth in the demand for petroleum fuels. In addition, the strategy is required to include recommendations to increase transportation energy efficiency as well as the use of non-petroleum fuels and advanced transportation technologies including alternative fuel vehicles, hybrid vehicles, and high-fuel efficiency vehicles. The strategy, *Reducing California's Petroleum Dependence*, was adopted by the CEC and ARB in 2003. The strategy recommends that California reduce inroad gasoline and diesel fuel demand to 15 percent below 2003 demand levels by 2020 and maintain that level for the foreseeable future; the Governor and Legislature work to establish national fuel economy standards that double the fuel efficiency of new cars, light trucks, and sport utility vehicles; and increase the use of nonpetroleum fuels to 20 percent of on-road fuel consumption by 2020 and 30 percent by 2030.
Alternative and Renewable Fuel and Vehicle Technology Program	Assembly Bill 118 (Statues of 2007) created the CEC's Alternative and Renewable Fuel and Vehicle Technology Program. The statute, subsequently amended by Assembly Bill 109 (Statues of 2008), authorizes the CEC to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the State's climate change policies.
Alternative Fuels Plan	Assembly Bill 1007 requires the CEC to prepare a state plan to increase the use of alternative fuels in California. Any environmental document prepared for a strategic growth plan,

Table 8: Applicable Laws and Regulations for Energy Resources	
Regulation	**Description**
	regional blueprint general plan metropolitan planning or transportation plan should include an evaluation of alternative fuels for emissions or criteria pollutants, TACs, GHGs, water pollutants, and other harmful substances, and their impacts on petroleum consumption, and set goals for increased alternative fuel use in the state for the next decades, and recommend policies to ensure the alternative fuel goals are attained, including standards on transportation fuels and vehicle and policy mechanisms to ensure vehicles operating on alternative fuels use those fuels to the maximum extent feasible.
Bioenergy Action Plan (Executive Order S-06-06)	Executive Order #S-06-06 establishes targets for the use and production of biofuels and biopower and directs state agencies to work together to advance biomass programs in California while providing environmental protection and mitigation. This executive order establishes the following target to increase the production and use of bioenergy, including ethanol and biodiesel fuels made from renewable resources: produce a minimum of 20 percent of its biofuels within California by 2010, 40 percent by 2020, and 75 percent by 2050. The Executive Order also calls for the state to meet a target for use of biomass electricity.
Governor's Low Carbon Fuel Standard (Executive Order S-01-07)	Executive Order #S-01-07 establishes a statewide goal to reduce the carbon intensity of California's transportation fuels by at least 10 percent by 2020 through establishment of the LCFS. The executive order requires LCFS to be incorporated into the State Alternative Fuels Plan required by AB 1007 and is one of the proposed discrete early action GHG reduction measures identified by CARB pursuant to AB 32. In January, 2010, the Office of Administrative Law approved the LCFS regulation.
Senate Bill 350, Statues of 2015 Clean Energy and Pollution Reduction Act of 2015	The Clean Energy and Pollution Reduction Act of 2015 requires the amount of electricity generated and sold to retail customers per year from eligible renewable energy resources be increased to 50 percent by December 31, 2030. This act also requires doubling of the energy efficiency savings in electricity and natural gas for retail customers, through energy efficiency and conservation, by December 31, 2030.
Local	
City/County General Plans	Many cities and counties have general plan elements and policies that specifically address energy use and conservation. Those energy conservation measures outlined in the various county and city general plans contain goals, objectives, and policies aimed at reducing energy consumption. Proponents of specific projects would be required to consult the applicable general plans and design the projects consistent with the

Table 8: Applicable Laws and Regulations for Energy Resources	
Regulation	**Description**
	guidelines of those general plans in which the projects are located.

7. GEOLOGY AND SOILS

A. Existing Conditions

1. United States

The U.S. has a diverse, complex, and seismically active geology that includes a vast array of landforms. Soils are as diverse as America's geology, and are described and characterized individually and collectively with other soils, and their various compatible uses in soil surveys published by the U.S. Department of Agriculture (USDA). Soils are fundamental and largely non-renewable resources that are the basis for high-level sustained yields of agricultural commodities, forest products, and provide support to the wide variety of ecological communities throughout the state.

The geology of the U.S. is very complex and can be divided into roughly five physiographic provinces: the American cordillera, the Canadian shield, the stable platform, the coastal plain, and the Appalachian orogenic belt. In Alaska, the geology is typical of the cordillera, whereas in Hawaii the major islands consist of Neogene volcanic erupted over a hotspot.

2. California

The state's topography is highly varied and includes 1,340 miles of seacoast, as well as high mountains, inland flat valleys, and deserts. Elevations in California range from 282 feet below sea level in Death Valley to 14,494 feet at the peak of Mount Whitney. The mean elevation of California is approximately 2,900 feet. The climate of California is as highly varied as its topography. Depending on elevation, proximity to the coast, and altitude, climate types include temperate oceanic, highland, sub-arctic, Mediterranean, steppe, and desert (USGS 1995). The average annual precipitation across all California climate types is approximately 23 inches and approximately 75 percent of the state's annual precipitation falls between November and March, primarily in the form of rain, with the exception of high mountain elevations (DWR 2003). Average annual precipitation ranges from more than 100 inches in the mountainous areas within the Smith River in Del Norte County to less than 2 inches in Death Valley, illustrating the extreme differences in precipitation levels within the State (Mount 1995). Overall, northern California is wetter than southern California with the majority of the State's annual precipitation occurring in the northern coastal region.

a) Geology

Plate tectonics and climate have played major roles in forming California's dramatic landscape. California is located on the active western boundary of the North American continental plate in contact with the oceanic Pacific Plate and the Gorda Plate north of the Mendocino Triple Junction. The dynamic interactions between these three plates and California's climate are responsible for the unique topographic characteristics of California, including rugged mountain ranges, long and wide flat valleys, and dramatic coastlines. Tectonics and climate also have a large effect on the occurrence natural environmental hazards, such as earthquakes, landslides, and volcanic formations.

b) Landslides

Landsliding or mass wasting is a common erosional process in California and has played an integral part in shaping the State's landscape. Typically, landslides occur in mountainous regions of the State, but they can also occur in areas of low relief, including coastal bluffs, along river and stream banks, and inland desert areas.

Landsliding is the gravity-driven downhill mass movement of soil, rock, or both and can vary considerably in size, style and rate of movement, and type depending on the climate of a region, the steepness of slopes, rock type and soil depth, and moisture regime (Harden 1997).

c) Earthquakes

Earthquakes are a common and unpredictable occurrence in California. The tectonic development of California began millions of years ago by a shift in plate tectonics that converted the passive margin of the North American plate into an active margin of compressional and translational tectonic regimes. This shift in plate tectonics continues to make California one of the most geomorphically diverse, active, and picturesque locations in the U.S. While some areas of California are more prone to earthquakes, such as northern, central, and southern coastal areas of California, all areas of California are prone to the effects of ground shaking due to earthquakes. While scientists have made substantial progress in mapping earthquake faults where earthquakes are likely to occur, and predicting the potential magnitude of an earthquake in any particular region, they have been unable to precisely predict where or when an earthquake will occur and what its magnitude will be.

d) Tsunamis

Coastal communities around the circum Pacific have long been prone to the destructive effects of tsunamis. Tsunamis are a series of long-period, high-magnitude ocean waves that are created when an outside force displaces large volumes of water. Throughout time, major subduction zone earthquakes in both the Northern and Southern Hemispheres have moved the Earth's crust at the ocean bottom sending vast amounts of waters into motion and spreading tsunami waves throughout the Pacific Ocean.

Tsunamis can also occur from subareal and submarine landslides that displace large volumes of water. Subaeral landslide-generated tsunamis can be caused by seismically generated landslides, rock falls, rock avalanches, and eruption or collapse of island or coastal volcanoes. Submarine landslide-generated tsunamis are typically caused by major earthquakes or coastal volcanic activity. In contrast to a seismically generated tsunami, seismic seiches are standing waves that are caused by seismic waves traveling through a closed (lake) or semi-enclosed (bay) body of water. Due to the long-period seismic waves that originate after an earthquake, seiches can be observed several thousand miles away from the origin of the earthquakes. Small bodies of water, including lakes and ponds, are especially vulnerable to seismic seiches.

e) Volcanoes

A volcano is an opening in the Earth's crust through which magma escapes to the surface where it is extruded as lava. Volcanism may be spectacular, involving great fountains of molten rock, or tremendous explosions that are caused by the build-up of gases within the volcano (Ritchie and Gates 2001). Some of the most active volcanic areas in California are located within the Cascade Range - a volcanic chain that is a result of compressional tectonics along the Cascadia subduction zone.

f) Active Faults

A fault is defined as a fracture or zone of closely associated fractures along rocks that on one side have been displaced with respect to those on the other side. Most faults are the result of repeated displacement that may have taken place suddenly or by slow creep. A fault is distinguished from fractures or shears caused by landsliding or other gravity-induced surficial failures. A fault zone is a zone of related faults that commonly are braided and subparallel, but may be branching and divergent. A fault zone has significant width (with respect to the scale of the fault being considered, portrayed, or investigated), ranging from a few feet to several miles (Bryant and Hart 2007).

In the State of California earthquake faults have been designated as being active through a process that has been described by the 1972 Alquist-Priolo Earthquake Fault Zoning Act. An active fault is defined by the State as one that has "had surface displacement within Holocene time (about the last 11,000 years)." This definition does not, of course, mean that faults lacking evidence for surface displacement within Holocene time are necessarily inactive. A fault may be presumed to be inactive based on satisfactory geologic evidence; however, the evidence necessary to prove inactivity sometimes is difficult to obtain and locally may not exist.

A. B. Regulatory Setting

Applicable laws and regulations associated with geology and soils are discussed in Table 9.

Table 9: Applicable Laws and Regulations for Geology and Soils	
Regulation	**Description**
Federal	
Safe Drinking Water Act - Federal Underground Injection Control Class VI Program for Carbon Dioxide Geology Sequestration Wells	Under the Safe Drinking Water Act (SDWA), the Federal Underground Injection Control (UIC) Class VI Program for Carbon Dioxide Geologic Sequestration Wells requires states and owners or operators to submit all permit applications to the appropriate EPA Region for a Class VI permit to be issued. These requirements, also known as the Class VI rule, are designed to protect underground sources of drinking water. The Class VI rule builds on existing UIC Program requirements, with extensive tailored requirements that address carbon dioxide injection for long-term storage to ensure that wells used for geologic sequestration are appropriately sited, constructed, tested, monitored, funded, and closed. The rule also affords owners or operators injection depth flexibility to address injection in various geologic settings in the U.S. in which geologic sequestration may occur, including very deep formations and oil and gas fields that are transitioned for use as carbon dioxide storage sites.
Safe Drinking Water Act - Federal Underground Injection Control Class II Program for Oil and Gas Related Injection Wells	The Class II Program for Oil and Gas Related Injection Wells requires states to meet EPA's minimum requirements for UIC programs including strict construction and conversion standards and regular testing and inspection. Enhanced oil and gas recovery wells may either be issued permits or be authorized by rule. Disposal wells are issued permits.
CWA	This law was enacted to restore and maintain the chemical, physical, and biological integrity of the nation's waters by regulating point and nonpoint pollution sources, providing assistance to publicly owned treatment works for the improvement of wastewater treatment, and maintaining the integrity of wetlands. This includes the creation of a system that requires states to establish discharge standards specific to water bodies (National Pollution Discharge Elimination System [NPDES]), which regulates storm water discharge from construction sites through the implementation of a Storm Water Pollution Prevention Plan (SWPPP). In California, the State's NPDES permit program is implemented and administered by the local Regional Water Quality Control Boards.
Earthquake Hazards Reduction Act and National Earthquake	This Act established the National Earthquake Hazards Reduction Program to reduce the risks to life and property from future earthquakes. This program was significantly amended in November 1990 by the National Earthquake Hazards Reduction

Table 9: Applicable Laws and Regulations for Geology and Soils	
Regulation	**Description**
Hazards Reduction Program Act	Program Act by refining the description of agency responsibilities, program goals and objectives.
State	
Seismic Hazards Mapping Act, PRC Section 2690–2699.	The Seismic Hazards Mapping Act (the Act) of 1990 (PRC, Chapter 7.8, Division 2) directs the California DOC, Division of Mines and Geology (now called California Geological Survey [CGS]) to delineate Seismic Hazard Zones. The purpose of the Act is to reduce the threat to public health and safety and to minimize the loss of life and property by identifying and mitigating seismic hazards. These include areas identified that are subject to the effects of strong ground shaking, such as liquefaction, landslides, tsunamis, and seiches. Cities, counties, and state agencies are directed to use seismic hazard zone maps developed by CGS in their land-use planning and permitting processes. The Act requires that site-specific geotechnical investigations be performed prior to permitting most urban development projects within seismic hazard zones.
Alquist-Priolo Earthquake Fault Zoning Act	California's Alquist-Priolo Act (PRC 2621 et seq.), originally enacted in 1972 as the Alquist-Priolo Special Studies Zones Act and renamed in 1994, is intended to reduce the risk to life and property from surface fault rupture during earthquakes. The Alquist-Priolo Act prohibits the location of most types of structures intended for human occupancy across the traces of active faults and strictly regulates construction in the corridors along active faults (Earthquake Fault Zones). It also defines criteria for identifying active faults, giving legal weight to terms such as "active," and establishes a process for reviewing building proposals in and adjacent to Earthquake Fault Zones. Under the Alquist-Priolo Act, faults are zoned, and construction along or across them is strictly regulated if they are "sufficiently active" and "well-defined." A fault is considered sufficiently active if one or more of its segments or strands shows evidence of surface displacement during Holocene time (defined for the purposes of the act as within the last 11,000 years). A fault is considered well-defined if its trace can be clearly identified by a trained geologist at the ground surface or in the shallow subsurface, using standard professional techniques, criteria, and judgment.
California Division of Oil, Gas, and Geothermal Resources	PRC Section 3106 mandates the supervision of drilling, operation, maintenance, and abandonment of oil wells for the purpose of preventing: damage to life, health, property, and natural resources; damage to underground and surface waters suitable for irrigation or domestic use; loss of oil, gas, or

Table 9: Applicable Laws and Regulations for Geology and Soils	
Regulation	**Description**
(DOGGR), PRC Section 3106.	reservoir energy; and damage to oil and gas deposits by infiltrating water and other causes. In addition, the DOGGR regulates drilling, production, injection, and gas storage operations in accordance with 14 CCR Chapter 4, Subchapter 1.
Landslide Hazard Identification Program, PRC Section 2687(a)	The Landslide Hazard Identification Program requires the State Geologist to prepare maps of landslide hazards within urbanizing areas. According to PRC Section 2687(a), public agencies are encouraged to use these maps for land use planning and for decisions regarding building, grading, and development permits.
California Building Standards Code (CBSC) (24 CCR)	California's minimum standards for structural design and construction are given in the CBSC (24 CCR). The CBSC is based on the Uniform Building Code (International Code Council 1997), which is used widely throughout U.S. (generally adopted on a state-by-state or district-by-district basis) and has been modified for California conditions with numerous, more detailed or more stringent regulations. The CBSC provides standards for various aspects of construction, including (i.e., not limited to) excavation, grading, and earthwork construction; fills and embankments; expansive soils; foundation investigations; and liquefaction potential and soil strength loss. In accordance with California law, proponents of specific projects would be required to comply with all provisions of the CBSC for certain aspects of design and construction.
Local	
Geotechnical Investigation	Local jurisdictions typically regulate construction activities through a process that may require the preparation of a site-specific geotechnical investigation. The purpose of a site-specific geotechnical investigation is to provide a geologic basis for the development of appropriate construction design. Geotechnical investigations typically assess bedrock and Quaternary geology, geologic structure, soils, and the previous history of excavation and fill placement. Proponents of specific projects that require design of earthworks and foundations for proposed structures will need to prepare geotechnical investigations on the physical properties of soil and rock at the site prior to project design.
Local Grading and Erosion Control Ordinances	Many counties and cities have grading and erosion control ordinances. These ordinances are intended to control erosion and sedimentation caused by construction activities. A grading permit is typically required for construction-related projects. As part of the permit, project applicants usually must submit a

Table 9: Applicable Laws and Regulations for Geology and Soils	
Regulation	**Description**
	grading and erosion control plan, vicinity and site maps, and other supplemental information. Standard conditions in the grading permit include a description of Best Management Practices similar to those contained in a SWPPP.
City/County General Plans	Most city and county general plans include an element that covers geology and soil resources within that jurisdiction.

8. GREENHOUSE GASES

A. Existing Conditions

1. United States and California

a) Existing Climate

Climate is the accumulation of daily and seasonal weather events over a long period of time, whereas weather is defined as the condition of the atmosphere at any particular time and place (Ahrens 2003). Like its topography, California's climate is varied and tends toward extremes. Generally there are two seasons in California: 1) a long, dry summer, with low humidity and cool evenings and 2) a mild, rainy winter, except in the high mountains, where four seasons prevail and snow lasts from November to April.

The one climatic constant for the state is summer drought.

California has four main climatic regions. Mild summers and winters prevail in central coastal areas, where temperatures are more equable than virtually anywhere else in the U.S. For example, differences between average summer and winter temperatures between San Francisco and Monterey for example are seldom more than 10°F (6°C). During the summer there are heavy fogs in San Francisco and all along the coast. Mountainous regions are characterized by milder summers and colder winters, with markedly low temperatures at high elevations. The Central Valley has hot summers and cool winters, while the Imperial Valley and eastern deserts are marked by very hot, dry summers, with temperatures frequently exceeding 100°F (38°C).

Average annual temperatures for the state range from 47°F (8°C) in the Sierra Nevada to 73°F (23°C) in the Imperial Valley. The highest temperature ever recorded in the U.S. was 134°F (57°C), registered in Death Valley on 10 July 1913. Death Valley has the hottest average summer temperature in the Western Hemisphere, at 98°F (37°C). The state's lowest temperature was -45°F (-43°C), recorded on 20 January 1937 at Boca, near the Nevada border.

Among the major population centers, Los Angeles has an average annual temperature of 63°F (17°C), with an average January minimum of 48°F (9°C) and an average July maximum of 75°F (24°C). San Francisco has an annual average of 57°F (14°C), with a January average minimum of 42°F (6°C) and a July average maximum of 72°F (22°C). The annual average in San Diego is 64°F (18°C), the January average minimum 49°F (9°C), and the July average maximum 76°F (24°C). Sacramento's annual average temperature is 61°F (16°C), with January minimums averaging 38°F (3°C) and July maximums of 93°F (34°C).

Annual precipitation varies from only 2 in (5 cm) in the Imperial Valley to 68 in (173 cm) at Blue Canyon, near Lake Tahoe. San Francisco had an average annual precipitation (1971–2000) of 20 in (51 cm), Sacramento 17.9 in (45.5 cm), Los Angeles 13.2 in (33.5 cm), and San Diego 10.8 in (27.4 cm). The largest one-month snowfall ever recorded in the U.S., 390 in (991 cm), fell in Alpine County in January 1911. Snow averages between 300 and 400 in (760 to 1,020 cm) annually in the high elevations of the Sierra Nevada, but is rare in the Central Valley and coastal lowlands.

Sacramento has the greatest percentage (73 percent) of possible annual sunshine among the State's largest cities; Los Angeles has 72 percent and San Francisco 71 percent. San Francisco is the windiest, with an average annual wind speed of 11 mph (18 km/hr). Tropical rainstorms occur often in California during the winter.

b) Attributing Climate Change—The Physical Scientific Basis

Climate change is a long-term shift in the climate of a specific location, region or planet. The shift is measured by changes in features associated with average weather, such as temperature, wind patterns, and precipitation. According to the Intergovernmental Panel on Climate Change (IPCC), a scientific body established by the World Meteorological Organization (WMO) and by the United Nations Environment Programme (UNEP), available scientific evidence supports the conclusion that most of the increased average global temperatures since the mid-20th century is very likely due to human-induced increases in greenhouse gas (GHG) concentrations. GHGs, which are emitted from both natural and anthropogenic sources, include water vapor, carbon dioxide, methane, nitrous oxide, halocarbons, and ozone. These gases play a role in the "greenhouse effect" that helps regulate the temperature of the earth.

The current post-industrial warming trend differs alarmingly from past changes in the Earth's climate because GHG emissions are higher and warming is occurring faster than at any other time on record within the past 650,000 years. Historical long-term as well as decadal and inter-annual fluctuations in the Earth's climate resulted from natural processes such as plate tectonics, the Earth's rotational orbit in space, solar radiation variability, and volcanism. The current trend derives from an added factor: human activities, which have greatly intensified the natural greenhouse effect, causing global warming. GHG emissions from human activities that contribute to climate change include the burning of fossil fuels (such as coal, oil and natural gas), cutting down trees (deforestation) and developing land (land-use changes). The burning of fossil fuels emits GHGs into the atmosphere, while deforestation and land-use changes remove trees and other kinds of vegetation that store ("sequester") carbon dioxide. Emissions of GHGs due to human activities have increased globally since pre-industrial times, with an increase of 70 percent between 1970 and 2004 (IPCC 2007).

A growing recognition of the wide-ranging impacts of climate change has fueled efforts over the past several years to reduce GHG emissions. In 1997, the Kyoto Protocol set legally binding emissions targets for industrialized countries, and created innovative mechanisms to assist these countries in meeting these targets. The Kyoto Protocol took effect in 2004, after 55 parties to the Convention had ratified it (The UN Climate Change Convention and the Kyoto Protocol). Six major GHGs have been the focus of efforts to reduce emissions and are included in AB 32: carbon dioxide (CO_2), methane, nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF_6). They are regulated under the Kyoto Protocol. Nitrogen trifluoride (NF_3) was later added to the list of important GHGs to reduce and codified in California statute.

The "global warming potential" (GWP) metric is used to convert all GHGs into "CO_2-equivalent" (CO_2e) units for a specific time frame. GWPs from the IPCC fourth assessment report over a 100-year warming horizon are used as the national and international standard in GHG inventory development; however, GWPs over a 20-year time horizon are also available and can be more applicable for consideration of short-lived climate pollutants. Each gas's GWP is defined relative to CO_2 for the given time frame. For example, N_2O's 100-yr GWP is 298, meaning a unit mass of N_2O warms the atmosphere 298 times more than a unit mass of CO_2. SF_6 and PFCs have extremely long atmospheric lifetimes, resulting in their essentially irreversible accumulation in the atmosphere once emitted. However, in terms of quantity of emissions, CO_2 dominates world and U.S. GHG emissions.

Because the major GHGs have longer lives, they build up in the atmosphere so that past, present and future emissions ultimately contribute to total atmospheric concentrations. Thus, while reducing emissions of conventional air pollutants decreases their concentrations in the atmosphere in a relatively short time, atmospheric concentrations of the major GHGs can only be gradually reduced over years and decades. More specifically, the rate of emission of CO_2 currently greatly exceeds its rate of removal, and the slow and incomplete removal implies that small to moderate reductions in its emissions would not result in stabilization of CO_2 concentrations, but rather would only reduce the rate of its growth in coming decades. Many of the same activities that emit conventional air pollutants also emit GHGs (e.g., the burning of fossil fuels to produce electricity, heat or drive engines and the burning of biomass). Some conventional air pollutants also have greenhouse effects; for example, soot/black carbon and tropospheric ozone (see Short-Lived Climate Pollutants below).

c) Attributing Climate Change—Greenhouse Gas Emission Sources

Emissions of GHGs contributing to global climate change are attributable in large part to human activities associated with the transportation, electricity, industrial/manufacturing, utility, residential, commercial and agricultural sectors. In California, the transportation sector is the largest emitter of GHGs, followed by electricity generation. Anthropogenic emissions of CO_2 are byproducts of fossil fuel combustion. Methane, a potent GHG, is primarily emitted by livestock and landfills with a smaller contribution from fugitive emissions from oil and gas operations and natural gas transmission and distribution.

N_2O is also largely attributable to agricultural practices, primarily from nitrogen-based fertilizer and manure application to soils.

CO_2 equivalent (CO_2e) is a measurement that uses global warming potentials (GWP) to account for the fact that different GHGs have different potential to retain infrared radiation in the atmosphere and contribute to the greenhouse effect. The GWP is dependent on the lifetime, or persistence, of the gas molecule in the atmosphere and the specific infrared absorption pattern and strength. For example, the IPCC fourth assessment report 100-yr GWP for methane used in the US EPA and California GHG inventory defines 1 ton of methane as equivalent to 25 tons of CO_2 (IPCC 2013).

Therefore, methane is a much more potent GHG than CO_2. Expressing emissions in CO_2e takes the contributions of all GHG emissions to the greenhouse effect and converts them to a single unit equivalent to the effect that would occur if only CO_2 were being emitted.

The California GHG inventory compiles statewide anthropogenic GHG emissions and sinks. It includes estimates for CO_2, methane, N_2O, SF_6, NF_3, HFCs, and PFCs. The current inventory covers years 2000 to 2013 (available at http://www.arb.ca.gov/cc/inventory/data/data.htm).

In 2013, total GHG emissions decreased by 1.5 million metric tons of CO^2 equivalents MMTCO^{2}e) from 2012, representing an overall decrease of 7 percent since peak levels in 2004. During the 2000 to 2013 period, per capita GHG emissions in California have continued to drop from a peak in 2001 of 14.0 tonnes per person to 12.0 tonnes per person in 2013; a 14 percent decrease. Overall trends in the inventory also demonstrate that the carbon intensity of California's economy (the amount of carbon pollution per million dollars of GDP) is declining; representing a 23 percent decline since the 2001 peak (ARB 2015).

d) Short-Lived Climate Pollutants

Climate policy and research have mainly concentrated on long-term climate change and controlling the long-lived GHGs. However, there is growing recognition within the scientific community that efforts to address climate change should also focus on actions to reduce climate-warming substances with much shorter atmospheric lifetimes. These non-CO_2 pollutants, known as "short-lived climate pollutants" (SLCP), include methane, short lived fluorinated-gases (primarily HFCs), black carbon, and tropospheric ozone.

e) Adaptation to Climate Change

According to the IPCC, which was established in 1988 by the World Meteorological Organization and the United Nations Environment Programme, global average temperature is expected to increase by 3–7°F by the end of the century, depending on future GHG emission scenarios (IPCC 2007). Resource areas other than air quality and global average temperature could be indirectly affected by the accumulation of GHG emissions. For example, an increase in the global average temperature is expected to result in a decreased volume of precipitation falling as snow in California and an overall reduction in snowpack in the Sierra Nevada. Snowpack in the Sierra Nevada provides both water supply (runoff) and storage (within the snowpack before melting), which is a major source of supply for the state.

According to the CEC (2012), statewide average temperatures increased by about degrees Fahrenheit from 1895 to 2011. Throughout the past century precipitation (i.e., rain and snow) has followed the expected pattern of a largely Mediterranean climate with wet winters and dry summers, and considerable variability from year to year. No consistent trend in the overall amount of precipitation has been detected, except that a larger proportion of total precipitation is falling as rain instead of snow. In addition, during the last 35 years, the Sierra Nevada range has witnessed both the wettest and the driest years on record of more than 100 years. While intermittent droughts have been a common feature of the State's climate, evidence from tree rings and other indicators reveal that over the past 1,500 years, California has experienced dry spells that persisted for several years or even decades (CEC 2012).

The effects of global climate change could lead to a variety of secondary effects to public health, water supply, energy supply, sea level, wildfire risks, and ecosystems. Recent data, climate projections, topographic, demographic, and land use information have led to the findings that:

12. The state's electricity system is more vulnerable than was previously understood.
13. The Sacramento-San Joaquin Delta is sinking, putting levees at growing risk.
14. Wind and waves, in addition to faster rising seas, will worsen coastal flooding.
15. Animals and plants need connected "migration corridors" to allow them to move to more suitable habitats to avoid serious impacts.
16. Native freshwater fish are particularly threatened by climate change.
17. Minority and low-income communities face the greatest risks from climate change.

There are effective ways to prepare for and manage climate change risks, but local governments face many barriers to adapting to climate change; these can be addressed so that California can continue to prosper.

At the same time, the State has recognized the need to adapt to climate change impacts that can no longer be avoided. In 2014, the CA Natural Resources Agency released the Safeguarding California Plan, which serves as an update to the 2009 California Climate Adaptation Strategy. The many adaptation planning efforts underway in virtually every State agency, in regional and local communities such as Chula Vista, San Diego, Los Angeles, Santa Barbara, Santa Cruz, San Francisco, Hayward, Marin County, Sacramento, and others, as well as in private businesses suggest that CEOs, elected officials, planners, and resource managers understand the reality that California and the world is facing.

In fact, the latest climate science makes clear that State, national and global efforts to mitigate climate change must be accelerated to limit global warming to levels that do not endanger basic life-support systems and human well-being. Success in mitigation will keep climate change within the bounds that allow ecosystems and society to adapt without major disruptions. Further advances in integrated climate change science can inform California's and the world's climate choices and help ensure a resilient future (CEC 2012).

B. Regulatory Setting

Applicable laws and regulations specific to the reduction of GHG emissions are listed in Table 10 below. It should be noted that other laws and regulations described under Energy Demand in this Environmental Setting would also reduce GHG emissions.

Table 10: Applicable Laws and Regulations for Greenhouse Gases

Regulation	Description
Federal	
Mandatory Greenhouse Gas Reporting Rule	On September 22, 2009, EPA issued a final rule for mandatory reporting of GHGs from large GHG emissions sources in the U.S. In general, this national reporting requirement will provide EPA with accurate and timely GHG emissions data from facilities that emit 25,000 metric tons or more of CO_2 per year. This publically available data will allow the reporters to track their own emissions, compare them to similar facilities, and aid in identifying cost effective opportunities to reduce emissions in the future. Reporting is at the facility level, except that certain suppliers of fossil fuels and industrial greenhouse gases along with vehicle and engine manufacturers will report at the corporate level. An estimated 85 percent of the total U.S. GHG emissions, from approximately 10,000 facilities, are covered by this final rule.
National Program to Cut Greenhouse Gas Emissions and Improve Fuel Economy for Cars	On September 15, 2009, EPA and the Department of Transportation's National Highway Traffic Safety Administration (NHTSA) proposed a new national program that would reduce GHG emissions and improve fuel efficiency for all new cars and trucks sold in the EPA proposed the first-ever national GHG

Table 10: Applicable Laws and Regulations for Greenhouse Gases	
Regulation	**Description**
and Trucks	emissions standards under the CAA, and NHTSA proposed CAFE standards under the Energy Policy and Conservation Act. This proposed national program would allow automobile manufacturers to build a single light-duty national fleet that satisfies all requirements under both Federal programs and the standards of California and other states. The President requested that EPA and NHTSA, on behalf of the Department of Transportation, develop, through notice and comment rulemaking, a coordinated National Program under the CAA and the Energy Policy and Conservation Act (EPCA), as amended by the Energy Independence and Security Act (EISA), to reduce fuel consumption by and GHG emissions of light-duty vehicles for model years 2017-2025. EPA and NHTSA are developing the proposal based on extensive technical analyses, an examination of the factors required under the respective statutes and on discussions with individual motor vehicle manufacturers and other stakeholders. The National Program would apply to passenger cars, light-duty trucks, and medium-duty passenger vehicles (light-duty vehicles) built in those model years (76 FR 48758). The first part of this program (i.e., 2012-2016) is implemented. The next part (i.e., 2017-2025) is currently in process for which ARB is proposed to accept compliance thereof as also being acceptable for California compliance, similar to what was done for the first part.
Endangerment and Cause or Contribute Findings	On December 7, 2009, EPA adopted its Proposed Endangerment and Cause or Contribute Findings for Greenhouse Gases under the CAA (Endangerment Finding). The Endangerment Finding is based on Section 202(a) of the CAA, which states that the Administrator (of EPA) should regulate and develop standards for "emission[s] of air pollution from any class of classes of new motor vehicles or new motor vehicle engines, which in [its] judgment cause, or contribute to, air pollution which may reasonably be anticipated to endanger public health or welfare." The rule addresses Section 202(a) in two distinct findings. The first addresses whether or not the concentrations of the six key GHGs (i.e., carbon dioxide [CO_2], methane, nitrous oxide [N_2O], hydrofluorocarbons [HFCs], perfluorocarbons [PFCs], and sulfur hexafluoride [SF_6]) in the atmosphere threaten the public health and welfare of current and future generations. The second addresses whether or not the combined emissions of GHGs from new motor vehicles and

Table 10: Applicable Laws and Regulations for Greenhouse Gases	
Regulation	**Description**
	motor vehicle engines contribute to atmospheric concentrations of GHGs and therefore the threat of climate change. The Administrator found that atmospheric concentrations of GHGs endanger the public health and welfare within the meaning of Section 202(a) of the CAA. The evidence supporting this finding consists of human activity resulting in "high atmospheric levels" of GHG emissions, which are very likely responsible for increases in average temperatures and other climatic changes. Furthermore, the observed and projected results of climate change (e.g., higher likelihood of heat waves, wild fires, droughts, sea level rise, and higher intensity storms) are a threat to the public health and welfare. Therefore, GHGs were found to endanger the public health and welfare of current and future generations. The Administrator also found that GHG emissions from new motor vehicles and motor vehicle engines are contributing to air pollution, which is endangering public health and welfare. EPA's final findings respond to the 2007 U.S. Supreme Court decision that GHGs fit within the CAA definition of air pollutants. The findings do not in and of themselves impose any emission reduction requirements but rather allow EPA to finalize the GHG standards proposed earlier in 2009 for new light-duty vehicles as part of the joint rulemaking with the Department of Transportation.
Significant New Alternatives Policy	USEPA's Significant New Alternatives Policy (SNAP) program provide an evolving list of alternatives (i.e., chemicals that may replace one that is currently in use for a specific purpose). USEPA makes decisions informed by the overall understanding of the environmental and human health impacts as well as the current knowledge regarding available substitutes. Where USEPA is determining whether to add a new substitute to the list, USEPA compares the risk posed by the new substitute to the risks posed by other alternatives on the list and determines whether that specific new substitutes poses more risk than already-listed alternatives for the same use. Section 612 of the Clean Air Act provides that USEPA must prohibit the use of a substitute where it has determined that there are other available substitutes that pose less overall risk to human health and the environment.
State	
Executive Order B- 30-15	Executive Order B-30-15 established a California GHG reduction target of 40 percent below 1990 levels by 2030. To

Table 10: Applicable Laws and Regulations for Greenhouse Gases	
Regulation	**Description**
	accomplish this goal, directs state agencies to take measures consistent with their existing authority to reduce greenhouse gas emissions. In addition, the California Air Resources Board will initiate a public process in the summer of 2015 and work closely with other state agencies to update the State's climate change Scoping Plan. The updated Scoping Plan will provide a framework for achieving the 2030 target and will be completed and adopted by the Air Resources Board in 2016. Concurrent planning efforts related to energy efficiency in existing buildings (AB 758), short-lived climate pollutants, sustainable freight, Greenhouse Gas Reduction Fund Investments, forest health, and others will be coordinated with, and feed into, the updated Scoping Plan.
Executive Order S- 3-05	Executive Order S-3-05, which was signed by former Governor Schwarzenegger in 2005, proclaims that California is vulnerable to the impacts of climate change. It declares that increased temperatures could reduce the Sierra's snowpack, further exacerbate California's air quality problems, and potentially cause a rise in sea levels. To combat those concerns, the Executive Order established total greenhouse gas emission targets. Specifically, emissions are to be reduced to the 2000 level by 2010, the 1990 level by 2020, and to 80 percent below the 1990 level by 2050. The Executive Order directed the Secretary of the California Environmental Protection Agency (CalEPA) to coordinate a multi-agency effort to reduce greenhouse gas emissions to the target levels. The Secretary will also submit biannual reports to the governor and state legislature describing: progress made toward reaching the emission targets; impacts of global warming on California's resources; and mitigation and adaptation plans to combat these impacts. To comply with the Executive Order, the Secretary of the Cal/EPA created the Climate Action Team (CAT) made up of members from various state agencies and commission. CAT released its first report in March 2006. The report proposed to achieve the targets by building on voluntary actions of California businesses, local government and community actions, as well as through state incentive and regulatory programs.
Senate Bill 605, Short-Lived Climate	Senate Bill 605 directs ARB to complete a comprehensive strategy to reduce emissions of short-lived climate pollutants in the state through the following actions:

Table 10: Applicable Laws and Regulations for Greenhouse Gases	
Regulation	**Description**
Pollutants	(1) Complete an inventory of sources and emissions of short-lived climate pollutants in the state based on available data. (2) Identify research needs to address any data gaps. (3) Identify existing and potential new control measures to reduce emissions. (4) Prioritize the development of new measures for short-lived climate pollutants that offer cobenefits by improving water quality or reducing other air pollutants that impact community health and benefit disadvantaged communities, as identified pursuant to Section 39711. (5) Coordinate with other state agencies and districts to develop measures identified as part of the comprehensive strategy.
Assembly Bill 32, the California Global Warming Solutions Act, Statutes of 2006	In September 2006, former Governor Arnold Schwarzenegger signed AB 32, the California Global Warming Solutions Act of 2006. AB 32 establishes regulatory, reporting, and market mechanisms to achieve quantifiable reductions in GHG emissions and a cap on statewide GHG emissions. AB 32 requires that statewide GHG emissions be reduced to 1990 levels by 2020. This reduction will be accomplished through an enforceable statewide cap on GHG emissions that will be phased in starting in 2012. To effectively implement the cap, AB 32 directs ARB to develop and implement regulations to reduce statewide GHG emissions from substantial stationary and mobile source categories. Requires ARB to produce a Scoping Plan by 1/1/2009 and at least every 5 years afterwards that details how the state will meet its GHG reduction targets. AB 32 requires that ARB adopt a quantified cap on GHG emissions representing 1990 emissions levels and disclose how it arrives at the cap; institute a schedule to meet the emissions cap; and develop tracking, reporting, and enforcement mechanisms to ensure that the state achieves the reductions in GHG emissions necessary to meet the cap. AB 32 also includes guidance to institute emissions reductions in an economically efficient manner and conditions to ensure that businesses and consumers are not unfairly affected by the reductions.
Assembly Bill 1493, Statutes of 2002	In September 2004, ARB approved regulations to reduce GHG emissions from new motor vehicles. The Board took this action pursuant to Chapter 200, Statutes of 2002 (AB 1493, Pavley) which directed the Board to adopt regulations that achieve the maximum feasible and cost effective reduction in greenhouse gas emissions from motor vehicles. The regulations, which took effect

Table 10: Applicable Laws and Regulations for Greenhouse Gases	
Regulation	**Description**
	in 2006 following an opportunity for legislative review, apply to new passenger vehicles and light duty trucks beginning with the 2009 model year.
Executive Order S- 1-07	Executive Order S-1-07, which was signed by former Governor Schwarzenegger in 2007, proclaims that the transportation sector is the main source of GHG emissions in California, at over 40 percent of statewide emissions. It establishes a goal that the carbon intensity of transportation fuels sold in California should be reduced by a minimum of 10 percent by 2020. This order also directed ARB to determine if this LCFS could be adopted as a discrete early action measure after meeting the mandates in AB 32. ARB first adopted the LCFS on April 23, 2009.
Senate Bill 1368, Statutes of 2006	SB 1368 is the companion bill of AB 32 and was signed by former Governor Schwarzenegger in September 2006. SB 1368 requires the CPUC to establish a GHG emission performance standard for baseload generation from investor owned utilities by February 1, 2007. The CEC must establish a similar standard for local publicly owned utilities by June 30, 2007. These standards cannot exceed the GHG emission rate from a baseload combined-cycle natural gas fired plant. The legislation further requires that all electricity provided to California, including imported electricity, must be generated from plants that meet the standards set by the CPUC and CEC.
Senate Bill 1078, Statutes of 2002, Senate Bill 107, Statutes of 2006, and SBx1 2	SB 1078 (Chapter 516, Statutes of 2002) requires retail sellers of electricity, including investor-owned utilities and community choice aggregators, to provide at least 20 percent of their supply from renewable sources by 2017. SB 107 (Chapter 464, Statutes of 2006) changed the target date to 2010. In 2010, SBx1 2 was chaptered, which expanded the State's Renewable Portfolio Standard to 33 percent renewable power by 2020.
Senate Bill 97, Statutes of 2007	As directed by SB 97, the Natural Resources Agency adopted Amendments to the CEQA Guidelines for GHG emissions on December 30, 2009. On February 16, 2010, the Office of Administrative Law approved the Amendments, and filed them with the Secretary of State for inclusion in the California Code of Regulations. The Amendments became effective on March 18, 2010.
Senate Bill 375, Statutes of 2008	SB 375, signed in September 2008, aligns regional transportation planning efforts, regional GHG reduction targets, and land use and housing allocation. SB 375 requires Metropolitan Planning Organizations (MPOs) to adopt a Sustainable Communities

Table 10: Applicable Laws and Regulations for Greenhouse Gases	
Regulation	**Description**
	Strategy (SCS) or Alternative Planning Strategy (APS), which will prescribe land use allocation in that MPO's Regional Transportation Plan (RTP). ARB, in consultation with MPOs, will provide each affected region with reduction targets for GHGs emitted by passenger cars and light trucks in the region for the years 2020 and 2035. These reduction targets will be updated every 8 years, but can be updated every 4 years if advancements in emissions technologies affect the reduction strategies to achieve the targets. ARB is also charged with reviewing each MPO's SCS or APS for consistency with its assigned targets. If MPOs do not meet the GHG reduction targets, transportation projects would not be eligible for funding programmed after January 1, 2012. This bill also extends the minimum time period for the Regional Housing Needs Allocation (RNHA) cycle from 5 years to 8 years for local governments located within an MPO that meets certain requirements. City or county land use policies (including general plans) are not required to be consistent with the RTP (and associated SCS or APS). However, new provisions of CEQA would incent qualified projects that are consistent with an approved SCS or APS, categorized as "transit priority projects."
Senate Bill 350, Statutes of 2015 Clean Energy and Pollution Reduction Act of 2015	The Clean Energy and Pollution Reduction Act of 2015 requires the amount of electricity generated and sold to retail customers per year from eligible renewable energy resources be increased to 50 percent by December 31, 2030. This act also requires doubling of the energy efficiency savings in electricity and natural gas for retail customers, through energy efficiency and conservation, by December 31, 2030.
Executive Order S- 13-08	Sea level rise is a foreseeable indirect environmental impact associated with climate change, largely attributable to thermal expansion of the oceans and melting polar ice. As discussed above in the environmental setting (subheading "Adaptation to Climate Change"), sea level rise presents impacts to California associated with coastal erosion, water supply, water quality, saline-sensitive species and habitat, land use compatibility, and flooding. Former Governor Arnold Schwarzenegger signed Executive Order S-13-08 on November 14, 2008. This executive order directed the California Natural Resources Agency (CNRA) to develop the 2009 California Climate Adaptation Strategy (CNRA 2009)), which summarizes the best known science on climate change impacts in seven distinct sectors—public health, biodiversity and habitat, ocean and

Table 10: Applicable Laws and Regulations for Greenhouse Gases

Regulation	Description
	coastal resources, water management, agriculture, forest resources, and transportation and energy infrastructure—and provides recommendations on how to manage against those threats. This executive order also directed OPR, in cooperation with the CNRA, to provide land use planning guidance related to sea level rise and other climate change impacts by May 30, 2009, which is also provided in the 2009 California Climate Adaptation Strategy (CNRA 2009) and OPR continues to further refine land use planning guidance related to climate change impacts. Executive Order S-13-08 also directed CNRA to convene an independent panel to complete the first California Sea Level Rise Assessment Report. This report is to be completed no later than December 1, 2010. The report is intended to provide information on the following: Relative sea level rise projections specific to California, taking into account issues such as coastal erosion rates, tidal impacts, El Niño and La Niña events, storm surge, and land subsidence rates; The range of uncertainty in selected sea level rise projections; A synthesis of existing information on projected sea level rise impacts to state infrastructure (such as roads, public facilities and beaches), natural areas, and coastal and marine ecosystems; and Discussion of future research needs regarding sea level rise for California.
ARB's Landfill Methane Control Measure	The regulation requires owners and operators of certain uncontrolled municipal solid waste landfills to install gas collection and control systems, and requires existing and newly installed gas and control systems to operate in an optimal manner. The regulation allows local air districts to voluntarily enter into agreements with ARB to implement and enforce the regulation and to assess fees to cover costs. Some local air districts have also adopted rules to implement federal standards for the installation of gas collection and control systems.
AB 341 (Chesbro, Chapter 476,	AB 341 (Chesbro, Chapter 476, Statutes of 2011 established a State target to reduce by 75 percent the amount of solid waste

Table 10: Applicable Laws and Regulations for Greenhouse Gases	
Regulation	**Description**
Statutes of 2011)	sent to landfills by 2020 through recycling, composting, and source reduction practices.
AB 1826 (Chesbro, Chapter 727, Statutes of 2014)	AB 1826 (Chesbro, Chapter 727, Statutes of 2014) requires businesses generating specified amounts of organic wastes to begin arranging for the recycling and diversion of those wastes from landfill disposal beginning in 2016.
Refrigerant Management Plan	The Refrigerant Management Plan requires facilities with refrigeration systems with more than 50 pounds of high-GWP refrigerant to: conduct and report periodic leak inspections; promptly repair leaks; and keep service records on site.
Compliance Offset Protocols under the State's Cap-and- Trade Program	Compliance Offset Protocols under the State's Cap-and-Trade Program include a livestock protocol, rice cultivation protocol, and mine methane capture protocol. The protocols provide methods to quantify, report, and credit GHG emission reductions from sectors not covered by the Cap-and-Trade Program.
Assembly Bill 1257 (Bocanegra, Chapter 749, Statutes of 2013)	AB 1257 directs the CEC to assemble a report by November 2015 (and every four years after), in consultation with other State agencies, to identify strategies for maximizing the benefits obtained from natural gas as an energy source.
Assembly Bill 1900 (Gatto, Chapter 602, Statutes of 2012)	AB 1900 directed the CPUC to adopt natural gas constituent standards (in consultation with ARB and the Office of Environmental Health and Hazard Assessment). The legislation is also designed to streamline and standardize customer pipeline access rules, and encourage the development of statewide policies and programs to promote all sources of biomethane production and distribution.
Low Carbon Fuel Standard	The Low Carbon Fuel Standard (LCFS) requires transportation fuel providers to procure clean fuels to reduce the carbon intensity of California's fuel mix. The LCFS provides a market signal to incentivize using captured methane as a transportation fuel, among other clean fuel options.
Senate Bill 1122 (Rubio, Chapter 612, Statutes 2012)	Senate Bill 1122 directed the California Public Utility Commission (CPUC) to require the State's investor-owned utilities to develop and offer 10 to 20 year market-price contracts to procure an additional 250 megawatts of cumulative electricity generation from biogas facilities that commence operating on or after June of 2013.

9. HAZARDS AND HAZARDOUS MATERIALS

A. Existing Conditions

1. United States

California Health and Safety Code (Section 25501) defines “hazardous materials” as any material that, because of its quantity, concentration, or physical or chemical characteristics, poses a significant present or potential hazard to human health and safety or to the environment if released into the workplace or the environment.

Hazardous materials are grouped into four categories based on their characteristics: toxic (causes human health effects), ignitable (has the ability to burn), corrosive (causes severe burns or damage to materials) and reactive (causes explosions or generates toxic gases). A hazardous waste is any hazardous material that is finished with its intended use and is discarded. This may include items, such as spent fuels, industrial solvents and chemicals, process water, and other spent materials (i.e., some types of batteries and fuel cells). California’s hazardous waste regulations provides the following means to determine whether or not a waste is hazardous: (1) a list of criteria (toxic, ignitable, corrosive and reactive) that a waste may exhibit; (2) a list of those wastes that are subject to regulation; and (3) a list of chemical names and common names that are presumed to be hazardous in California.

2. California

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B. Regulatory Setting

Applicable laws and regulations associated with hazards and hazardous materials are discussed in Table 11.

Table 11: Applicable Laws and Regulations for Hazards and Hazardous Materials	
Regulations	**Description**
Federal	
CWA (40 CFR 112)	The 1972 amendments to the CWA provide the statutory basis for the NPDES permit program and the basic structure for regulating the discharge of pollutants from point sources to waters of the U.S. Section 402 of the CWA specifically required EPA to develop and implement the NPDES program.
Safe Drinking Water Act (SDWA)	SDWA is the main federal law that ensures the quality of Americans' drinking water. Under SDWA, EPA sets standards for drinking water quality and oversees the states, localities, and water suppliers who implement those standards. SDWA was originally passed by Congress in 1974 to protect public health by regulating the nation's public drinking water supply. The law was amended in 1986 and 1996 and requires many actions to protect drinking water and its sources: rivers, lakes, reservoirs, springs, and ground water wells. SDWA does not regulate private wells which serve fewer than 25 individuals.
Federal Hazardous Materials Regulations (FHMR) Title 49, Code of Federal Regulations, Parts 100-180	The regulations establish criteria for the safe transport of hazardous materials. Compliance is mandatory for intrastate and interstate transportation.
Toxic Substances Control Act (TSCA)15 U.S.C. Section 2601 et seq.	TSCA provides EPA with authority to require reporting, record-keeping and testing requirements, and restrictions relating to chemical substances and/or mixtures. TSCA addresses the production, importation, use, and disposal of specific chemicals including polychlorinated biphenyls (PCBs), asbestos, radon and lead-based paint.
Resource Conservation and Recovery Act (RCRA) 42 U.S.C. Section 6901 et seq. (40 CFR)	RCRA of 1976 gives EPA the authority to control hazardous waste from the "cradle-to-grave." This includes the generation, transportation, treatment, storage, and disposal of hazardous waste. RCRA also set forth a framework for the management of non-hazardous solid wastes. The 1986 amendments to RCRA enabled EPA to address environmental problems that could result from underground tanks storing petroleum and other hazardous substances. HSWA - the Federal Hazardous and

Table 11: Applicable Laws and Regulations for Hazards and Hazardous Materials	
Regulations	**Description**
	Solid Waste Amendments - are the 1984 amendments to RCRA that focused on waste minimization and phasing out land disposal of hazardous waste as well as corrective action for releases. Some of the other mandates of this law include increased enforcement authority for EPA, more stringent hazardous waste management standards, and a comprehensive underground storage tank program. Federal regulations adopted by EPA are found in Title 40, Code of Federal Regulations (40 CFR).
Comprehensive Environmental Response, Compensation and Liability Act (CERCLA)	CERCLA, commonly known as Superfund, was enacted by Congress on December 11, 1980. This law created a tax on the chemical and petroleum industries and provided broad Federal authority to respond directly to releases or threatened releases of hazardous substances that may endanger public health or the environment. CERCLA also enabled the revision of the National Contingency Plan (NCP). The NCP provided the guidelines and procedures needed to respond to releases and threatened releases of hazardous substances, pollutants, or contaminants. The NCP also established the NPL. The Superfund Amendments and Reauthorization Act (SARA) of 1986 reauthorized CERCLA to continue cleanup activities around the country. Several site-specific amendments, definitions clarifications, and technical requirements were added to the legislation, including additional enforcement authorities. Also, Title III of SARA authorized the Emergency Planning and Community Right-to-Know Act (EPCRA).
Emergency Planning and Community Right-to-Know Act (EPCRA) (42 USC Section 9601 et seq.)	The SARA of 1986 created EPCRA (40 CFR Parts 350-372), also known as SARA Title III, a statute designed to improve community access to information about chemical hazards and to facilitate the development of chemical emergency response plans by state/tribe and local governments. EPCRA required the establishment of state/tribe emergency response commissions (SERCs/TERCs), responsible for coordinating certain emergency response activities and for appointing local emergency planning committees.
State	
Hazardous Materials Transportation California Vehicle Code Sections 31301-	Regulations pertaining to the safe transport of hazardous materials are in California Vehicle Code Sections 31301-31309. All motor carriers and drivers involved in transportation of hazardous materials must comply with the requirements contained in federal and state regulations, and must apply for and obtain a hazardous materials transportation license from

Table 11: Applicable Laws and Regulations for Hazards and Hazardous Materials	
Regulations	**Description**
31309	the California Highway Patrol. A driver is required to obtain a hazardous materials endorsement issued by the driver's country or state of domicile to operate any commercial vehicle carrying hazardous materials. The driver is required to display placards or markings while hauling hazardous waste, unless the driver is exempt from the endorsement requirements. A driver who is a California resident is required to obtain an endorsement from California Highway Patrol.
Hazardous Waste Control Law California Health & Safety Code, Division 20, Chapter 6.5, 22 CCR, Division 4.5	California requirements and statutory responsibilities in managing hazardous waste in California – this includes the generation, transportation, storage, treatment, recycling, and disposal of hazardous waste. The statute and regulation are implemented by Cal/EPA Department of Toxic Substances Control.
California Accidental Release Prevention (CalARP) Program 19 CCR Division 2, Chapter 4.5, Sections 2735-2785	The purpose of the CalARP program is to prevent accidental releases of substances that can cause serious harm to the public and the environment, to minimize the damage if releases do occur, and to satisfy community right-to-know laws. This is accomplished by requiring businesses that handle more than a threshold quantity of a regulated substance listed in the regulations to develop a Risk Management Plan (RMP). An RMP is a detailed engineering analysis of the potential accident factors present at a business and the mitigation measures that can be implemented to reduce this accident potential.
Hazardous Material Business Plan & Area Plan Program Health and Safety Code Sections 25500 – 25520 19 CCR, Division 2, Chapter 4, Article 3 & 4	The business and area plans program, relating to the handling and release or threatened release of hazardous materials, was established in California to protect the public health and safety and the environment. Basic information on the location, type, quantity, and the health risks of hazardous materials handled, used, stored, or disposed of in the state, which could be accidently released into the environment, is not now available to firefighters, health officials, planners, public safety officers, health care providers, regulatory agencies, and other interested persons. The information provided by business and area plans is necessary in order to prevent or mitigate the damage to the health and safety of persons and the environment from the release or threatened release of hazardous materials into the workplace and environment. Certified Unified Program Agencies (CUPAs) use information collected from the Business Plan and CalARP programs to identify hazardous materials in their communities. This information provides the basis for the

Table 11: Applicable Laws and Regulations for Hazards and Hazardous Materials	
Regulations	**Description**
	Area Plan and is used to determine the appropriate level of emergency planning necessary to respond to a release.
Unified Program Administration Health and Safety Code, Chapter 6.11, Sections 25404-25404.8 27 CCR, Division 1, Subdivision 4, Chapter 1, Sections 15100-15620	A CUPA, which is authorized by the Secretary of Cal/EPA to carry out several of the hazardous waste/hazardous materials regulatory programs administered by the State in a coordinated and consistent manner. The six hazardous waste and materials program elements covered by the CUPA include: 1) Hazardous Waste Generators 2) Underground Tanks 3) Above Ground Tanks 4) Accidental Release Program 5) Hazardous Material Release Response Plans & Spill Notification 6) Hazardous Materials Management Plans & Inventory Reporting The intent of the CUPA is to simplify the hazardous materials regulatory environment and provide a single point of contact for businesses to address inspection, permitting, billing, and enforcement issues.
Fuels and Fuel Additive Program (40 CFR 79)	EPA regulates diesel fuels under two programs; one is administered under the Office of Pollution Prevention and Toxic Substances (OPPTS) and the other is administered under the Transportation and Air Quality group. The OPPTS requires that all chemicals produced in the U.S. are registered with the Toxic Substances Control Act. The Transportation and Air Quality group requires that any fuels sold for ground transportation purposes must be registered with EPA and the volumes reported on a quarterly basis.
Local	
Various Local Ordinances	Various ordinances and codes may be adopted at the local level to provide stricter requirements in the management of hazardous materials and waste activities within the jurisdiction.

10. HYDROLOGY AND WATER QUALITY

A. Existing Conditions

1. Surface Waters

Surface waters occur as streams, lakes, ponds, coastal waters, lagoons, estuaries, floodplains, dry lakes, desert washes, wetlands and other collection sites. Water bodies modified or developed by man, including reservoirs and aqueducts, are also considered surface waters. Surface water resources are very diverse throughout the state, due to the high variance in tectonics, topography, geology/soils, climate, precipitation, and hydrologic conditions. Overall, California has the most diverse range of watershed conditions in the U.S., with varied climatic regimes ranging from Mediterranean climates with temperate rainforests in the north coast region to desert climates containing dry desert washes and dry lakes in the southern central region.

The average annual runoff for the State is 71 million acre-feet (DWR 2003). The state has more than 60 major stream drainages and more than 1,000 smaller, but significant drainages that drain coastal mountains and inland mountainous areas. High snowpack levels and resultant spring snowmelt yield high surface runoff and peak discharge in the Sierra Nevada and Cascade Mountains that feed surface flows, fill reservoirs and recharge groundwater. Federal, state and local engineered water projects, aqueducts, canals, and reservoirs serve as the primary conduits of surface water sources to areas that have limited surface water resources. Most of the surface water storage is transported for agricultural, urban, and rural residential needs to the San Francisco Bay Area and to cities and areas extending to southern coastal California. Surface water is also transported to southern inland areas, including Owens Valley, Imperial Valley, and Central Valley areas.

2. Groundwater

The majority of runoff from snowmelt and rainfall flows down mountain streams into low gradient valleys and either percolates into the ground or is discharged to the sea. This percolating flow is stored in alluvial groundwater basins that cover approximately 40 percent of the geographic extent of the state (DWR 2003). Groundwater recharge occurs more readily in areas underlain by coarse sediments, primarily in mountain base alluvial fan settings. As a result, the majority of California’s groundwater basins are located in broad alluvial valleys flanking mountain ranges, such as the Cascade Range, Coast Ranges, Transverse Ranges, and the Sierra Nevada.

There are 250 major groundwater basins that serve approximately 30 percent of California’s urban, agricultural and industrial water needs, especially in southern portion of San Francisco Bay, the Central Valley, greater Los Angeles area, and inland desert areas where surface water is limited. On average, more than 15 million acre-feet of groundwater are extracted each year in the State, of which more than 50 percent is extracted from 36 groundwater basins in the Central Valley.

3. Water Quality

Land uses have a great effect on surface water and groundwater water quality in the State of California. Water quality degradation of surface waters occurs through nonpoint- and point- source discharges of pollutants. Nonpoint source pollution is defined as not having a discrete or discernible source and is generated from land runoff, precipitation, atmospheric deposition, seepage, and hydrologic modification (EPA 1993). Nonpoint-source pollution includes runoff containing pesticides, insecticides, and herbicides from agricultural areas and residential areas; acid drainage from inactive mines; bacteria and nutrients from septic systems and livestock; VOCs and toxic chemicals from urban runoff and industrial discharges; sediment from timber harvesting, poor road construction, improperly managed construction sites, and agricultural areas; and atmospheric deposition and hydromodification. In comparison, point-source pollution is generated from identifiable, confined, and discrete sources, such as a smokestack, sewer, pipe or culvert, or ditch. These pollutant sources are regulated by the EPA and SWRCB through RWQCB. Many of the pollutants discharged from point- sources are the same as for nonpoint-sources, including municipal (bacteria and nutrients), agricultural (pesticides, herbicides, and insecticides), and industrial pollutants (VOCs and other toxic effluent).

B. Regulatory Setting

Applicable laws and regulations associated with hydrology, water quality, and water supply are discussed in Table 12.

Table 12: Applicable Laws and Regulations for Hydrology, Water Quality, and Water Supply

Regulation	Description
Federal	
National Flood Insurance Program (FEMA)	Designated floodplain mapping program, flooding and flood hazard reduction implementation, and federal subsidized flood insurance for residential and commercial property. Administered by the FEMA.
Executive Order 11988	Requires actions to be taken for federal activities to reduce the risks of flood losses, restore and preserve floodplains, and minimize flooding impacts to human health and safety.
CWA	Administered primarily by the EPA. Pertains to water quality standards, state responsibilities, and discharges of waste to waters of the U.S. Sections 303, 401, 402, and 404.
CWA Section 303	Defines water quality standards consisting of: 1) designated beneficial uses of a water, 2) the water quality criteria (or “objectives” in California) necessary to support the uses, and 3) an antidegradation policy that protects existing uses and high water quality. Section 303(d) requires states to identify water quality impairments where conventional

Table 12: Applicable Laws and Regulations for Hydrology, Water Quality, and Water Supply	
Regulation	**Description**
	control methods will not achieve compliance with the standards, and establish Total Maximum Daily Load (TMDL) programs to achieve compliance.
CWA Section 401	State certification system for federal actions which may impose conditions on a project to ensure compliance with water quality standards.
CWA Section 402	Section 402 mandates permits for municipal stormwater discharges, which are regulated under the NPDES General Permit for Municipal Separate Storm Sewer Systems (MS4) (MS4 Permit). Several of the cities and counties issue their own NPDES municipal stormwater permits for the regulations of stormwater discharges. These permits require that controls are implemented to reduce the discharge of pollutants in stormwater discharges to the maximum extent possible, including management practices, control techniques, system design and engineering methods, and other measures as appropriate. As part of permit compliance, these permit holders have created Stormwater Management Plans for their respective locations. These plans outline the requirements for municipal operations, industrial and commercial businesses, construction sites, and planning and land development. These requirements may include multiple measures to control pollutants in stormwater discharge. During implementation of specific projects, applicants will be required to follow the guidance contained in the Stormwater Management Plans as defined by the permit holder in that location.
CWA Section 404	Permit system for dredging or filling activity in waters of the U.S., including wetlands, and administered by USACE.
National Toxics Rule and California Toxics Rule	Applicable receiving water quality criteria promulgated by EPA for priority toxic pollutants consisting generally of trace metals, synthetic organic compounds, and pesticides.
State	
California Water Rights	The SWRCB administers review, assessment, and approval of appropriative (or priority) surface water rights permits/licenses for diversion and storage for beneficial use. Riparian water rights apply to the land and allow diversion of natural flows for beneficial uses without a permit, but users must share the resources equitably during drought. Groundwater management planning is a function of local government. Groundwater use by overlying property owners is not formally regulated, except in cases where the groundwater basin supplies are limited and uses have been adjudicated, or through appropriative

Table 12: Applicable Laws and Regulations for Hydrology, Water Quality, and Water Supply	
Regulation	**Description**
	procedures for groundwater transfers.
Public Trust Doctrine	Body of common law that requires the state to consider additional terms and conditions when issuing or reconsidering appropriative water rights to balance the use of the water for many beneficial uses irrespective of the water rights that have been established. Public trust resources have traditionally included navigation, commerce, and fishing and have expanded over the years to include protection of fish and wildlife, and preservation goals for scientific study, scenic qualities, and open-space uses.
Porter-Cologne Water Quality Control Act and California Water Code (Title 23)	The SWRCB is responsible for statewide water quality policy development and exercises the powers delegated to the State by the federal government under the CWA. Nine RWQCBs adopt and implement water quality control plans (Basin Plans) which designate beneficial uses of surface waters and groundwater aquifers, and establish numeric and narrative water quality objectives for beneficial use protection. RWQCBs issue waste discharge requirements for discharge activities to water and land, require monitoring and maintain reporting programs, and implement enforcement and compliance policies and procedures. Other state agencies with jurisdiction in water quality regulation in California include the Department of Public Health (drinking water regulations), Department of Pesticide Regulation, Department of Toxic Substances Control, CDFW, and the Office of Environmental Health and Hazard Assessment.
Policy for Implementation of Toxics Standards for Inland Surface Waters, Enclosed Bays, and Estuaries of California	Commonly referred to as the State Implementation Policy (or SIP), the SIP provides implementation procedures for discharges of toxic pollutants to receiving waters.
Thermal Plan	The Water Quality Control Plan for Control of Temperature in the Coastal and Interstate Water and Enclosed Bays and Estuaries of California was adopted by the SWRCB in 1972 and amended in 1975. The Thermal Plan restricts discharges of thermal waste or elevated temperature waste to waters of the state. Generally, the Thermal Plan prohibits discharges from increasing ambient temperatures by more than 1ºF over more than 25 percent of a stream cross section, increasing ambient

Table 12: Applicable Laws and Regulations for Hydrology, Water Quality, and Water Supply	
Regulation	**Description**
	temperatures by more than 4ºF in any location, and prohibits discharge of waste that exceeds more than 20ºF above the ambient temperature.
Statewide NPDES General Permit for Stormwater Associated with Land Disturbance and Construction Activity (Order No. 2009-0009-DWQ, NPDES No. CAR000002)	NPDES permit for stormwater and non-storm discharges from construction activity that disturbs greater than 1 acre. The general construction permit requires the preparation of a SWPPP that identifies BMPs to be implemented to control pollution of storm water runoff. The permit specifies minimum construction BMPs based on a risk-level determination of the potential of the project site to contribute to erosion and sediment transport and sensitivity of receiving waters to sediment. While small amounts of construction-related dewatering are covered under the General Construction Permit, the RWQCB has also adopted a General Order for Dewatering and Other Low Threat Discharges to Surface Waters (General Dewatering Permit). This permit applies to various categories of dewatering activities and may apply to some construction sites, if construction of specific projects required dewatering in greater quantities than that allowed by the General Construction Permit and discharged the effluent to surface waters. The General Dewatering Permit contains waste discharge limitations and prohibitions similar to those in the General Construction Permit.
Statewide NPDES General Permit for Discharges of Stormwater Associated with Industrial Facilities (Order No. 97-003-DWQ, NPDES No. CAS000001)	NPDES permit for stormwater and non-storm discharges from types of industrial sites based on the Standard Industrial Classification. The general industrial permit requires the preparation of a SWPPP that identifies potential onsite pollutants, BMPs to be implemented, and inspection/monitoring.
Senate Bill 1168	This bill requires all groundwater basins designated as high- or medium-priority basins by DWR that are designated as basins subject to critical conditions of overdraft to be managed under a groundwater sustainability plan or coordinated groundwater sustainability plans by January 31, 2020, and requires all other groundwater basins designated as high- or medium-priority basins to be managed under a groundwater sustainability plan or coordinated groundwater sustainability plans by January 31, 2022. This bill would require a groundwater sustainability plan to be developed and implemented to meet the sustainability

Table 12: Applicable Laws and Regulations for Hydrology, Water Quality, and Water Supply	
Regulation	**Description**
	goal, established as prescribed, and would require the plan to include prescribed components.
Assembly Bill 1739	This bill establishes groundwater reporting requirements for a person extracting groundwater in an area within a basin that is not within the management area of a groundwater sustainability agency or a probationary basin. The bill requires the reports to be submitted to the SWRCB or, in certain areas, to an entity designated as a local agency by the SWRCB.
Senate Bill 1319	This bill allows the SWRCB to designate a groundwater basin as a probationary basin subject to sustainable groundwater management requirements. This bill also authorizes SWRCB to develop an interim management plan in consultation with the DWR under specified conditions.
Local	
Water Agencies	Water agencies enter into contracts or agreements with the federal and state governments to protect the water supply and to ensure the lands within the agency have a dependable supply of suitable quality water to meet present and future needs.
<u>Waste Discharge Requirements General Order for Existing Milk Cow Dairies – Order R5-2013-1022</u>	<u>Order R5-2013-1022 applies to dairies within the Central Valley RWQCB. It addresses considerations such as recycling flush water, grading, establishing setbacks, installing flow meters, and exporting manure. Dischargers must make any necessary interim facility modifications first in order to prevent discharges to surface water, improve storage capacity, and improve the facility's nitrogen balance before completing any necessary infrastructure changes.</u>
Floodplain Management	General plans guide county land use decisions, and require the identification of water resource protection goals, objectives, and policies. Floodplain management is addressed through ordinances, land use planning, and development design review and approval. Local actions may be coordinated with FEMA for the National Flood Insurance Program. Typical provisions address floodplain use restrictions, flood protection requirement, allowable alteration of floodplains and stream channels, control of fill and grading activities in floodplains, and prevention of flood diversions where flows would increase flood hazards in other areas.
Drainage, Grading, and Erosion Control Ordinances	Counties regulate building activity under the federal Uniform Building Code, local ordinances, and related development design review, approval, and permitting. Local ordinances are common for water quality protection addressing drainage,

Table 12: Applicable Laws and Regulations for Hydrology, Water Quality, and Water Supply	
Regulation	**Description**
	stormwater management, land grading, and erosion and sedimentation control.
Environmental Health	The RWQCBs generally delegate permit authority to county health departments to regulate the construction and operation/maintenance of on-site sewage disposal systems (e.g., septic systems and leach fields, cesspools).

11. LAND USE AND PLANNING

A. Existing Conditions

1. California

In California, the State Planning and Zoning Law (California Government Code section 65000 et seq.) provides the primary legal framework that cities and counties must follow in land use planning and controls. Planned land uses are designated in the city or county general plan, which serves as the comprehensive master plan for the community. Also, city and county land use and other related resource policies are defined in the General Plan. The primary land use regulatory tool provided by the California Planning and Zoning Law is the zoning ordinance adopted by each city and county. Planning and Zoning Law requirements are discussed in the regulatory setting below.

When approving land use development, cities and counties must comply with CEQA, which requires that they consider the significant environmental impacts of their actions and the adoption of all feasible mitigation measures to substantially reduce significant impacts, in the event a project causes significant or potentially significant effects on the environment. In some cases, building permits may be ministerial, and therefore exempt from CEQA, but most land use development approval actions by cities and counties require CEQA compliance.

Land use decisions in California are also be governed by state agencies such as the California Coastal Commission, California State Lands Commission, California Department of Parks and Recreation, and others, where the state has land ownership or permitting authority with respect to natural resources or other state interests.

B. Regulatory Setting

Applicable laws and regulations associated with land use and planning are discussed in Table 13.

Table 13: Applicable Laws and Regulations for Land Use and Planning	
Regulation	**Description**
Federal	
FLPMA	FLPMA is the principal law governing how the BLM manages public lands. FLPMA requires the BLM to manage public land resources for multiple use and sustained yield for both present and future generations. Under FLPMA, the BLM is authorized to grant right-of-ways for generation, transmission, and distribution of electrical energy. Although local agencies do not have jurisdiction over the federal lands managed by the BLM, under FLPMA and the BLM regulations at 43 CFR Part 1600, the BLM must coordinate its planning efforts with state and local planning initiatives. FLPMA defines an Area of Critical Environmental Concern (ACEC) as an area within the public lands where special management attention is required (when such areas are developed or used or where no development is required) to protect and prevent irreparable damage to important historic, cultural, or scenic values, fish and wildlife resources, or other natural systems or processes, or to protect life and safety from natural hazards. The BLM identifies, evaluates, and designates ACECs through its resource management planning process. Allowable management practices and uses, mitigation, and use limitations, if any, are described in the planning document and the concurrent or subsequent ACEC Management Plan. ACECs are considered land use authorization avoidance areas because they are known to contain resource values that could result in denial of applications for land uses that cannot be designed to be compatible with management objectives and prescriptions for the ACEC.
BLM Resource Management Plans	Established by FLPMA, Resource Management Plans are designed to protect present and future land uses and to identify management practices needed to achieve desired conditions within the management area covered by the Resource Management Plans. Management direction is set forth in the Resource Management Plans in the form of goals, objectives, standards, and guidelines. These, in turn, direct management actions, activities, and uses that affect land management, and water, recreation, visual, natural, and cultural resources.
National Forest Management Act (NFMA)	NFMA is the primary statute governing the administration of national forests. The act requires the Secretary of Agriculture to assess forest lands, develop a management program based on multiple-use, sustained-yield principles, and implement a resource management plan for each unit of the National Forest System. Goal 4 of the USFS's National

Table 13: Applicable Laws and Regulations for Land Use and Planning	
Regulation	**Description**
	Strategic Plan for the National Forests states that the nation's forests and grasslands play a significant role in meeting America's need for producing and transmitting energy. Unless otherwise restricted, National Forest Service lands are available for energy exploration, development, and infrastructure (e.g., well sites, pipelines, and transmission lines). However, the emphasis on non-recreational special uses, such as utility corridors, is to authorize the special uses only when they cannot be reasonably accommodated on non-National Forest Service lands.
State	
State Planning and Zoning Law	California Government Code section 65300 et seq. establishes the obligation of cities and counties to adopt and implement general plans. The general plan is a comprehensive, long-term, and general document that describes plans for the physical development of the city or county. The general plan addresses a broad range of topics, including, at a minimum, land use, circulation, housing, conservation, open space, noise, and safety. In addressing these topics, the general plan identifies the goals, objectives, policies, principles, standards, and plan proposals that support the city or county's vision for the area. The general plan is also a long-range document that typically addresses the physical character of an area over a 20-year period. Although the general plan serves as a blueprint for future development and identifies the overall vision for the planning area, it remains general enough to allow for flexibility in the approach taken to achieve the plan's goals.
Subdivision Map Act (Government Code section 66410 et seq.)	In general, land cannot be divided in California without local government approval. The primary goals of the Subdivision Map Act are: (a) to encourage orderly community development by providing for the regulation and control of the design and improvements of the subdivision with a proper consideration of its relation to adjoining areas; (b) to ensure that the areas within the subdivision that are dedicated for public purposes will be properly improved by the subdivider so that they will not become an undue burden on the community; and (c) to protect the public and individual transferees from fraud and exploitation. (61 Ops. Cal.Atty. Gen. 299, 301 [1978]; 77 Ops. Cal.Atty. Gen. 185 [1994]). Dividing land for sale, lease or financing is regulated by local ordinances based on the state Subdivision Map Act (Government Code section 66410 et seq.).

Table 13: Applicable Laws and Regulations for Land Use and Planning	
Regulation	**Description**
Local	
General Plans	The most comprehensive land use planning is provided by city and county general plans, which local governments are required by State law to prepare as a guide for future development. The general plan contains goals and policies concerning topics that are mandated by state law or which the jurisdiction has chosen to include. Required topics are: land use, circulation, housing, conservation, open space, noise, and safety. Other topics that local governments frequently choose to address are public facilities, parks and recreation, community design, or growth management, among others. City and county general plans must be consistent with each other. County general plans must cover areas not included by city general plans (i.e., unincorporated areas).
Specific and Community Plans	A city or county may also provide land use planning by developing community or specific plans for smaller, more specific areas within their jurisdiction. These more localized plans provide for focused guidance for developing a specific area, with development standards tailored to the area, as well as systematic implementation of the general plan. Specific and community plans are required to be consistent with the city or county's general plan.
Zoning	The city or county zoning code is the set of detailed requirements that implement the general plan policies at the level of the individual parcel. The zoning code presents standards for different uses and identifies which uses are allowed in the various zoning districts of the jurisdiction. Since 1971, state law has required the city or county zoning code to be consistent with the jurisdiction's general plan, except in charter cities.

12. MINERAL RESOURCES

A. Existing Conditions

The CGS classifies the regional significance of mineral resources in accordance with the California Surface Mining and Reclamation Act of 1975 and assists in the designation of land containing significant aggregate resources. Mineral Resources Zones (MRZs) have been designated to indicate the significance of mineral deposits. The MRZ categories follow:

18. **MRZ-1:** Areas where adequate information indicates that no significant mineral deposits are present or where it is judged that little likelihood exists for their presence.
19. **MRZ-2:** Areas where adequate information indicates significant mineral deposits are present, or where it is judged that a high likelihood exists for their presence.
20. **MRZ-3:** Areas containing mineral deposits the significance of which cannot be evaluated from available data.
    21. **MRZ-4:** Areas where available information is inadequate for assignment to any other MRZ.

California ranks as 7th in the U.S. for non-fuel mineral production, accounting for approximately 3.9 percent of the nation's total. In 2011, there were approximately 700 active mineral mines that produced: sand and gravel, boron, Portland cement, crushed stone, gold, masonry cement, clays, gemstones, gypsum, salt, silver, and other minerals (Clinkenbeard and Smith 2013).

B. Regulatory Setting

Applicable laws and regulations associated with mineral resources are discussed in Table 14.

Table 14: Applicable Laws and Regulations for Mineral Resources

Regulation	Description
Federal	
Mining and Mineral Policy Act	The Mining and Mineral Act of 1970 declared that the Federal Government policy is to encourage private enterprise in the development of a sound and stable domestic mineral industry, domestic mineral deposits, minerals research, and methods for reclamation in the minerals industry.
State	
Surface Mining and Reclamation Act (SMARA)	The intent of SMARA of 1975 is to promote production and conservation of mineral resources, minimize environmental effects of mining, and to assure that mined lands will be reclaimed to conditions suitable for alternative uses. An important part of the SMARA legislation requires the State Geologist to classify land according to the presence or absence of significant mineral deposits. Local jurisdictions are given the authority to permit or restrict mining operations, adhering to the SMARA legislation. Classification of an area using MRZs to designate lands that contain mineral deposits are designed to protect mineral deposits from encroaching urbanization and land uses that are incompatible with mining. The MRZ classifications reflect varying degrees of mineral significance, determined by available knowledge of the presence or absence of mineral deposits as well as the economic potential of the

Table 14: Applicable Laws and Regulations for Mineral Resources	
Regulation	**Description**
	deposits.
CBSC (24 CCR)	California's minimum standards for structural design and construction are given in the CBSC (24 CCR). The CBSC is based on the Uniform Building Code (International Code Council 1997), which is used widely throughout U.S. (generally adopted on a state-by-state or district-by-district basis) and has been modified for California conditions with numerous, more detailed or more stringent regulations. The CBSC provides standards for various aspects of construction, including (i.e., not limited to) excavation, grading, and earthwork construction; fills and embankments; expansive soils; foundation investigations; and liquefaction potential and soil strength loss. In accordance with California law, proponents of specific projects would be required to comply with all provisions of the CBSC for certain aspects of design and construction.
Local	
Local Grading and Erosion Control Ordinances	Many counties and cities have grading and erosion control ordinances. These ordinances are intended to control erosion and sedimentation caused by construction activities. A grading permit is typically required for construction-related projects. As part of the permit, project applicants usually must submit a grading and erosion control plan, vicinity and site maps, and other supplemental information. Standard conditions in the grading permit include a description of BMPs similar to those contained in a SWPPP.
City/County General Plans	Most city and county general plans have an element that addresses mineral resources within that jurisdiction.

13. NOISE

A. Existing Conditions

Acoustics is the scientific study that evaluates perception, propagation, absorption, and reflection of sound waves. Sound is a mechanical form of radiant energy, transmitted by a pressure wave through a solid, liquid, or gaseous medium. Sound that is loud, disagreeable, unexpected, or unwanted is generally defined as noise. Common sources of environmental noise and noise levels are presented in Table 15.

Table 15: Typical Noise Levels		
Common Outdoor Activities	**Noise Level (dB)**	**Common Indoor Activities**
	110	Rock band
Jet flyover at 1,000 feet	100	--
Gas lawnmower at 3 feet	90	--
Diesel truck moving at 50 mph at 50 feet	80	Food blender at 3 feet, Garbage disposal at 3 feet
Noisy urban area, Gas lawnmower at 100 feet	70	Vacuum cleaner at 10 feet, Normal speech at 3 feet
Commercial area, Heavy traffic at 300 feet	60	
Quiet urban daytime	50	Large business office, Dishwasher in next room
Quiet urban nighttime	40	Theater, Large conference room (background)
Quiet suburban nighttime	30	Library, Bedroom at night, Concert hall (background)
Quiet rural nighttime	20	Broadcast/Recording Studio
	10	--
Threshold of Human Hearing	0	Threshold of Human Hearing
Notes: dB=A-weighted decibels; mph=miles per hour Source: Caltrans 2009: p.2-21		

1. Sound Properties

A sound wave is initiated in a medium by a vibrating object (e.g., vocal chords, the string of a guitar, the diaphragm of a radio speaker). The wave consists of minute variations in pressure, oscillating above and below the ambient atmospheric pressure. The number of pressure variation cycles occurring per second is referred to as the frequency of the sound wave and is expressed in hertz.

Directly measuring sound pressure fluctuations would require the use of a very large and cumbersome range of numbers. To avoid this and have a more useable numbering system, the decibel (dB) scale was introduced. A sound level expressed in decibels is the logarithmic ratio of two like pressure quantities, with one pressure quantity being a reference sound pressure. For sound pressure in air the standard reference quantity is generally considered to be 20 micropascals, which directly corresponds to the threshold of human hearing. The use of the decibel is a convenient way to handle the million-fold range of sound pressures to which the human ear is sensitive. A decibel is logarithmic; it does not follow normal algebraic methods and cannot be directly summed. For example, a 65 dB source of sound, such as a truck, when joined by another 65 dB source results in a sound amplitude of 68 dB, not 130 dB (i.e., doubling the source strength increases the sound pressure by 3 dB). A sound level increase of 10 dB corresponds to 10 times the acoustical energy, and an increase of 20 dB equates to a 100 fold increase in acoustical energy.

The loudness of sound perceived by the human ear depends primarily on the overall sound pressure level and frequency content of the sound source. The human ear is not equally sensitive to loudness at all frequencies in the audible spectrum. To better relate overall sound levels and loudness to human perception, frequency-dependent weighting networks were developed. The standard weighting networks are identified as A through E. There is a strong correlation between the way humans perceive sound and A-weighted sound levels (dBA). For this reason the dBA can be used to predict community response to noise from the environment, including noise from transportation and stationary sources. Sound levels expressed as dB in this section are A-weighted sound levels, unless noted otherwise.

Noise can be generated by a number of sources, including mobile sources (i.e., transportation) such as automobiles, trucks, and airplanes and stationary sources (i.e., non-transportation) such as construction sites, machinery, and commercial and industrial operations. As acoustic energy spreads through the atmosphere from the source to the receiver, noise levels attenuate (i.e., decrease) depending on ground absorption characteristics, atmospheric conditions, and the presence of physical barriers. Noise generated from mobile sources generally attenuate at a rate of 4.5 dB per doubling of distance. Stationary noise sources spread with more spherical dispersion patterns that attenuate at a rate of 6 to 7.5 dB per doubling of distance.

Atmospheric conditions such as wind speed, turbulence, temperature gradients, and humidity may additionally alter the propagation of noise and affect levels at a receiver. Furthermore, the presence of a large object (e.g., barrier, topographic features, and intervening building façades) between the source and the receptor can provide significant attenuation of noise levels at the receiver. The amount of noise level reduction (i.e., shielding) provided by a barrier primarily depends on the size of the barrier, the location of the barrier in relation to the source and receivers, and the frequency spectra of the noise. Natural (e.g., berms, hills, and dense vegetation) and human-made features (e.g., buildings and walls) may be used as noise barriers.

All buildings provide some exterior-to-interior noise reduction. A building constructed with a wood frame and a stucco or wood sheathing exterior typically provides a minimum exterior-to-interior noise reduction of 25 dB with its windows closed, whereas a building constructed of a steel or concrete frame, a curtain wall or masonry exterior wall, and fixed plate glass windows of one-quarter-inch thickness typically provides an exterior-to-interior noise reduction of 30–40 dB with its windows closed (Paul S. Veneklasen & Associates 1973, cited in Caltrans 2002: p. 7-37).

2. Common Noise Descriptors

The intensity of environmental noise fluctuates over time, and several different descriptors of time-averaged noise levels are used. The selection of a proper noise descriptor for a specific source depends on the spatial and temporal distribution, duration, and fluctuation of both the noise source and the environment. The noise descriptors most often in relation to the environment are defined below (Caltrans 2009).

Equivalent Noise Level (L_{eq}): The equivalent steady-state noise level in a stated period of time that would contain the same acoustic energy as the time-varying noise level during the same period (i.e., average noise level).

Maximum Noise Level (L_{max}): The highest instantaneous noise level during a specified time period.

Minimum Noise Level (L_{min}): The lowest instantaneous noise level during a specified time period.

Day-Night Noise Level (L_{dn}): The 24-hour L_{eq} with a 10-dB penalty applied during the noise-sensitive hours from 10 p.m. to 7 a.m., which are typically reserved for sleeping.

Community Noise Equivalent Level (CNEL): Similar to the L_{dn} described above with an additional 5-dB penalty applied during the noise-sensitive hours from 7 p.m. to 10 p.m., which are typically reserved for relaxation, conversation, reading, and watching television.

Community noise is commonly described in terms of the ambient noise level, which is defined as the all-encompassing noise level associated with a given noise environment. A common statistical tool to measure the ambient noise level is the L_{eq} descriptor listed above, which corresponds to a steady-state A-weighted sound level containing the same total energy as a time-varying signal over a given time period (usually one hour). The L_{eq} is the foundation of the composite noise descriptors such as L_{dn} and CNEL, as defined above, and shows very good correlation with community response to noise.

3. Effects of Noise on Humans

Excessive and chronic exposure to elevated noise levels can result in auditory and non-auditory effects on humans. Auditory effects of noise on people are those related to temporary or permanent hearing loss caused by loud noises. Non-auditory effects of exposure to elevated noise levels are those related to behavioral and physiological effects. The non-auditory behavioral effects of noise on humans are associated primarily with the subjective effects of annoyance, nuisance, and dissatisfaction, which lead to interference with activities such as communications, sleep, and learning. The non-auditory physiological health effects of noise on humans have been the subject of considerable research attempting to discover correlations between exposure to elevated noise levels and health problems, such as hypertension and cardiovascular disease.

The mass of research infers that noise-related health issues are predominantly the result of behavioral stressors and not a direct noise-induced response. The extent to which noise contributes to non-auditory health effects remains a subject of considerable research, with no definitive conclusions.

The degree to which noise results in annoyance and interference is highly subjective and may be influenced by several non-acoustic factors. The number and effect of these non-acoustic environmental and physical factors vary depending on individual characteristics of the noise environment such as sensitivity, level of activity, location, time of day, and length of exposure. One key aspect in the prediction of human response to new noise environments is the individual level of adaptation to an existing noise environment. The greater the change in the noise levels that are attributed to a new noise source, relative to the environment an individual has become accustom to, the less tolerable the new noise source will be perceived.

With respect to how humans perceive and react to changes in noise levels, a 1 dB increase is imperceptible, a 3 dB increase is barely perceptible, a 6 dB increase is clearly noticeable, and a 10 dB increase is subjectively perceived as approximately twice as loud (Egan 2007: p. 21). These subjective reactions to changes in noise levels was developed on the basis of test subjects' reactions to changes in the levels of steady-state pure tones or broad-band noise and to changes in levels of a given noise source. It is probably most applicable to noise levels in the range of 50 to 70 dB, as this is the usual range of voice and interior noise levels. For these reasons, a noise level increase of 3 dB or more is typically considered substantial in terms of the degradation of the existing noise environment.

Negative effects of noise exposure include physical damage to the human auditory system, interference, and disease. Exposure to noise may result in physical damage to the auditory system, which may lead to gradual or traumatic hearing loss. Gradual hearing loss is caused by sustained exposure to moderately high noise levels over a period of time; traumatic hearing loss is caused by sudden exposure to extremely high noise levels over a short period. Gradual and traumatic hearing loss both may result in permanent hearing damage. In addition, noise may interfere with or interrupt sleep, relaxation, recreation, and communication. Although most interference may be classified as annoying, the inability to hear a warning signal may be considered dangerous. Noise may also be a contributor to diseases associated with stress, such as hypertension, anxiety, and heart disease. The degree to which noise contributes to such diseases depends on the frequency, bandwidth, and level of the noise, and the exposure time (Caltrans 2009).

4. Vibration

Vibration is the periodic oscillation of a medium or object with respect to a given reference point. Sources of vibration include natural phenomena (e.g., earthquakes, volcanic eruptions, sea waves, landslides) and those introduced by human activity (e.g., explosions, machinery, traffic, trains, construction equipment). Vibration sources may be continuous, (e.g., operating factory machinery or transient in nature, explosions). Vibration levels can be depicted in terms of amplitude and frequency, relative to displacement, velocity, or acceleration.

Vibration amplitudes are commonly expressed in peak particle velocity (PPV) or root-mean-square (RMS) vibration velocity. PPV is defined as the maximum instantaneous positive or negative peak of a vibration signal. PPV is typically used in the monitoring of transient and impact vibration and has been found to correlate well to the stresses experienced by buildings (FTA 2006, Caltrans 2004). PPV and RMS vibration velocity are normally described in inches per second (in/sec).

Although PPV is appropriate for evaluating the potential for building damage, it is not always suitable for evaluating human response. It takes some time for the human body to respond to vibration signals. In a sense, the human body responds to average vibration amplitude. The RMS of a signal is the average of the squared amplitude of the signal, typically calculated over a 1-second period. As with airborne sound, the RMS velocity is often expressed in decibel notation as vibration decibels (VdB), which serves to compress the range of numbers required to describe vibration (FTA 2006). This is based on a reference value of 1micro (μ) inch/second.

The typical background vibration-velocity level in residential areas is approximately 50 VdB. Groundborne vibration is normally perceptible to humans at approximately 65 VdB. For most people, a vibration-velocity level of 75 VdB is the approximate dividing line between barely perceptible and distinctly perceptible levels (FTA 2006).

Typical outdoor sources of perceptible groundborne vibration are construction equipment, steel-wheeled trains, and traffic on rough roads. If a roadway is smooth, the groundborne vibration is rarely perceptible. The range of interest is from approximately 50 VdB, which is the typical background vibration-velocity level, to 100 VdB, which is the general threshold where minor damage can occur in fragile buildings. Construction activities could generate groundborne vibrations that potentially pose a risk to nearby structures. Constant or transient vibrations can weaken structures, crack facades, and disturb occupants (FTA 2006).

Construction vibrations can be transient, random, or continuous. Transient construction vibrations are generated by blasting, impact pile driving, and wrecking balls. Continuous vibrations result from vibratory pile drivers, large pumps, and compressors. Random vibration can result from jackhammers, pavement breakers, and heavy construction equipment. Table 16 describes the general human response to different levels of groundborne vibration-velocity levels.

Table 16: Human Response to Different Levels of Groundborne Noise and Vibration	
Vibration-Velocity Level	**Human Reaction**
65 VdB	Approximate threshold of perception.
75 VdB	Approximate dividing line between barely perceptible and distinctly perceptible. Many people find that transportation-related vibration at this level is unacceptable.
85 VdB	Vibration acceptable only if there are an infrequent number of events per day.

Notes: VdB = vibration decibels referenced to 1 μ inch/second and based on the root mean square (RMS) velocity amplitude.
Source: FTA 2006: p. 7-8

5. Sensitive Land Uses

Noise-sensitive land uses are generally considered to include those uses where noise exposure could result in health-related risks to individuals, as well as places where quiet is an essential element of their intended purpose. Residential dwellings are of primary concern because of the potential for increased and prolonged exposure of individuals to both interior and exterior noise levels. Additional land uses such as parks, schools, historic sites, cemeteries, and recreation areas are also generally considered sensitive to increases in exterior noise levels. Places of worship and transit lodging, and other places where low interior noise levels are essential are also considered noise-sensitive. These types of receptors are also considered vibration-sensitive land uses in addition to commercial and industrial buildings where vibration would interfere with operations within the building, including levels that may be well below those associated with human annoyance.

B. Regulatory Setting

Applicable laws and regulations associated with noise are discussed in Table 17.

Table 17: Applicable Laws and Regulations for Noise	
Regulation	**Description**
Federal	
Federal Noise Control Act (1972) EPA (40 CFR 201-211)	This act established a requirement that all federal agencies administer their programs to promote an environment free of noise that jeopardizes public health or welfare. EPA was given the responsibility for providing information to the public regarding identifiable effects of noise on public health or welfare, publishing information on the levels of environmental noise that will protect the public health and welfare with an adequate margin of safety, coordinating federal research and

Table 17: Applicable Laws and Regulations for Noise	
Regulation	**Description**
	activities related to noise control, and establishing federal noise emission standards for selected products distributed in interstate commerce. This act also directed that all federal agencies comply with applicable federal, state, interstate, and local noise control regulations.
Quiet Communities Act (1978)	This act promotes the development of effective state and local noise control programs, to provide funds for noise research, and to produce and disseminate educational materials to the public on the harmful effects of noise and ways to effectively control it.
14 CFR, Part 150 (FAA)	These address airport noise compatibility planning and include a system for measuring airport noise impacts and present guidelines for identifying incompatible land uses. All land uses are considered compatible with noise levels of less than 65 dBA L_{dn}. At higher noise levels, selected land uses are also deemed acceptable, depending on the nature of the use and the degree of structural noise attenuation provided.
International Standards and Recommended Practices (International Civil Aviation Organization)	This contains policies and procedures for considering environmental impacts (e.g., aircraft noise emission standards and atmospheric sound attenuation factors).
32 CFR, Part 256 (Department of Defense Air Installations Compatible Use Zones [AICUZ] Program)	AICUZ plans prepared for individual airfields are primarily intended as recommendations to local communities regarding the importance of maintaining land uses which are compatible with the noise and safety impacts of military aircraft operations.
23 CFR, Part 772, Federal Highway Administration (FHWA) standards, policies, and procedures	FHWA standards, policies, and procedures provide procedures for noise studies and noise abatement measures to help protect the public health and welfare, to supply noise abatement criteria, and to establish requirements for information to be given to local officials for use in the planning and design of highways.
29 CFR, Part 1910, Section 1910.95 (U.S. Department of Labor Occupational Safety and Health Administration [OSHA])	This regulation established a standard for noise exposure in the workplace.

Table 17: Applicable Laws and Regulations for Noise	
Regulation	**Description**
FTA Guidance	This guidance presents procedures for predicting and assessing noise and vibration impacts of proposed mass transit projects. All types of bus and rail projects are covered. Procedures for assessing noise and vibration impacts are provided for different stages of project development, from early planning before mode and alignment have been selected through preliminary engineering and final design. Both for noise and vibration, there are three levels of analysis described. The framework acts as a screening process, reserving detailed analysis for projects with the greatest potential for impacts while allowing a simpler process for projects with little or no effects. This guidance contains noise and vibration impact criteria that are used to assess the magnitude of predicted impacts. A range of mitigation is described for dealing with adverse noise and vibration impacts.
49 CFR 210 (Federal Rail Administration [FRA] Railroad Noise Emission Compliance Standards) and FRA Guidance (2005)	This section and guidance provides contains criteria and procedures for use in analyzing the potential noise and vibration impacts of various types of high-speed fixed guideway transportation systems.
State	
CPUC Section 21670	The State Aeronautics Act of the CPUC establishes statewide requirements for airport land use compatibility planning and requires nearly every county to create an Airport Land Use Commission or other alternative.
Section 5000 et seq. (21 CCR Division 2.5, Chapter 6), California Airport Noise Regulations promulgated in accordance with the State Aeronautics Act	In Section 5006, the regulations state that: “The level of noise acceptable to a reasonable person residing in the vicinity of an airport is established as a CNEL value of 65 dBA for purposes of these regulations. This criterion level has been chosen for reasonable persons residing in urban residential areas where houses are of typical California construction and may have windows partially open. It has been selected with reference to speech, sleep, and community reaction.
24 CCR, Part 2	These establish standards governing interior noise levels that apply to all new single-family and multi-family residential units in California. These standards require that acoustical studies be performed before construction at building locations where the existing L_{dn} exceeds 60 dBA. Such acoustical studies are

Table 17: Applicable Laws and Regulations for Noise	
Regulation	**Description**
	required to establish mitigation that will limit maximum L_{dn} levels to 45 dBA in any habitable room.

14. EMPLOYMENT, POPULATION, AND HOUSING

A. Existing Conditions

1. Population

The estimated population of California in 2015 was estimated to be approximately 38,897,000 (DOF 2014). Since California became a state in 1850, the population has been increasing rapidly. Within the first 150 years of California's statehood, the population increased from fewer than 100,000 citizens to approximately 37 million in 2000 (DOF 2013). It is expected that the population of California will reach approximately 44 million in 2030 and approximately 50 million in 2050 (DOF 2013).

2. Housing

As population within the state increases, housing distribution and household conditions are expected to evolve. Estimated housing units, households, and vacancy rates for the State of California in 2013 are shown below in Table 18. Data was derived from the 2010 Census (US Census Bureau 2014).

Table 18: California Housing Profile	
Housing units, 2014	13,900,766
Homeownership rate, 2009-2013	55.3 percent
Households, 2009-2013	12,542,460
Persons per Household, 2009-2013	2.94
Housing units in Multi-units structures, 2009-2013	31 percent
Source: US Census 2014	

3. Employment

In mid-2015, the civilian labor force in California was approximately 19,043,000. Of this labor force, approximately 17,484,000 people were employed and 1,195,000 were considered unemployed. The number of and the unemployment rate decreased steadily decreased in 2015 from 7.0 percent in January to 6.3 percent in June (DOF 2015).

B. Regulatory Setting

See land use planning and housing-related regulations in Section 11.0, Land Use and Planning.

15. PUBLIC SERVICES

A. Existing Conditions

1. Law Enforcement

Enforcement of environmental laws in California is the responsibility of the Attorney General's Office and the CalEPA. The Attorney General represents the people of California in civil and criminal matters before trial courts, appellate courts and the supreme courts of California and the U.S. In regards to environmental issues, the Attorney General enforces laws that safeguard the environment and natural resources in the state. Recent actions by the Attorney General related to air quality and climate change issues include: legally defending the state's clean cars law against multiple challenges, filing numerous actions against the Bush Administration regarding regulation of global warming pollution, working with local governments to ensure that land use planning processes take account of global warming, promoting renewable energy and enhanced energy efficiency in California, and working with other state leaders and agencies to implement AB 32, the Global Warming Solutions Act of 2006.

CalEPA was created in 1991 by Governor's Executive Order. CalEPA's mission is to restore, protect and enhance the environment, to ensure public health, environmental quality and economic vitality. The CalEPA is comprised of various boards, departments and offices, including: ARB, Department of Pesticide Regulation, DTSC, Office of Environmental Health Hazard Assessment, and SWRCB (including the nine RWQCBs).

California's environmental laws are enforced by state and local agencies, each charged with enforcing the laws governing a specific media such as air, water, hazardous waste, solid waste, and pesticides. Enforcement agencies for these media are as follows:

22. Air: ARB (part of CalEPA) and Local Air Districts.
23. Water: SWRCB (part of CalEPA), RWQCBs (part of CalEPA), local waste water officials, and the California Department of Public Health.
24. Hazardous Waste: DTSC (part of CalEPA) and CUPA.
Carcinogens/Reproductive Toxins: Prop. 65 through the Office of
25. Environmental Health Hazard Assessment (part of CalEPA).
    26. Pesticides: Department of Pesticide Regulation (part of CalEPA) and County Agricultural Commissioners

Statewide law enforcement service is provided by the California Highway Patrol, which is responsible for protecting State resources and providing crime prevention services and traffic enforcement along the State's highways and byways.

Community law enforcement service is provided by local police and sheriff agencies (i.e., cities and counties, respectively) to prevent crime, respond to emergency incidents, and provide traffic enforcement on local roadways.

2. Fire Protection and Emergency Medical Response Services

State-level fire protection and emergency response service is provided by the California Department of Forestry and Fire Protection (CAL FIRE), primarily in rural areas of the State. CAL FIRE is an emergency response and resource protection department. CAL FIRE protects lives, property and natural resources from fire, responds to emergencies of all types, and protects and preserves timberlands, wildlands, and urban forests.

Local and urban fire protection service is provided by local fire districts and/or local agencies (e.g., fire departments of cities and counties). In addition to providing fire response services most fire agencies also provide emergency medical response services (i.e., ambulance services) within their service areas.

3. Schools

Statewide, the regulation of education for youth is provided by the California Department of Education. The State Board of Education (SBE) is the governing and policy-making body of the California Department of Education. The SBE sets K-12 education policy in the areas of standards, instructional materials, assessment, and accountability. Locally, school districts are responsible for the management and development of elementary, middle, and high-school facilities.

B. B. Regulatory Setting

Applicable laws and regulations associated with public services are discussed in Table 19.

Table 19: Applicable Laws and Regulations for Public Services

Regulation	Description
Federal	**None applicable.**
American with Disabilities Act	Guidelines to ensure that facilities are accessible to individuals with disabilities. Implements requirements for the design and construction of buildings.
State	
State Fire Responsibility Areas	Areas delineated by the CAL FIRE for which the state assumes primary financial responsibility for protecting natural resources from damages of fire. Local jurisdictions are required to adopt minimum recommended requirements for road design, road identification, emergency fire suppression and fuel breaks and greenbelts. All projects within or adjacent to a State Fire Responsibility Area must meet these requirements.
State School	Education Code Section 17620 authorizes school districts to levy

Funding	a fee, charge, dedication, or other requirement for any development project for the construction or reconstruction of school facilities.

16. RECREATION

A. Existing Conditions

California contains 118 state parks, nine state recreation areas, 8 state forests, as well as numerous reserve, wildlife areas, and fish hatcheries. General plans for State parks, recreation areas, and beaches are publicly available. The California Outdoor Recreation Plan and associated research provide policy guidance to all public agencies – federal, state, local, and special districts that oversee outdoor recreation on lands, facilities and services throughout California. Agencies and departments that have involvement in recreational activities include Boating and Waterways, Fish and Wildlife, Tahoe Regional Planning Association, various conservancies, and others (California State Parks 2008).

Recreational lands and facilities are also managed by regional and local park and recreation agencies and open space districts. City and county general plans contain recreation elements that provide framework for planning agencies to consider when projects are developed and implemented.

B. Regulatory Setting

Applicable laws and regulations associated with recreation are discussed in Table 20.

Table 20: Applicable Laws and Regulations for Recreation

Regulation	Description
Federal	
FLPMA, 1976 – 43 CFR 1600	Establishes public land policy; guidelines for administration; and provides for the "multiple use" management, protection, development, and enhancement of public lands. Multiple use management, defined as "management of the public lands and their various resource values so that they are utilized in the combination that will best meet the present and future needs of the American people" with recreation identified as one of the resource values.
State	
	None applicable
Local	
General Plans	General plans for cities and counties contain designations for recreational areas. These are policy documents with planned land use maps and related information that are designed to give long-range guidance to those local officials making decisions

	affecting the growth and resources of their jurisdictions. Because of the number and variety of general plans and related local plans, they are not listed individually.

17. TRANSPORTATION, TRAFFIC, AND SHIPPING

A. Existing Conditions

Existing roadway systems in the U.S. and California generally consist of highways, freeways, arterials, local streets, and intersections/ramps. The existing average annual daily traffic (AADT) volumes on the roadway segments that comprise these systems vary considerably (i.e., from hundreds to hundreds of thousands). The level of service (LOS), a scale used to determine the operating quality of a roadway segment or intersection based on volume-to-capacity ratio (V/C) or average delay, also vary from LOS A, the best and smoothest operating conditions, to LOS F, most congested operating conditions. Other roadway and traffic volume characteristics such as roadway length, number of lanes and facility type (e.g., two-lane freeway), right-of-way width and pavement width, terrain classification (e.g., flat), percent of heavy-duty truck traffic, and accident rates (e.g., number of accidents per million vehicle miles traveled) also vary substantially depending on the location. In addition to the roadway systems, circulation networks provide additional transportation opportunities and include mass transit, airports, and non-motorized travel (e.g., pedestrian and bicycle paths).

B. Regulatory Setting

Applicable laws and regulations associated with transportation and traffic are discussed in Table 21.

Table 21: Applicable Laws and Regulations for Transportation and Traffic

Regulation	Description
Federal	
40 CFR, Part 77 (FAA)	Requires a determination of no hazard to air navigation for structures that will be more than 200 feet above ground level.
State	
California Vehicle Code (VC) Sections 353; 2500-2505; 31303-31309; 32000-32053; 32100-32109; 31600-31620; California Health and Safety Code Section 25160 et seq.	Regulates the highway transport of hazardous materials.
VC Sections 13369; 15275 and 15278	Addresses the licensing of drivers and the classification of licenses required for the operation of particular types of vehicles and also requires certificates permitting operation of

Table 21: Applicable Laws and Regulations for Transportation and Traffic	
Regulation	**Description**
	vehicles transporting hazardous materials.
VC Sections 35100 et seq.; 35250 et seq.; 35400 et seq.	Specifies limits for vehicle width, height, and length.
VC Section 35780	Requires permits for any load exceeding Caltrans weight, length, or width standards on public roadways.
California Streets and Highways Code Section 117, 660-672	Requires permits for any load exceeding Caltrans weight, length, or width standards on County roads.
California Streets and Highways Code Sections 117, 660-670, 1450, 1460 et seq., and 1480 et seq.	Regulate permits from Caltrans for any roadway encroachment from facilities that require construction, maintenance, or repairs on or across State highways and County roads.

18. UTILITIES AND SERVICE SYSTEMS

A. Existing Conditions

1. United States

The U.S. Bureau of Reclamation (USBR) is a federal agency and it is the largest wholesaler of water in the U.S. and the second largest producer of hydroelectric power (USBR 2011). The Federal Power Commission regulates both the interstate transmission of electricity and the sale of hydroelectric power at the wholesale level in the U.S., and the Federal Energy Regulatory Commission (FERC) has authority over intrastate as well as interstate natural gas production.

2. California

a) Water Supply and Distribution

The principal water supply facilities in California are operated by the USBR and DWR. In California, the Mid-Pacific Region of the USBR is responsible for the management of the Central Valley Project (CVP). The CVP serves farms, homes, and industry in California's Central Valley as well as the major urban centers in the San Francisco Bay Area. The CVP consists of 20 dams and reservoirs, 11 power plants, and 500 miles of major canals and reaches from the Cascade Mountains near Redding in the north to the Tehachapi Mountains near Bakersfield in the south. In addition to delivering water for municipal and industrial uses and the environment, the CVP produces electric power and provides flood protection, navigation, recreation, and water quality benefits (USBR 2011).

DWR is a State agency that is responsible for managing and implementing the State Water Project (SWP). The SWP is a water storage and delivery system of reservoirs, aqueducts, power plants and pumping plants. Its main purpose is to store water and distribute it to 29 urban and agricultural water suppliers in Northern California, the San Francisco Bay Area, the San Joaquin Valley, the Central Coast, and Southern California (DWR 2010).

Local water districts, irrigation districts, special districts, and jurisdictions (e.g., cities and counties) manage and regulate the availability of water supplies and the treatment and delivery of water to individual projects. Depending on their location and the source of their supplies, these agencies may use groundwater, surface water through specific water entitlements, or surface water delivered through the CVP or SWP. In some remote areas not served by a water supply agency, individual developments may need to rely upon the underlying groundwater basin for their water supply. In these cases, the project would be required to secure a permit from the local or state land use authority and seek approval for development of the groundwater well(s).

b) Wastewater Collection and Treatment

The SWRCB is the state agency responsible for the regulation of wastewater discharges to surface waters and groundwater via land discharge. The SWRCB and nine RWQCBs are responsible for development and enforcement of water quality objectives and implementation plans that protect the beneficial uses of the federal and state waters. The SWRCB also administers water rights in California. The RWQCB's are responsible for issuing permits or other discharge requirements to individual wastewater dischargers and for ensuring that they are meeting the requirements of the permit through monitoring and other controls.

Wastewater collection, treatment, and discharge service for developed and metropolitan areas is typically provided by local wastewater service districts or agencies that may or may not be operated by the local jurisdiction (e.g., city or county). These agencies are required to secure treatment and discharge permits for the operation of a wastewater facility from the RWQCB. Wastewater is typically collected from a specific development and conveyed through a series of large pipelines to the treatment facility where it is treated to permitted levels and discharged to surface waters or the land.

In areas that are remote or that are not served by an individual wastewater service provider, developments would be required to install an individual septic tank or other on-site wastewater treatment system. These facilities would need to be approved by the local or state land use authority and the RWQCB.

c) Electricity and Natural Gas

The CPUC regulates investor-owned electric and natural gas companies located within California. The CPUC's Energy Division develops and administers energy policy and programs and monitors compliance with the adopted regulations. One-third of California's electricity and natural gas is provided by one of three companies: Pacific

Gas and Electric Company, Southern California Edison, San Diego Gas and Electric Company (CPUC 2010).

Locally, energy service is provided by a public or private utility. New development projects would need to coordinate with the local service provider to ensure adequate capacity is available to serve the development.

d) Solid Waste Collection and Disposal

Statewide, the California Department of Resources Recycling and Recovery (CalRecycle), which is a department of the CNRA, is responsible for the regulation of the disposal and recycling of all solid waste generated in California. Cal Recycle acts as an enforcement agency in the approval and regulation of solid waste disposal and recycling facilities. Local agencies can create local enforcement agencies and, once approved by Cal Recycle, they can serve as the enforcement agency for landfills and recycling facilities with their jurisdictions.

Local agencies or private companies own and operate landfill facilities and solid waste is typically hauled to these facilities by private or public haulers. Individual projects would need to coordinate with the local service provider and landfill to determine if adequate capacity exists to serve the project.

B. Regulatory Setting

Applicable laws and regulations associated with utilities are discussed in Table 22.

Table 22: Applicable Laws and Regulations for Utilities

Regulation	Description
Federal	
Federal Power Act of 1935	In the Federal Power Act of 1935 (49 Stat. 803), created the Federal Power Commission, an independent regulatory agency with authority over both the interstate transmission of electricity and the sale of hydroelectric power at the wholesale level. The act requires the commission to ensure that electricity rates are “reasonable, nondiscriminatory and just to the consumer.” The Federal Power Act of 1935 also amended the criteria that the commission must apply in deciding whether to license the construction and operation of new hydroelectric facilities.
Natural Gas Act of 1938	Together with the Federal Power Act of 1935, the Natural Gas Act of 1938 (NGA) (P.L. 75-688, 52 Stat. 821) was an essential piece of energy legislation in the first half of the 20th century. These statutes regulated interstate activities of the electric and natural gas industries, respectively. The acts are similarly structured and constitute the classic form of command-and-control regulation authorizing the federal government to enter into a regulatory compact with utilities. In short, the Natural Gas Act enabled federal regulators to set prices for gas sold in

Table 22: Applicable Laws and Regulations for Utilities	
Regulation	**Description**
	interstate commerce in exchange for exclusive rights to transport the gas.
Natural Gas Policy Act of 1978	The Natural Gas Policy Act of 1978 (NGPA) granted the FERC authority over intrastate as well as interstate natural gas production. The NGPA established price ceilings for wellhead first sales of gas that vary with the applicable gas category and gradually increase over time.
State	
Waste Heat and Carbon Emissions Reduction Act of 2007	The Waste Heat and Carbon Emissions Reduction Act of 2007 (AB 1613), placed requirements on the CPUC, the CEC, and local electric utilities to develop incentive programs and technical efficiency guidelines to encourage the installation of small CHP systems. The CEC approved efficiency and certification guidelines for eligible systems under AB 1613 in January 2010, and the CPUC approved standardized contracting and pricing provisions between CHP operators and the Investor Owned Utilities in November 2012.
Assembly Bill 1900 (Gatto, Chapter 602, Statutes of 2012)	AB 1900 directed the CPUC to adopt natural gas constituent standards (in consultation with ARB and the Office of Environmental Health and Hazard Assessment). The legislation is also designed to streamline and standardize customer pipeline access rules, and encourage the development of statewide policies and programs to promote all sources of biomethane production and distribution.
Section 21151.9 of the PRC/ Section 10910 et seq. of the Water Code	Required the preparation of a water supply assessment (WSA) for large developments. These assessments are prepared by public water agencies responsible for providing service and address whether there are adequate existing and projected future water supplies to serve the proposed project. All projects that meet the qualifications for preparing a WSA must identify the water supplies and quantities that would serve the project as well as project the total water demand for the service area (including the project's water demands) by source in 5-year increments over a 20-year period. This information must include data for a normal, single-dry, and multiple-dry years. The WSA is required to be approved by the water service agency before the project can be implemented.

ATTACHMENT B: SUMMARY OF IMPACTS BY REDUCTION MEASURES

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Attachment B: Summary of Impacts by Reduction Measures			
	Black Carbon	**Methane**	**HFCs**
Aesthetics			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts	LTS	PSU	
Agriculture & Forest Resources			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts			
Air Quality			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts	B	PSU	LTS
Short-Term and Long-Term Odor Impacts		PSU	LTS
Biological Resources			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts	LTS		LTS
Cultural Resources			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts	LTS	NA	NA
Energy Demand			
Short-Term Construction-Related Impacts	LTS	LTS	LTS
Long-Term Operational-Related Impacts	LTS	LTS	
Geology and Soils			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts	LTS	LTS	LTS
Greenhouse Gas			
Short-Term Construction-Related Impacts	LTS	LTS	LTS
Long-Term Operational-Related Impacts	B	B	B
Hazards & Hazardous Materials			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts	LTS	LTS	LTS

Attachment B: Summary of Impacts by Reduction Measures			
	Black Carbon	**Methane**	**HFCs**
Hydrology and Water Quality			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts	LTS	LTS	LTS
Land Use Planning			
Short-Term Construction-Related Impacts	May not be consistent	May not be consistent	May not be consistent
Long-Term Operational-Related Impacts			
Mineral Resources			
Short-Term Construction-Related Impacts	LTS	LTS	LTS
Long-Term Operational-Related Impacts			
Noise			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts	LTS	PSU	LTS
Population and Housing			
Short-Term Construction-Related Impacts	LTS	LTS	LTS
Long-Term Operational-Related Impacts			
Public Services			
Short-Term Construction-Related Impacts	LTS	LTS	LTS
Long-Term Operational-Related Impacts			
Recreation			
Short-Term Construction-Related Impacts	LTS	LTS	LTS
Long-Term Operational-Related Impacts			
Transportation/Traffic			
Short-Term Construction-Related Impacts	LTS	PSU	LTS
Long-Term Operational-Related Impacts	LTS	PSU	LTS
Utilities and Service Systems			
Short-Term Construction-Related Impacts	NA	NA	NA
Long-Term Operational-Related Impacts	LTS	PSU	LTS
Notes: B = Beneficial; LTS = Less-than-Significant; HFCs=Hydrofluorocarbons; NA = Not Applicable; PSU = Potentially Significant and Unavoidable After Mitigation.			

Appendix F: Supporting Documentation for the Economic Assessment of Measures in the SLCP Strategy

Supporting Documentation for the Economic Assessment of Measures in the SLCP Strategy

This Appendix presents technical information and calculations that support the economic analysis in Chapter VIII of the SLCP Strategy. Appendix F contains information for three measures for which there is great potential for low-cost emission reductions. Reducing methane from dairy manure, diversion of landfilled organic waste, and hydrofluorocarbon (HFC) emission reductions all have large economic and environmental potential as outlined in the subsequent sections.

A. Methane Emission Reductions from Dairy Manure

The dairy economic analysis presented in Section VIII of the SLCP Strategy, examined five mitigation pathways and two sector wide cost bounding scenarios to achieve a 22 MMTCO2e (20-yr GWP) reduction in dairy manure methane in 2030. This appendix provides more detail about the assumptions and calculation methodologies used for these analyses. First, each pathway is described along with a summary of the assumptions used to calculate capital costs, annual operations and maintenance (O&M), and annual revenue (Table 1 through Table 8). Next, a more detailed breakout of the total capital costs, annual O&M, and annual revenue for an example 2,000 cow dairy are provided for each pathway (Table 9 through Table 16). Finally, additional detail is provided for the two sector-wide economic analyses that we used to bound the estimate for total costs to reduce dairy manure methane by 22 MMTCO2e (20-yr GWP) in 2030 (Table 17 through Table 19).

List of Tables Related to Methane Emission Reductions from Dairy Manure

1. Cost Analysis Methodology

Five potential pathways to reduce manure methane emissions were analyzed. Not every pathway may be feasible for every dairy, and a variety of pathways will be employed to reach the targets. These pathways do not represent an exhaustive list of mitigation options and variations may be used by some dairies. The assumptions used to analyze these pathways are subject to uncertainty and any actual project cost will vary from the estimate here. The five pathways include:

1) Scrape conversion and onsite manure digestion producing:
   a) electricity or
   b) pipeline-injected renewable natural gas vehicle fuel
2) Scrape conversion and transport of manure offsite for centralized digestion producing:
   a) electricity or
   b) pipeline injected renewable natural gas as a vehicle fuel
3) Retain existing manure lagoon management with onsite covered lagoon digestion producing:
   a) electricity or
   b) pipeline-injected renewable natural gas vehicle fuel
4) Conversion of dairy operations to pasture-based management
5) Scrape conversion, collection and open solar drying of manure onsite

Pathway 1 assumes solid manure management, which includes solid scrape and vacuum systems. There is a cost for dairies that use anaerobic lagoons to convert to solid systems. Each dairy uses an above ground tank or plug-flow digester to produce biogas. The biogas use was analyzed for two sub-pathways: 1a assumed electricity production, and 1b assumed biogas was converted to transportation fuel. In pathway 1a, electricity was produced by a microturbine with the intention to emit less local NOx emissions compared to an internal combustion reciprocating engine generator. In pathway 1b biogas is injected into the transmission pipeline. Table 1 contains a summary of costs and revenues for Pathway 1a and Table 2 contains a summary of costs and revenue for Pathway 1b.

Table 1: Summary of Assumptions for Dairy Pathway 1a
- Scrape Conversion and Onsite Manure Digestion Producing Electricity

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion[1]	$350 per milking head	3%	ARB Estimated Value
Digester and Microturbine with Electricity Equipment	Cost per head = 18,431*[# milking head]^-0.275	8.5%	UC Davis Report
Interconnection	$1,000,000	5%	Suscon Report
Biogas Upgrading	Included in O&M	$6 per 1,000 SCF biogas[2]	

Revenue		
Item	**Value**	**Reference**
Electricity Generation	0.123 kW per milking cow	UC Davis Report and ARB Inventory assuming 100% methane utilization
SB1122 Electricity Tariff Price	$ 0.1263 per kWh	SB1122 Feed in Tariff Price[3]
Mitigatable methane (lagoon management)	7.38 metric tons CO_2e per milking head per year (100-yr GWP)	ARB GHG Inventory
Mitigatable methane (other management)	2.13 metric tons CO_2e per milking head per year (100-yr GWP)	ARB GHG Inventory
Cap-and-Trade Offset	$13 per ton CO_2e mitigated (100-yr GWP)	Estimate
Soil Amendment	$0[4]	

[1] Scrape conversion costs were only assumed for lagoon manure management. Other manure management types were assumed to require no capital to convert to solid manure management.
[2] These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
[3] https://www.pge.com/en_US/for-our-business-partners/floating-pages/biomat/biomat.page
[4] Soil amendments were assumed to have zero value due to uncertainty in future markets, but could provide additional revenue.

Table 2: Summary of Assumptions for Dairy Pathway 1b - Scrape Conversion and Onsite Manure Digestion Producing Pipeline-Injected Renewable Natural Gas

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion[5]	$350 per milking head	3%	ARB Estimated Value
Digester without Electricity Equipment	Cost per head = 64% * 18,431*[# milking head]^-0.275	6%	UC Davis Report and Suscon Report[6]
Interconnection	$2,000,000	5%	Suscon Report
Pipeline	$200,000 per mile	5%	Suscon Report[7]
Biogas Upgrading	Included in O&M	$8 per 1,000 SCF biogas[8]	Suscon Report

Revenue		
Item	**Value**	**Reference**
Biomethane production	21,601 cubic feet per milking cow per year	UC Davis Report[9]
Biogas price	$ 3.46 per 1,000 cubic feet	
RIN Credits (above ground or plug-flow digester)	145 RINS per cow per year	LCFS LHV for CA ULSD of 127,460 Btu and 77,500 Btu per RIN under RFS2
RIN Credit Price	$1.85 per RIN credit	Estimate
LCFS Credit Price	$100	Estimate
Soil Amendment	$0[10]	

Pathway 2 is similar to Pathway 1, except centralized digesters are used instead of individual digesters on each dairy, and only dairies using anaerobic lagoon manure management are included in the analysis. ARB staff selected 55 centralized locations that would pull from 1.05 million dairy cows to digest manure and inject it into the pipeline. The number and location of centralized facilities was estimated, but not optimized, and there may be configurations that could reduce collective costs among clustered dairy farmers more than shown here. As modeled, the statewide scenario required building approximately 200 miles of low-pressure pipeline and 55 miles of new natural gas transmission pipeline. The average centralized digester was fed by approximately 40 truckloads of manure per day, with the trucks traveling an average round-trip distance of approximately 7 miles per load. This analysis includes assumed costs for new low-NOx CNG trucks, a small fleet refueling station for each cluster, and hauling costs. The number of trucks needed was estimated assuming 1 roundtrip per hour running 7.5 hours per day hauling 33.2 tons of manure per trip. The central digesters are assumed to be plug-flow or above ground tank digester types. The biogas use was analyzed for two sub-pathways: 2a assumed electricity production, and 2b

[5] Scrape conversion costs were only assumed for lagoon manure management. Other manure management types were assumed to require no capital to convert to solid manure management.
[6] O&M assumed to be lower than electricity generating pathways because there is no electricity generating equipment
[7] Low pressure rural pipeline
[8] These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
[9] Above ground tank or plug flow with uncovered effluent pond, adjusted to assume 100% of manure volatile solids reached the digester.
[10] Soil amendments were assumed to have zero value due to uncertainty in future markets but could provide additional revenue.

assumed biogas was converted to transportation fuel. In pathway 2a, electricity was produced by a microturbine with the intention to emit less local NOx emissions compared to an internal combustion reciprocating engine generator. In pathway 2b, a portion of the transportation fuel was used in a small local station to fuel manure hauling trucks and a portion was injected into the transmission pipeline. Costs and revenue are distributed among the dairies in a cluster according to milking population. Table 3 contains a summary of costs and revenues for Pathway 2a and Table 4 contains a summary of costs and revenue for Pathway 2b.

Table 3: Summary of Assumptions for Dairy Pathway 2a - Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Electricity

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion	$350 per milking head	3%	ARB Estimated Value
Digester and Microturbine with Electricity Equipment	Cost per head = 18,431*[# milking head]^-0.275	8.5%	UC Davis Report
Interconnection	$5,500,000 per cluster	3.5%	Suscon Report
Biogas Upgrading	Included in O&M	$2 per 1,000 SCF biogas[11]	
Low NOx Natural Gas Truck Purchase	$250,000 each	Assumed to be included in trucking costs below	Suscon Report
Manure transport cost		$2 per mile plus $15 per trip	Compilation[12]
Constants			
Manure trips	1 truckload per hour 7.5 hours per day	Estimate based on average trip distance from GIS analysis	
Manure per cow	140 lbs per day (wet)	UC Davis[13]	
Manure hauling capacity	33.2 tons (wet) per trip	Calculation[14]	

Revenue		
Item	**Value**	**Reference**
Electricity Generation	0.123 kW per milking cow	UC Davis Report and ARB Inventory assuming 100% methane utilization
SB1122 Electricity Tariff Price	$ 0.1263 per kWh	SB1122 Feed in Tariff Price[15]
Mitigatable methane (lagoon management)	7.38 metric tons CO_2e per milking head per year (100-yr GWP)	ARB GHG Inventory
Cap-and-Trade Offset	$13 per ton CO_2e mitigated (100-yr GWP)	Estimate
Soil Amendment	$0[16]	

[11] These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
[12] $2 per mile is based on California rates from http://www.dat.com/resources/trendlines/van/west-regional-rates and rounded up to assume it includes added incremental cost of ultra-low NOx natural gas truck. $15 per trip covers future minimum wage, assuming 1 trip per hour. Trip costs were calculated using the amount of manure produced, the number of truckloads needed and the round trip distance to the central digester.
[13] http://energy.ucdavis.edu/files/09-16-2014-08_Biomass_Resource-and-Facilities-Database-Update.pdf
[14] Assuming a truck can haul 40 cubic yards and manure is 62 pounds per cubic foot (wet) from http://pss.uvm.edu/vtcrops/articles/ManureCalibration.pdf, http://www.mastersonloam.com/trucks/ and http://www.calrecycle.ca.gov/SWFacilities/Directory/38-AA-0020/Document/298055
[15] https://www.pge.com/en_US/for-our-business-partners/floating-pages/biomat/biomat.page
[16] Soil amendments were assumed to have zero value due to uncertainty in future markets but could provide additional revenue.

Table 4: Summary of Assumptions for Dairy Pathway 2b - Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Pipeline-Injected Renewable Natural Gas

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion	$350 per milking head	3%	ARB Estimated Value
Digester with No Electricity Equipment	Cost per head = 64% * 18,431*[# milking head]^-0.275	6%	UC Davis Report and Suscon Report[17]
Interconnection	$5,500,000 per cluster	3.5%	Suscon Report
Biogas Upgrading	Included in O&M	$6 per 1,000 SCF biogas[18]	
Low NOx Natural Gas Truck Purchase	$250,000 each	Assumed to be included in trucking costs below	Suscon Report
Manure transport cost		$2 per mile plus $15 per trip	Compilation[19]
Pipeline	$200,000 per mile	5%	Suscon Report[20]
Transmission Pipeline	$1,000,000 per mile	5%	SoCal Gas[21]
Small CNG Station	$150,000 each, 1 per cluster	10%	Suscon Report
Constants			
Manure trips	1 truckload per hour 7.5 hours per day	Estimate based on average trip distance from GIS analysis	
Manure per cow	140 lbs per day (wet)	UC Davis[22]	
Manure hauling capacity	33.2 tons (wet) per trip	Calculation[23]	

Revenue		
Item	**Value**	**Reference**
Biomethane production	21,601 cubic feet per milking cow per year	UC Davis Report[24]
Biogas price	$ 3.46 per 1,000 cubic feet	
RIN Credits (above ground or plug-flow digester)	145 RINS per cow per year	LCFS LHV for CA ULSD of 127,460 Btu and 77,500 Btu per RIN under RFS2
RIN Credit Price	$1.85 per RIN credit	Estimate
LCFS Credit Price	$100	Estimate
Soil Amendment	$0[25]	

[17] O&M assumed to be lower than electricity generating pathways because there is no electricity generating equipment

[18] These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.

[19] $2 per mile is based on California rates from http://www.dat.com/resources/trendlines/van/west-regional-rates and rounded up to assume it includes added incremental cost of ultra-low NOx natural gas truck. $15 per trip covers future minimum wage, assuming 1 trip per hour. Trip costs were calculated using the amount of manure produced the number of truckloads needed and the round trip distance to the central digester.

[20] Low pressure rural pipeline connecting central digester to the transmission pipeline.

[21] SoCal Gas suggests pipelines might cost $200-300 per foot near roadways (http://americanbiogascouncil.org/webinars/22may14_pipelineBiogasCA.pdf), which would translate to about $1-$1.5 million per mile. 55 miles of transmission pipeline extensions are assumed to be needed, and costs are divided among all clusters by milking population.

[22] http://energy.ucdavis.edu/files/09-16-2014-08_Biomass_Resource-and-Facilities-Database-Update.pdf

[23] Assuming a truck can haul 40 cubic yards and manure is 62 pounds per cubic foot (wet) from http://pss.uvm.edu/vtcrops/articles/ManureCalibration.pdf, http://www.mastersonloam.com/trucks/ and http://www.calrecycle.ca.gov/SWFacilities/Directory/38-AA-0020/Document/298055

[24] Above ground tank or plug flow with uncovered effluent pond, adjusted to assume 100% of manure volatile solids reached the digester.

[25] Soil amendments were assumed to have zero value due to uncertainty in future markets but could provide additional revenue.

Pathway 3 assumes individual dairies retain existing anaerobic lagoon manure management and collect biogas from the covered lagoons. Only dairies already using anaerobic lagoon manure management are included in this scenario. Biogas use was analyzed for two sub-pathways: 3a assumed electricity production, and 3b assumed biogas was converted to transportation fuel. In pathway 3a, electricity was produced by a micro turbine to reduce local NOx emissions. In pathway 3b, transportation fuel was injected into the transmission pipeline. Pipeline injection of renewable natural gas avoids new onsite NOx generation that would occur from on-site electricity generation. Table 5 contains a summary of costs and revenues for Pathway 3a and Table 6 contains a summary of costs and revenue for Pathway 3b.

Table 5: Summary of Assumptions for Dairy Pathway 3a – Covered Lagoon Manure Management with Collected Methane Producing Electricity

Costs			
Item	**Capital**	**O&M**	**Reference**
Covered Lagoon Digester	Cost per head = 12,146*[# milking head]^-0.25	6%	UC Davis Report
Interconnection	$1,000,000	5%	Suscon Report
Biogas Upgrading	Included in O&M	$6 per 1,000 SCF biogas[26]	

Revenue		
Item	**Value**	**Reference**
Electricity Generation	0.066 kW per milking cow	UC Davis Report[27]
SB1122 Electricity Tariff Price	$ 0.1263 per kWh	SB1122 Feed in Tariff Price[28]
Mitigatable methane (lagoon management)	7.38 metric tons CO_2e per milking head per year (100-yr GWP)	ARB GHG Inventory
Cap-and-Trade Offset	$13 per ton CO_2e mitigated (100-yr GWP)	Estimate
Soil Amendment	$0[29]	

[26] These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
[27] Adjusted to match biogas production assumptions. Covered lagoon digesters are approximately 11 percent less efficient at biogas production per pound of manure based on the UC Davis Report, and 40% of manure volatile solids are assumed to be lost during solids separation.
[28] https://www.pge.com/en_US/for-our-business-partners/floating-pages/biomat/biomat.page
[29] Soil amendments were assumed to have zero value due to uncertainty in future markets, but could provide additional revenue.

Table 6: Summary of Assumptions for Dairy Pathway 3b – Covered Lagoon Manure Management with Collected Methane Producing Pipeline-Injected Renewable Natural Gas

Costs			
Item	**Capital**	**O&M**	**Reference**
Covered Lagoon Digester	Cost per head = 12,146*[# milking head]^-0.25	6%	UC Davis Report
Interconnection	$2,000,000	5%	Suscon Report
Pipeline	$200,000 per mile	5%	Suscon Report[30]
Biogas Upgrading	Included in O&M	$8 per 1,000 SCF biogas[31]	Suscon Report

Revenue		
Item	**Value**	**Reference**
Biomethane production	11,520 cubic feet per milking cow per year	UC Davis Report[32]
Biogas price	$ 3.46 per 1,000 cubic feet	
RIN Credits (covered lagoon)	77.4 RINS per cow per year	Calculation[33]
RIN Credit Price	$1.85 per RIN credit	Estimate
LCFS Credit Price	$100	Estimate
Soil Amendment	$0[34]	

Pathway 4 assumed some dairies could convert to a pasture-based model where manure decays aerobically in the field and emits a negligible amount of methane. GIS analysis was used to analyze existing land area associated with dairies and to estimate the remaining amount of land purchase needed to meet the target cow density. Resulting diet changes are assumed to increase enteric emissions and reduce milk production. The impact of these effects on cost effectiveness was assessed by assuming manure methane reductions were partially offset by a 35 percent increase in enteric emissions. Revenue loss from decreased milk production was not directly accounted for due to a lack of information on this effect. Little information is available on the economics associated with converting to pasture, and most of the capital and operations and maintenance costs are assumptions based on ARB staff best estimates, review of limited studies, or direct calls to manufacturers. Table 7 contains a summary of assumptions used to calculate costs for Pathway 4; the pathway does not produce any new revenue.

30 Low pressure rural pipeline

31 These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.

32 Lagoon digester, assumes 60% of manure volatile solids reaches digester because 40% are lost in solids separation.

33 Uses the same assumptions as for above ground tank or plug-flow (LCFS LHV for CA ULSD of 127,460 Btu and 77,500 Btu per RIN under RFS2) but adjusted for the 11% reduction in biogas efficiency for covered lagoon compared to above ground or plug-flow digesters based on UC Davis report and 40% reduction in volatile solids reaching the lagoon due to solids separation

34 Soil amendments were assumed to have zero value due to uncertainty in future markets but could provide additional revenue.

Table 7: Summary of Assumptions for Dairy Pathway 4 – Conversion to Pasture

Costs			
Item	**Capital**	**O&M**	**Reference**
Land Purchase	$7,700 per acre	n/a	USDA[35]
Fencing	$1.07 per foot	2.5%	ARB Analysis[36]
Irrigation	$5,000 per acre	10%	ARB Analysis
Shade Structures	$6,500 per structure	2.5%	ARB Analysis
Water Troughs	$180 per parcel	1%	ARB Analysis

Constants		
Item	**Value**	**Reference**
Milking Cow Density	3 cows per acre	
Parcel Size	5 acres	
Additional Acres to Purchase	200,000 acres	ARB GIS Analysis
Fencing per Parcel	1,980 feet	
Water Troughs per Parcel	1	
Shade Structures per Parcel	1	

Pathway 5 assumes all dairies use open solar drying of manure for 8 months of the year. This pathway may be an option for dairy operations not suitable for digestion or not near natural gas pipelines or transportation corridors to sell fuel, or for dairy farmers that wish to avoid the complexity of digester operation, power purchase agreements, and utility interconnections. This method could reduce methane emissions by minimizing anaerobic manure processing and storage. Dairies that used anaerobic lagoons require conversion to solid scrape or vacuum manure management. This process can potentially produce compost for sale, but costs and revenues associated with that operation are not included here. Table 8 contains a summary of assumptions used to calculate costs for Pathway 5.

Table 8: Summary of Assumptions for Dairy Pathway 5 – Scrape Conversion and Solar Drying

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion[37]	$350 per milking head	3%	ARB Estimated Value
Land and concrete drying pads	$400 per milking head	4.5%	UC Davis Report[38]

[35] USDA Land Values 2015 Summary http://usda.mannlib.cornell.edu/usda/nass/AgriLandVa//2010s/2015/AgriLandVa-08-05-2015.pdf

[36] ARB staff determined typical costs from studies and calls to manufacturers for estimates. Operations and maintenance was estimated based on the complexity of the system.

[37] Scrape conversion costs were only assumed for lagoon manure management. Other manure management types were assumed to require no capital to convert to solid manure management.

[38] Capital cost per cow represents interpolated value between 1,500 and 3,000 cow values for scrape to open solar drying (8 months) pathway in UC Davis study. O&M based on O&M as a function of total average cost in UC Davis pathway.

2. Costs and Revenues for an Example 2,000 Milking Cow Dairy

An economic analysis was performed for each pathway on a dairy-by-dairy basis to account for cost differences between dairies of different sizes. However, to provide an overview comparison by pathway, the costs and revenues for an example 2,000 cow dairy that manages manure using anaerobic lagoons were analyzed. The effect of regulation on this theoretical project was also analyzed. The pre regulation scenario assumes the project is operating before regulation that would affect revenue, and all revenue is available for the full 10 year analysis timeframe. The post regulation scenario assumes the project begins operating after regulation, which affects some revenue streams. Once a regulation to control manure emissions is in place, LCFS credits for new dairy digester projects no longer include credit for capturing and utilizing methane that would have otherwise been emitted into the atmosphere, which reduces the LCFS revenue by approximately 90 percent. The negative carbon intensity, or "negative CI" LCFS credit prices are more valuable, as they include additional credit for capturing and utilizing methane that would have otherwise been emitted into the atmosphere.[39] Additionally, cap and trade offset credits would no longer be available after regulation.

Tables 9 through Table 16 provide a detailed breakdown of costs and revenues for the example 2,000 cow dairy for each pathway. Total capital costs, annual operations and maintenance (O&M) costs, and annual revenues are provided for each pathway, considering the two regulation scenarios. Two values are listed for revenues affected by regulation; one if the project began operating before regulation ("Pre reg") and one if the project began operating after regulation ("Post reg").

The net present value (NPV) is calculated assuming capital costs are amortized over 10 years with 7% interest, and includes 10 years of annual O&M and revenue. All costs and revenues used for NPV calculations are discounted at 5% per year. If applicable, NPV is calculated for two scenarios: a project that begins operating before regulation, and a project that begins operating after regulation. If a project begins operating before regulation is in place, revenue is assumed to be at the "Pre reg" value for all 10-years of the analysis. If the project begins operating after regulation is in place, revenue is assumed to be at the "Post reg" value for all 10-years.

Assumptions used to calculate these costs are summarized by pathway in Table 1 through Table 8. Note that the values in Table 9 through Table 16 may not add precisely due to rounding.

[39] The negative carbon intensity, or "negative CI" LCFS credits are available for projects that begin operating before regulation and are more valuable because they include additional revenue for capturing and utilizing methane that would have otherwise been emitted into the atmosphere. The positive carbon intensity or "positive CI" LCFS credits are available for projects that begin operating after regulation and are less valuable because the capture and destruction of methane. Any sources with a regulatory requirement to reduce emissions cannot receive credits for those reductions.

Table 9: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 1a - Scrape Conversion and Onsite Manure Digestion Producing Electricity

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Digester with Microturbine	$4,538,000	$386,000	
Interconnection	$1,000,000	$50,000	
Biogas Upgrading		$86,000	
Electricity Generation			$271,000
Cap-and-Trade Offset			Pre reg: $191,000 Post reg: $0
Total	**$6,234,000**	**$543,000**	**Pre reg: $461,000 Post reg: $271,000**
NPV Pre-Regulation (10yrs)	**-$7,481,000**		
NPV Post-Regulation (10yrs)	**-$8,954,000**		

Table 10: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 1b - Scrape Conversion and Onsite Manure Digestion Producing Pipeline-Injected Renewable Natural Gas

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Digester	$2,905,000	$174,000	
Pipeline	$914,000	$46,000	
Interconnection	$2,000,000	$100,000	
Biogas Upgrading		$344,000	
Fuel			$149,000
RINs			$533,000
LCFS Credits			Pre reg: $865,000 Post reg: $110,000
Total	**$6,514,000**	**$684,000**	**Pre reg:$1,547,000 Post reg: $792,000**
NPV Pre-Regulation (10yrs)	**-$503,000**		
NPV Post-Regulation (10yrs)	**-$6,333,000**		

Table 11: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 2a - Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Electricity

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Digester with Microturbine*	$4,538,000	$386,000	
Low NOx Truck Purchase*	$140,000		
Manure Hauling		$95,000	
Interconnection*	$849,000	$30,000	
Biogas Upgrading*		$86,000	
Electricity			$271,000
Cap-and-Trade Offsets			Pre reg: $191,000 Post reg: $0
Total	**$6,223,000**	**$617,000**	**Pre reg: $461,000** **Post reg: $271,000**
NPV Pre-Regulation (10yrs)	**-$8,042,000**		
NPV Post-Regulation (10yrs)	**-$9,515,000**		

*Costs are shared among dairies in the cluster, these costs represent a share of the total

Table 12: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 2b - Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Pipeline-Injected Renewable Natural Gas

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Digester without Microturbine*	$2,905,000	$174,000	
Low NOx Truck Purchase*	$140,000		
Manure Hauling		$95,000	
Interconnection*	$849,000	$30,000	
Pipeline (rural low pressure)*	$75,000	$4,000	
Pipeline (transmission)*	$103,000	$5,000	
Biogas Upgrading*		$258,000	
CNG Station (small)*	$23,000	$2,000	
Fuel			$149,000
RIN Credits			$533,000
LCFS Credits			Pre reg: $865,000 Post reg: $ 110,000
Total	**$4,792,000**	**$588,000**	**Pre reg: $1,547,000** **Post reg: $792,000**
NPV Pre-Regulation (10yrs)	**$2,132,000**		
NPV Post-Regulation (10yrs)	**-$3,698,000**		

*Costs are shared among dairies in the cluster, these costs represent a share of the total

Table 13: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 3a – Covered Lagoon Manure Management with Collected Methane Producing Electricity

Component	Total Capital	Annual O&M	Annual Revenue
Covered Lagoon Digester	$3,616,000	$217,000	
Interconnection	$1,000,000	$50,000	
Biogas Upgrading		$258,000	
Electricity			$144,000
Cap-and-Trade Offsets			Pre reg: $191,000 Post reg: $0
Total	**$4,616,000**	**$525,000**	**Pre reg: $335,000** **Post reg: $144,000**
NPV Pre-Regulation (10yrs)	**-$6,538,000**		
NPV Post-Regulation (10yrs)	**-$8,010,000**		

Table 14: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 3b – Covered Lagoon Manure Management with Collected Methane Producing Pipeline-Injected Renewable Natural Gas

Component	Total Capital	Annual O&M	Annual Revenue
Covered Lagoon Digester	$3,616,000	$217,000	
Interconnection	$2,000,000	$100,000	
Rural Low Pressure Pipeline	$914,000	46,000	
Fuel			$79,000
RIN Credits			$285,000
LCFS Credits			Pre reg: $831,000 Post reg: $ 59,000
Total	**$4,792,000**	**$588,000**	**Pre reg: $1,195,000** **Post reg: $423,000**
NPV Pre-Regulation (10yrs)	**-$3,404,000**		
NPV Post-Regulation (10yrs)	**-$9,369,000**		

Table 15: Estimated Costs for a 2,000 Cow Dairy: Pathway 4 – Conversion to Pasture

Component	Total Capital	Annual O&M	Annual Revenue
Land Purchase	$2,041,000		
Fencing	$281,000	$7,000	
Irrigation	$3,313,000	$331,000	
Water Troughs	$24,000	$200	
Shade	$861,000	$22,000	
Total	**$6,520,000**	**$360,000**	**$0**
NPV* (10yrs)	**-$9,949,000**		

*NVP is the same regardless of regulation

Table 16: Estimated Costs for a 2,000 Cow Dairy: Pathway 5 – Scrape Conversion and Solar Drying

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Concrete Drying Pads and Land	$795,000	$36,000	
Total	**$1,491,000**	**$57,000**	**$0**
NPV* (10yrs)		**-$2,077,000**	

*NVP is the same regardless of regulation

3. Costs and Revenues for Sector-Wide Scenarios

Two pathways were selected to bound potential sector-wide cost and revenue from mitigation of dairy manure. Dairy operations were assumed to choose the pathway with the highest net present value if LCFS and RIN credits were available (2b – central digestion producing transportation fuels), or the lowest cost option in the absence of revenue (5 – scrape conversion). This provides a likely cost bounding considering scenarios with and without LCFS and RIN credits. It is important to note that these scenarios were selected as an economic bounding exercise, and they are not intended to suggest a preferred or expected path forward. Actual implementation of any regulatory requirements will likely include a suite of potential mitigation options.

The sector-wide scenarios use the same assumptions as the individual pathways, but aggregate cumulative costs and revenues from 2017 through 2030, based on individual dairy economics assuming a model build out timeline. There are additional costs and benefits after 2030, but these are not included in the analysis. The effect of regulation timing on revenue was also analyzed. Regulation affects the value of LCFS credits and cap-and-trade offsets, thus has an impact on the overall economics of pathway 2b, but not pathway 5, which has no revenue. Specific assumptions used for each sector-wide scenario can be found in Table 17 and Table 19.

A summary of cluster implementation schedule, costs, and revenues for sector-wide scenario 2b can be found in Table 17. All costs and revenues through 2030 were included in the calculation, though there would be additional costs, revenue and methane mitigation after 2030. Upfront capital represents the amount of capital needed to finance the new projects in a given year. This upfront capital is paid back as annual loan amortized over 10 years at 7 percent interest and a 5 percent discount rate. The annual capital spent by all dairies represents the total loan payment in a given year across all dairies. Annual O&M and revenue were assessed for each dairy and each year through 2030, with 5% discounting.

Table 17: Annual Build Out Schedule, Costs, and Revenue for Sector-Wide Scenario 2b - Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Pipeline-Injected Renewable Natural Gas [40]

Year	New Clusters	Dairies in New Clusters	Milking Head in New Clusters	Upfront Capital for New Clusters	Annual Capital Spent, All Dairies	Annual O&M Spent, All Dairies	Annual LCFS Revenue, All Dairies			RIN Credit Revenue	Other Revenue
							No Reg	2026 Reg	2024 Reg		
2017	1	7	32,070	$58	$8	$8	$14	$14	$14	$9	$2
2018	3	21	79,018	$143	$28	$25	$46	$46	$46	$28	$8
2019	4	31	89,109	$164	$50	$44	$79	$79	$79	$49	$14
2020	3	36	75,430	$138	$67	$59	$104	$104	$104	$64	$18
2021	4	42	96,136	$166	$88	$76	$133	$133	$133	$82	$23
2022	4	32	59,584	$108	$99	$85	$147	$147	$147	$91	$25
2023	4	37	88,521	$140	$114	$98	$169	$169	$169	$104	$29
2024	5	38	86,974	$136	$128	$110	$188	$188	$164	$116	$32
2025	4	50	94,631	$140	$142	$121	$207	$207	$160	$127	$35
2026	4	45	71,722	$108	$151	$128	$217	$199	$155	$134	$37
2027	4	52	73,207	$107	$154	$134	$217	$184	$141	$139	$39
2028	4	34	53,875	$77	$145	$136	$201	$157	$116	$141	$39
2029	6	52	75,503	$105	$139	$141	$188	$130	$91	$146	$41
2030	5	66	76,712	$104	$135	$146	$179	$109	$72	$150	$42
Total	**55**	**543**	**1,052,492**	**$1,694**	**$1,448**	**$1,312**	**$2,087**	**$1,863**	**$1,591**	**$1,379**	**$384**

LCFS revenue was assessed for three regulation scenarios: 1) no regulation, 2) 2026 regulation, and 3) 2024 regulation. Regulation effective dates were assumed to be January 1st of the regulation year. A summary of LCFS calculation for each regulation scenario can be found in Table 18. Any project started before the effective date of the regulation receives LCFS credits at the “negative CI” including methane destruction for 10 years. After 10 years the dairy no longer receives credit for methane destruction which reduces LCFS revenue for any remaining year through 2030. Some dairies could potentially reapply for LCFS methane destruction credits for an additional 10 years. This option was excluded for simplicity, and due to uncertainty in the number of projects that would reapply. Projects established after regulation receive the positive CI LCFS price for all years through 2030. In the no regulation case, all projects receive LCFS credits including methane destruction for up to10 years then drop down to the lower LCFS revenue for any remaining years through 2030.

[40] All costs and revenue in millions of dollars, and discounted at 5% per year.

Table 18: LCFS Revenue Assumptions for Three Regulation Scenarios[41]

	No Regulation	Regulation 2026	Regulation 20204
Cluster Established Before Regulation	Up to 10-years of LCFS credit at negative CI, remaining years through 2030 at positive CI	Up to 10-years of LCFS credit at negative CI, remaining years through 2030 at positive CI	Up to 10-years of LCFS credit at negative CI, remaining years through 2030 at positive CI
Cluster Established After Regulation	n/a	LCFS credit for all years at positive CI	LCFS credit for all years at positive CI

A summary of dairy implementation schedule, costs, and revenues for sector-wide scenario 5 can be found in Table 19. As in Table 17, upfront capital represents the amount of capital needed to finance the new projects in a given year. This upfront capital is paid back as annual loan amortized over 10 years at 7 percent interest and a 5 percent discount rate. The annual capital spent by all dairies represents the total loan payment in a given year across all dairies. Annual O&M and revenue were assessed for each dairy and each year through 2030, with 5% discounting.

[41] The negative carbon intensity, or "negative CI" LCFS credits are available for projects that begin operating before regulation and are more valuable because they include additional revenue for capturing and utilizing methane that would have otherwise been emitted into the atmosphere. The positive carbon intensity or "positive CI" LCFS credits are available for projects that begin operating after regulation and are less valuable because the capture and destruction of methane. Any sources with a regulatory requirement to reduce emissions cannot receive credits for those reductions.

Table 19: Annual Build Out Schedule, Costs, and Revenue for Sector-Wide Scenario 5 - Scrape Conversion and Solar Drying

Year	New Scrape Conversion Projects	Milking Head in New Projects	Upfront Capital for New Projects	Annual Capital Spent, All Dairies	Annual O&M Spent, All Dairies
2017	4	34,363	$26	$4	$1
2018	14	78,714	$56	$11	$3
2019	18	85,430	$58	$19	$5
2020	20	81,038	$53	$26	$7
2021	26	90,865	$56	$33	$9
2022	19	59,383	$35	$36	$10
2023	33	91,977	$51	$42	$11
2024	35	86,682	$46	$46	$12
2025	44	94,306	$48	$51	$14
2026	40	73,957	$36	$53	$14
2027	45	71,123	$33	$53	$15
2028	40	53,114	$23	$49	$15
2029	65	73,293	$31	$46	$15
2030	90	78,488	$31	$44	$16
Total	**493**	**1,052,733**	**$583**	**$513**	**$147**

B. Methane Emission Reductions from Landfill Organic Waste Diversion

Achieving California’s methane reduction targets requires optimizing the use and disposal of methane generating organic materials. To that end, the SLCP Strategy recommends reducing organics deposited to landfills 50 percent from 2014 levels by 2020 and 75 percent from 2014 levels by 2025, consistent with SB 1383. These ambitious targets require putting organic materials to the highest feasible use and developing infrastructure and markets to optimize the economic and environmental value of California’s waste streams across sources.

When considering waste diversion options it is essential to balance environmental and economic benefits with any potential impacts on criteria pollutant emissions and ecosystem and human health, especially in disadvantaged communities. Avoiding organic waste generation entirely is the best option to reduce emissions, protect health, and minimize costs. However, once generated, there are many options for creating environmental and economic benefit through the appropriate utilization organic waste. Organics can be diverted to waste facilities with existing excess capacity, including composting facilities, stand-alone anaerobic digesters, and wastewater treatment anaerobic digesters. New facilities can also be built in optimized locations.

This analysis attempts to bound the potential cost of achieving the organic diversion targets outlined in this SLCP Strategy by exploring the use of three types of facilities for the handling of diverted materials. The scenarios are illustrative and do not represent a preferred strategy or technology or the realized mixture of voluntary and regulatory actions that may achieve the organic diversion targets. The final mix of strategies used to meet the organic diversion target cannot be predicted, but will likely involve a variety of facility types analyzed in the three illustrative scenarios.

The analysis begins with the methodology used to estimate the organic waste targets through 2025 and feasible diversion paths. These waste diversion targets and diversion options are then used to develop three scenarios by which California can achieve the targets in SB 1383. The estimated costs and potential revenue streams for each strategy are then discussed.

1. Organic Waste Diversion Targets

SB 1383 requires a 50 percent reduction in the level of statewide disposal of organic waste from the 2014 level by 2020, and a 75 percent reduction from the 2014 level by 2025. The organic diversion targets were calculated using the composition of California's waste stream in 2014,[42] as outlined in Table 4. Organic waste, as defined by AB 1826, includes food waste, green waste, landscape and pruning waste, nonhazardous wood waste, and food-soiled paper waste that is mixed in with food waste.[43] This analysis relies upon existing definitions of what types of materials are considered organics. CalRecycle, in consultation with ARB and stakeholders, will be establishing a definition of organics that is specific to addressing the novel requirements of SB 1383. As such, the targets in this chapter are for illustrative purposes and are subject to change.

Not all paper is included in the AB 1826 definition of organic waste. Compostable paper in Table 20 includes two subcategories that approximate food-soiled paper waste: compostable other miscellaneous paper and compostable remainder/composite paper.[44] The remaining paper in California landfills, while not included in this analysis, is a critical component in achieving the goals of AB 341 and must also be diverted to the highest value usage, including source reduction, reuse, and recycling. To meet the targets required by SB 1383, 50 percent of 2014 organic waste in Table 20 must be diverted by 2020 and 75 percent by 2025.

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[42] The 2014 Disposal-Facility-Based Characterization of Solid Waste in California was produced under contract by Cascadia Consulting Group and released by CalRecycle on October 6, 2015. For the waste characterization utilized in this analysis, see Table 7 in the Significant Tables and Figures document available at: http://www.calrecycle.ca.gov/wastechar/PubExtracts/2014/SigTableFig.pdf.
[43] AB 1826 text available at: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1826&search_keywords.
[44] These subcategories are estimated from the 2014 Disposal-Facility-Based Characterization of Solid Waste in California by CalRecycle.

Table 20: 2014 Organic Waste Characterizations

Waste Type	2014 (wet tons)
Compostable Paper*	2,093,462
Food	5,591,179
Leaves and Grasses	1,172,925
Prunings and Trimmings	962,262
Branches and Stumps	528,493
Lumber	3,676,710
Remainder/Composite Organic	1,323,465
TOTAL	**15,348,496**
2020 Organic Waste Diversion Target	***7,674,248***
2025 Organic Waste Diversion Target	***11,511,372***

a. Waste Diversion or Recovery Pathways

Organic waste in landfills is not homogeneous, and represents different sources, composition, methane generating potential, and challenges for recycling and diversion. As such, not all organic waste can, or should, be handled through the same processes. ARB and CalRecycle collaborated to outline potential diversion strategies by organic waste subcategory to meet the waste diversion targets. For each organic waste subcategory, Table 21 and Table 22 estimate the percentage of material diverted to each type of facility over time to achieve the 2020 or 2025 organic diversion targets, respectively. These diversion options are illustrative and do not represent all pathways that may be employed.

Table 21: Possible Organic Waste Diversion Pathway to Meet 2020 Target

Waste Type	2014 Waste (Wet Tons)	Estimated Distribution of Organic Waste (Wet Tons)					
		Landfill	Reduction or Recycle	Food Recovery	Compost	AD or Compost	Chip & Grind
Compostable Paper	2,093,462	628,039	209,346		1,256,077		
Food	5,591,179	1,146,192		559,118		3,885,869	
Leaves and Grasses	1,172,925	879,694			293,231		
Prunings and Trimmings	962,262	721,697			240,566		
Branches and Stumps	528,493	396,370					132,123
Lumber	3,676,710	2,573,697	183,836				919,178
Remainder/Composite Organic	1,323,465	1,323,465					
2014 TOTAL	**15,348,496**	**7,669,152**	**393,182**	**559,118**	**1,789,874**	**3,885,869**	**1,051,301**
Percent of 2014 Waste		**50%**	**50%**				

Table 22: Possible Organic Waste Diversion Pathway to Meet 2025 Target

Waste Type	2014 Waste (Wet Tons)	Estimated Distribution of Organic Waste (Wet Tons)					
		Landfill	Reduction or Recycle	Food Recovery	Compost	AD or Compost	Chip & Grind
Compostable Paper	2,093,462	628,039	209,346		1,256,077		
Food	5,591,179	385,791		1,118,236		4,087,152	
Leaves and Grasses	1,172,925				586,463	586,463	
Prunings and Trimmings	962,262				962,262		
Branches and Stumps	528,493	396,370					132,123
Lumber	3,676,710	1,103,013	367,671				2,206,026
Remainder/Composite Organic	1,323,465	1,323,465					
2014 TOTAL	**15,348,496**	**3,836,678**	**577,017**	**1,118,236**	**2,804,802**	**4,673,614**	**2,338,149**
Percent of 2014 Waste		**25%**	**75%**				

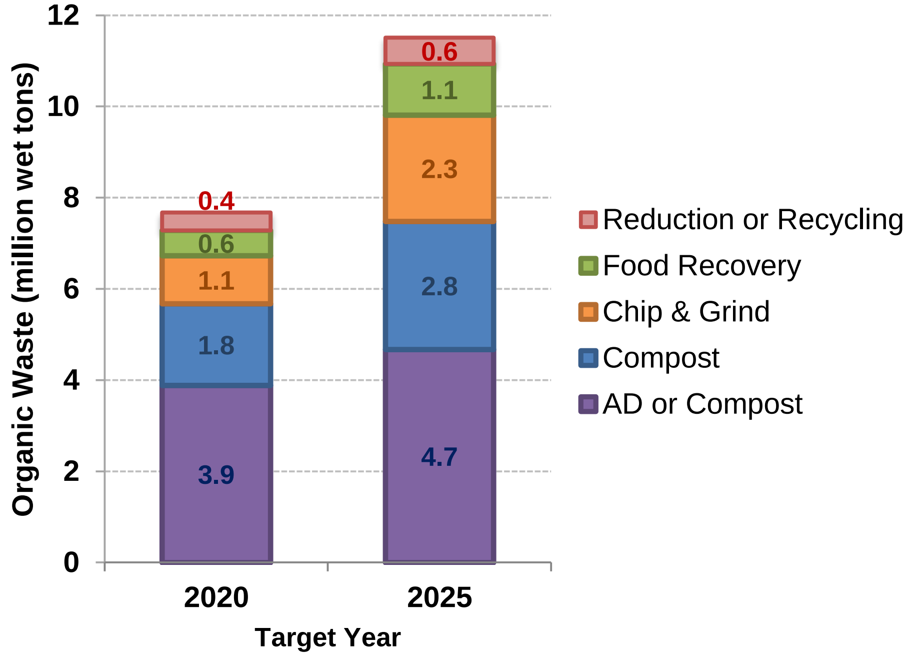
Conventional waste diversion options outlined in Tables 21 and 22 include composting, anaerobic digestion (AD), and chipping or grinding materials (Chip & Grind). In addition, reduction or recycling can be used to avoid waste generation or reuse and recycle the waste before it reaches the landfill. Food recovery is another important strategy that can remove potent methane-generating waste from landfills while minimizing nutritional loss in the food system. The US Department of Food and Agriculture estimates that approximately one-third of all food produced in the United States is not consumed, representing 1,249 calories per person per day.[45] In addition to generalized waste diversion goals, under SB 1383 20 percent of the edible food waste must be recovered for human consumption by 2025. In this SLCP Strategy, food recovery includes:

- Source Reduction - reducing the volume of surplus food generated in households and businesses
- Feeding the Hungry - donating appropriately safe extra food to food banks and shelters

Figure 1 outlines the organic waste diversion by pathway from Tables 21 and 22.

[45] USDA (2014). The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States. Available at: http://www.ers.usda.gov/media/1282296/eib121.pdf.

Figure 1: Proposed Organic Waste Utilization Pathways by Year



Diverting a significant fraction of organic waste from landfills will cause a sharp decline in tipping fee revenue for landfills, which includes governmental fee revenue for both local governments and the State. In 2015, CalRecycle estimated the median tipping fee at California landfills as $45 per ton.[46] Holding this tipping fee constant through 2025 and assuming the organic diversion targets are met, revenue to California landfills could decrease by $345 million in 2020 and $520 million in 2025. This loss in revenue could impact the State's ability to meet existing statutory obligations and thus as California optimizes reduction, diversion, and disposal of waste, additional funding options should be explored that are not solely reliant on landfill fees.

b. Existing Excess Capacity at Waste Treatment Facilities

Leveraging existing excess capacity at California's waste treatment facilities can dramatically reduce the number of new facilities that may be required to handle diverted organic waste and help maximize the environmental and economic potential of organic waste diversion. Existing facilities that may accept organics from landfill include compost facilities, wastewater treatment facilities with anaerobic digestion, and Chip & Grind facilities. Table 23 presents the estimated excess capacity currently available at California wastewater treatment plants with anaerobic digesters and compost facilities. Though Chip & Grind excess capacity is not included in Table 22, CalRecycle estimates that existing Chip & Grind facilities will have sufficient capacity (and there will be

[46] Tipping fees vary by geographic region, type of waste, operational factors and consumer type. The median tipping fee is utilized to reflect the state mass balance of the waste characterization, www.calrecycle.ca.gov/publications/Documents/1520%5C20151520.pdf.

sufficient product demand) to handle all diverted organic materials in this analysis through 2025.

Table 23: Estimated Current Excess Capacity

Facility Type	Estimated Annual Excess Capacity (Wet Tons)
Compost	1,000,000
Wastewater Treatment	7,000,000
Total	**8,000,000**

CalRecycle estimates the excess capacity at existing compost facilities based on the 2014 Disposal-Facility-Based Characterization of Solid Waste in California. To meet the 2025 diversion target, California's compost needs are estimated to range from 3 and 8 million wet tons per year.[47] Therefore, current excess composting capacity of 1 million wet tons per year is insufficient to handle future diversion needs.

US EPA estimates that the nearly 140 wastewater treatment facilities with anaerobic digesters in California have an estimated excess capacity of 15 – 30 percent.[48] The California Association of Sanitation Agencies (CASA) estimates existing excess capacity at wastewater treatment facilities for food waste and fats, oils, and grease is approximately 7 million wet tons per year (Table 23),[49] which could theoretically handle the 4 million wet tons of food waste diverted to AD in 2025 (Table 22) as well as the 600,000 wet tons of leaves and grasses that can be diverted to AD facilities.[50]

Additionally, a geospatial analysis carried out by ARB indicates that food waste and wastewater treatment excess capacity are spatially correlated throughout California, as highlighted in Figure 2. The analysis compared the location of landfilled food waste and wastewater treatment excess capacity to estimate the additional distance food waste would travel from landfill to wastewater treatment plant. The analysis found that all food waste from landfills could theoretically be consumed by wastewater treatment plants within 30 miles. In this analysis, the landfill is treated as the source of waste (including food waste); therefore waste is transported to the nearest landfill where organics are separated, processed, and transported to their final destination including centralized digester, wastewater treatment plant, or compost facility. Alternatively, though this option was not analyzed, food waste could be separated by households, and travel

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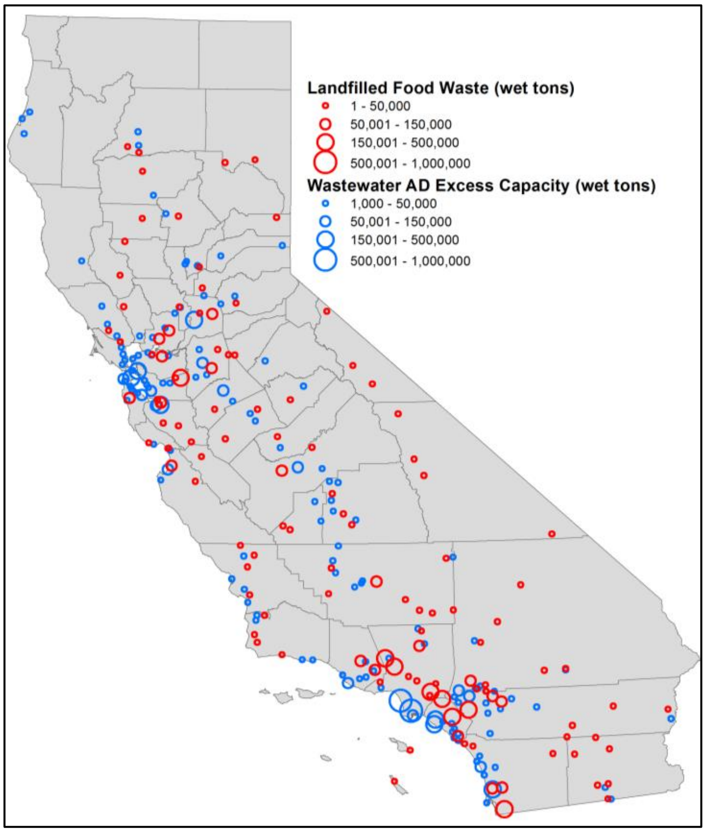
[47] Figure 2, depends on the assumptions for how much waste is utilized by AD.
[48] US EPA (2016). https://www3.epa.gov/region9/waste/features/foodtoenergy/wastewater.html.
[49] Assuming a MCRT of 15 days, CASA estimates that 17 facilities have an existing excess capacity of 5,805,000 gallons per day. The total estimate, when expanded across all facilities in California handling at least a million gallons a day, is estimated as 8,000,000 gallons per day. Applying mass loading for food waste and fats, oils, and grease results in an excess capacity for food waste of 6,035 dry tons per day or 7,342,500 wet tons per year. This information was provided by CASA on November 9, 2015.
[50] Does not include additional facilities needed to handle the potential increase in residual biosolids and assumes that co-digestion at wastewater treatment plans is both technologically and economically feasible for food waste as well as grasses and leaves. This analysis assumes that 100 percent of food waste can feasibly be diverted from landfills.

directly to pre-processing locations, then to wastewater treatment plants with excess capacity. Each of these options results in economic and environmental trade-offs that should be analyzed at the regional level to identify the best course of action. It is likely that a combination of these methods will be utilized, depending on the region.

Figure 2: Co-Location of Landfilled Food Waste and Wastewater Treatment Excess Capacity



2. Scenarios

The three scenarios are based on the potential organic waste diversion options outlined in Tables 21 and 22. All scenarios include the following assumptions:

- Existing excess compost capacity is fully utilized
- New compost facilities are constructed to handle all materials listed under the ‘compost’ heading in Tables 21 and 22
- Each new compost facility has a throughput of 100,000 wet tons per year
- Existing Chip & Grind facilities have capacity to handle all materials projected to be diverted to ‘Chip & Grind’ in Tables 21 and 22
- Food recovery targets are reached (10 percent in 2020 and 20 percent in 2025)

Therefore, the only difference between the scenarios is the waste utilization of food waste and grass and leaves (‘Compost or AD’ in Tables 21 and 22). The three scenarios are described below. The actual future utilization of food waste and grass and leaves will most likely be some mix of these options. Since it is not possible to predict the exact mix of utilization pathways, these three scenarios were developed to bound potential costs and revenues.

Scenario 1 - New Centralized AD Facilities

All 'Compost or AD' food waste, grass and leaves in Tables 21 and 22 are handled by new centralized AD treatment facilities, and the methane is injected to pipelines. It is assumed that there is a modest market for AD digestate, which represents 36 percent of the digested waste. 50 percent of AD digestate are assumed to be disposed of at no cost; i.e., the cost to process and ship the digestate is offset by any potential revenue. The other 50 percent of AD digestate is processed and shipped to compost facilities, and AD facilities pay the cost for transportation and compost tipping fees. This composted digestate requires construction of additional compost facilities. New centralized AD facilities are assumed to accept 100,000 tons of organic material, including both food waste and grass and leaves, per year on average.

Scenario 2 - Existing Wastewater Treatment Plant AD

Scenario 2 assumes that all 'Compost or AD' materials in Tables 21 and 22 are diverted to existing wastewater treatment facilities with AD, utilizing a majority of the estimated existing excess capacity. Upgrading and permitting costs are included for each facility, which could include digester expansion to allow for additional capacity. The scenario assumes there is no market for AD biosolids, which represents 36 percent of total digested waste, and new compost facilities are constructed to handle the residual biosolids. There is a cost to process the biosolids at wastewater treatment plants, and the materials are trucked to new compost facilities. The wastewater treatment plants pay for the cost to transport biosolids to compost facilities and pays tipping fees. It is assumed that, with modification, existing wastewater treatment facilities can accept 50,000 tons of organic material per year on average by 2025, with some facilities accepting more or less depending on size. The 50,000 capacity includes 45,000 wet tons of food waste and up to 5,000 wet tons of grasses and leaves.

Scenario 3 - New Compost Facilities

Scenario 3 assumes that all 'Compost or AD' materials in Tables 21 and 22 are composted at new facilities, after filling existing excess capacity at compost facilities.

Waste Diversion By Scenario

Table 24 estimates the organic waste diverted by pathway for the two target years. The overall waste diverted from landfills is the same in each scenario, but the pathway for diversion differs. Scenarios 1 and 2 require processing of more total organic material, because some portion of AD material is processed twice: once for the AD process and once to compost the biosolids or digestate. This double counting is necessary to accurately predict the number of new composting facilities needed, however, no additional organic material is diverted from the landfill in these scenarios.

Table 24: Organic Waste Utilization by Scenario

Diversion Target Year	Waste Diversion Pathway		Scenario		
			1. New AD	2. Existing WWTP	3. Compost Only
			(Million Wet Tons of Waste)		
2020	Reduction, Recycle, Food Rescue		1.0	1.0	1.0
	Compost	Existing Excess Capacity	1.0	1.0	1.0
		New Facilities	0.8	0.8	4.7
		New Facilities for Biosolids	0.7	1.4	--
	Anaerobic Digestion		3.9	3.9	--
	Chip and Grind		1.1	1.1	1.1
2025	Reduction, Recycle, Food Rescue		1.7	1.7	1.7
	Compost	Existing Excess Capacity	1.0	1.0	1.0
		New Facilities	1.8	1.8	6.5
		New Facilities for Biosolids	0.8	1.7	--
	Anaerobic Digestion		4.7	4.7	--
	Chip and Grind		2.3	2.3	2.3

A principal difference in outcomes from these three scenarios is the number of new facilities needed to achieve the organic diversion targets. Table 25 shows the number of new compost or AD facilities needed for each scenario.

Table 25: Estimated Number of New Facilities

Scenario	Estimated Number of New Compost Facilities		Estimated Number of New AD Facilities	
	2020	2025	2020	2025
1. New AD	15	26	39	47
2. Existing WWTP	22	35	--	--
3. Compost Only	47	65	--	--

3. Facility-Level Cost and Revenue Calculations

This section outlines the facility-specific costs and revenues that underlie the three statewide scenarios for organic diversion. Cost estimates rely on information obtained from California agencies, academic researchers, and industry estimates. This analysis estimates the incremental impact of the scenarios, therefore, only the impact associated with the diverted material is considered. Net present value calculations are used to determine the profitability of the three potential scenarios. By calculating the present value of future cost and organic diversion over a 10-year financing period, the net present value calculation provides insight into the feasibility of projects at the facility level.

There is uncertainty regarding the costs, savings, and potential revenue streams associated with organic waste diversion. Social welfare impacts, including those related to health, noise, odor, ecosystem benefit, and water impacts, are not included in this analysis but require additional consideration and analysis prior to the implantation of any organic diversion measure. Additional uncertainty related to existing infrastructure and technology development may also create economic impacts not analyzed in this analysis, which relies on available data to estimate the direct economic impact, including costs, fuel and energy savings, and potential revenue streams, of achieving California's organic waste diversion target.

This analysis assumes that organic waste is handled through existing collection routes for households, businesses, and industrial entities and no additional costs are incurred from curbside to arrival at the landfill. This assumption, while simplifying, may ignore both costs and efficiencies that result from optimized organic waste disposal within a geographic region.

The costs of diverting organic materials to existing facilities are assumed to be equal across all three scenarios. This analysis assumes that there is no net economic impact from reducing organic waste or diverting organics to existing facilities as detailed in the sections below. Scenario costs vary based on the relative cost of new AD and compost facilities as well as costs associated with retrofitting existing wastewater treatment plants to accept food waste.

a. Education and Outreach

Education and outreach is helpful to support any major change to public systems. While not quantified in this analysis, State and federal funds could contribute to awareness of California's organic waste diversion goals and provide support for organic waste reduction, recycling, and food recovery. Given the uncertainty surrounding measure implementation, these costs are not included in the analysis but represent the potential use of State and federal funding to achieve the organic diversion targets.

b. Food Recovery

The food recovery target in this SLCP Strategy can be achieved through source reduction, diverting food to feed the hungry, and utilizing food scraps as animal feed. A 2016 report estimates that achieving a national 20 percent reduction in food waste by 2025 will require an investment of $18 billion, but results in a societal benefit of $100 billion and the creation of 15,000 jobs per year.[51] The report finds that the most cost-effective way to reduce food waste is through food waste prevention and recovery. Scaling the investments to California (assuming the State comprises 12 percent of the US population in 2025) achieving a 20 percent food recovery target could require investments of $1.8 billion, or $200 million a year from 2016 through 2025.[52] These investment requirements are mitigated by an estimated annual business profit potential of $228 million in food waste savings. These figures do not include benefits that arise from household savings and food donations, which could result in an estimated annual economic value of $1.2 billion for California. Food recovery will also generate cost savings in avoided tipping fees, estimated at $25 million in 2020 and increasing to $50 million in 2025 (assuming a tipping fee of $45).

Given the variability in methods that can be used to achieve California's food recovery targets and the uncertainty surrounding costs and scalability, the analysis assumes that food recovery will have no net impact on the California economy. Because potential revenues and avoided tipping fees outweigh costs of achieving a 20 percent food recovery target (as estimated at a national level), this is a conservative approach.

c. Chip & Grind

The location of Chip & Grind facilities may require additional transportation of materials, resulting in increased fuel and vehicle costs. However, Chip & Grind facilities also produce salable products including mulch, and woodchips, and compost.[53] In the analysis, revenue from the increased sale of materials is assumed to offset any costs from transportation and processing of lumber and branches and stumps, resulting in no net economic impact.

d. Existing Compost Facilities

The analysis assumes that existing compost facilities are permitted and able to operable at full capacity and that no there are no additional operating and maintenance costs associated with filling excess capacity. It is assumed there is no cost for the transportation of organic materials, as material is already traveling to the existing compost facility from the landfill and the material represents a small fraction of the total compost amount.

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[51] A Roadmap to Reduce U.S. Food Waste by 20 percent is available for download at: http://www.refed.com/download. The 20 percent reduction in food waste includes 27 strategies to reduce food waste including prevention, recovery, and recycling.

[52] See the marginal food waste abatement cost curve on page 23 of A Roadmap to Reduce U.S. Food Waste by 20 percent for additional information. The required investment of $14.9 billion includes food waste prevention and recovery only. The additional investments outlined by ReFED are captured through the AD or compost pathway.

[53] An example of the products produced at one Chip & Grind facility in San Diego is available at: http://www.sandiego.gov/environmental-services/miramar/greenery/cmw.shtml.

e. New Compost Facilities

New compost facilities are required in all three scenarios. To comply with federal, State, and local air quality requirements, the analysis assumes that all facilities are Gore positive aerated static pile (ASP) compost facilities with costs outlined in Table 26.[54] Gore ASP compost facilities have demonstrated the ability to meet strict VOC emission controls set by the San Joaquin Valley Air Pollution Control District and the South Coast Air Quality Management District and significantly reduce odor, making them a feasible option across California.

Table 26: Estimated Cost of a Representative New Compost Facilities

Gore Positive Aerated Static Pile (ASP) Compost Facility	
Facility Component	**Capital Investment**
Permitting	$900,000
Infrastructure	$11,500,000
Equipment	$3,900,000
Land	$200,000[55]
Total Cost	**$16,500,000**

Table 27 presents the estimated costs and revenue stream for a representative new compost facility over a 10-year period.. Transportation of organic materials from the centralized processing point (either landfill or materials recovery facilities) to the compost facility are included in the analysis, although these costs may not be explicitly born by the compost facility. In the Co-Digestion Economic Analysis Tool (CoEAT), US EPA estimates a waste hauling cost of $0.18 per ton-mile.[56] This analysis assumes that waste is transported 40-miles round trip between landfills and new compost facilities. This allows for location flexibility in geographic regions where permitting of new compost facilities may be difficult. In this analysis, each new facility purchases one low NOx compressed natural gas (CNG) truck to transport organic materials.

[54] Costs estimates based on information provided by CalRecycle.
[55] Assumes 25 acre facility with a cost of $7,700 per acre, the average value of an acre of farm land in California, http://www.usda.gov/nass/PUBS/TODAYRPT/land0815.pdf.
[56] https://archive.epa.gov/region9/organics/web/html/index-2.html

Table 27: Estimated Costs and Revenue per Compost Facility Through 2030[57]

Component	Capital Cost	Average Annual O&M Cost	Average Annual Revenue
Gore ASP Compost Facility	$16,500,000	$1,650,000	
CNG Vehicles	$250,000	$25,000	
Transportation		$720,000	
Tipping Fee			$4,500,000
Total	**$16,750,000**	**$2,395,000**	**$4,500,000**
10-Year Net Present Value	**-$2,200,000**		

The net present value assumes a 10-year finance period with 7 percent interest and a discount rate of 5 percent. This representative compost facility has a net present value of - $2.2 million over the 10-year period, therefore is not economically viable without additional funding sources. An upfront grant of $2 million would allow this project to break even, highlighting the need for incentives and State action to achieve the organic diversion goals.

This analysis does not include the sale of compost products,[58] because there is large variation and uncertainty in the processing costs and demand for compost products. In the analysis any revenue generated from compost materials is assumed to mitigate costs associated with processing and transporting the final products, resulting in no net economic impact. However, this may underestimate future revenue at compost facilities. A 2014 analysis of the economic impact of composting found that over 30 percent of compost revenues were related to the sale of soil, compost, and mulch,[59] while the sale of compost in San Francisco and Palo Alto has been recorded at $12 to $26 per ton.[60]

f. Upgrading Existing Wastewater Treatment Facilities with Anaerobic Digesters

Costs for diverting organic waste to existing wastewater treatment facilities is estimated as the incremental costs and benefits that result from the addition of organic waste to the wastewater facility anaerobic digester. While wastewater treatment facilities have significant revenue potential, difficulty in securing financing, potential restrictions in permitting and land use, and aging facilities may restrict the ability of facilities to receive new organic waste streams. For facilities that are able to secure financing and accept organic waste, costs include facility improvements, construction of pre-processing facilities, transportation costs, costs associated with biosolid processing transportation

[57] Capital costs are amortized over 10 years with 7% interest. The discount rate is 5% and all values are rounded.
[58] http://www.calrecycle.ca.gov/publications/Documents/1520%5C20151520.pdf
[59] http://www.mncompostingcouncil.org/uploads/1/5/6/0/15602762/economic_impact_study_final-2-2-15.pdf
[60] http://www.sfgate.com/bayarea/article/S-F-s-scraps-bring-joy-to-area-farmers-3246412.php and http://www.cityofpaloalto.org/civicax/filebank/documents/15113

and disposal, and costs associated with biogas generation, cleaning, and injection into pipelines.

The analysis assumes that all biogas generated through organic waste diversion will be used as transportation fuel, as this represents the highest value use of biomethane. There are 118 wastewater treatment facilities located less than 8 miles from a natural gas pipeline. These facilities represent 95 percent of the existing excess capacity and it is assumed in this analysis that these facilities can upgrade to allow food waste generated biogas to be pipeline injected. Assuming each wastewater treatment facility can accept 45,000 wet tons of food waste a year, meeting the SB 1383 targets will require diversion of organic food waste to 86 facilities in 2020 and 104 facilities in 2025. Three miles of pipeline is apportioned to each facility in the cost calculation, assuming that facilities greater than 3 miles from a pipeline are not economically feasible options for pipeline injection.

The analysis only considers the incremental biogas produced from the addition of food waste to the wastewater treatment facility, and excludes any potential biogas production from anaerobic digestion of grass and leaves. While capital costs include upgrades to the entire wastewater treatment facility, the analysis assumes that any biogas produced by the facilities prior to the addition of food waste continues to be used in the same capacity to satisfy existing contractual obligations. However, it is possible that some or all facilities would inject all biogas into the pipeline, resulting in additional revenue.

The costs associated with processing food waste at wastewater treatment facilities can vary greatly by facility and are subject to a great degree of technological and regulatory uncertainty. While costs and potential revenue will vary by facility, Table 28 represents an illustrative facility that processes 45,000 tons of food waste[61] and produces approximately 175 million standard cubic feet (scf) of biomethane each year for injection into the natural gas pipeline.[62] This generates revenues streams from sale of CNG fuel, LCFS credits, and RINs as outlined in Table 28.

[61] This limit is subject to permitting but is within the range of East Bay MUD's limit of 250 tons of food waste per day (91,250 tons per year) and Central Marin Sanitation Agency's limit of 5,474 tons per year. http://nepis.epa.gov/Adobe/PDF/P100LDEL.pdf.

[62] Biomethane calculation assumes 45,000 tons per year of food waste or 291,655,440 ft^3 of biogas per facility per year, converted to biomethane assuming the conversions outlined in Table 33. The calculation is based on EPA's CoEAT tool available at: https://archive.epa.gov/region9/organics/web/html/index-2.html.

Table 28: Estimated Cost and Revenue per Existing Wastewater Treatment Facility[63]

Component	Capital Cost	Average Annual O&M Cost	Average Annual Revenue
Organic Processing Facility and Facility Upgrades	$12,000,000	$1,200,000	
CNG Vehicles (2)	$500,000	$50,000	
Organic Waste Transportation		$450,000	
Biosolid Processing		$975,000	
Biosolid Transportation		$425,000	
Pipeline	$3,000,000	$150,000	
Pipeline Interconnection	$3,000,000	$150,000	
Biogas Upgrading		$1,400,000	
Tipping Fee			$3,250,000
Fuel Sales			$600,000
LCFS Credits (CNG020)			$1,350,000
RINs			$4,300,000
Total	**$18,500,000**	**$4,600,000**	**$9,500,000**
10-Year Net Present Value	**$17,600,000**		

The calculations outlined in Table 28 are highly sensitive to assumptions regarding the price of LCFS credits and RINs. It is assumed that wastewater treatment facilities generate LCFS credits through the CNG020 pathway with a proposed biomethane carbon intensity of 7.75,[64] assuming a LCFS credit price of $100 and a total RIN value of $1.85.[65] To further explore sensitivity to LCFS credit and RIN pricing, Table 29 presents the 10-year net present value of diverting organic waste to wastewater treatment facilities under a range of LCFS credit and RIN prices.

[63] Capital costs are amortized over 10 years with 7% interest. The discount rate is 5% and all values are rounded.

[64] This analysis assumes wastewater treatment facilities are medium to large as outlined in Alternative Case 2 in under the CNG020 pathway as outlined in Table 6 of the LCFS Regulation available at: www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf.

[65] The assumed cellulosic RIN credit value of $1.85 for biomethane includes a D5 RIN ($0.85), cellulosic waiver credit ($0.90) and value from the Blenders Tax Credit ($0.10 per D5 RIN). These assumptions for RIN credit prices are somewhat lower than current credit prices. The latest available information at the time of this writing (November 20, 2016), suggests that cellulosic RINs could be worth about $2.10.

Table 29: Net Present Value of Wastewater Treatment Facility Under Varying LCFS Credit and RIN Credit Prices (Million Dollars)

		Wastewater Treatment Facility				
		LCFS credit price				
		$0	$50	$100	$150	$200
Cellulosic RIN credit prices	$0.00	-$26.2	-$21.0	-$15.7	-$10.5	-$5.3
	$0.50	-$17.2	-$12.0	-$6.7	-$1.5	$3.7
	$1.00	-$8.2	-$2.9	$2.3	$7.5	$12.7
	$1.85	$7.1	$12.4	$17.6	$22.9	$28.0
	$2.50	$18.9	$24.1	$29.3	$34.6	$39.8
	$3.00	$27.9	$33.1	$38.4	$43.6	$48.8
	$3.50	$36.9	$42.1	$47.4	$52.6	$57.8
	$4.00	$45.9	$51.2	$56.4	$61.6	$66.9

For the facility outlined in Table 28, the 10-year net present value is positive across a wide combination of RIN and LCFS credit prices. However, in the absence of revenue generated from LCFS credits or RINs, the 10-year net present value is negative. If LCFS and RIN credit revenues do not materialize, State resources could be deployed to shore up financing of biomethane projects through mechanisms such as upfront grants, loan assistance programs, and tax incentives. For example, the illustrative facility in Table 12 would break even over a 10-year financing period with an upfront grant of $24 million. State agencies are collaborating to find solutions to the economic challenges associated with upfront capital costs and financing for wastewater treatment projects.

Wastewater treatment facilities are not limited to generating transportation fuels from diverted organic material. In 2013, 85 percent of wastewater treatment facilities with anaerobic digesters used biogas on site and 22 percent generated electricity.[66] Generating electricity for on-site use and selling excess electricity to the grid is an option for many facilities and can provide stable yet less lucrative potential revenue streams. However, these options generally emit criteria pollutants, including NOx, which might make operations unviable, especially in nonattainment areas. Additional revenue potential can be realized through the development of sustainable markets for residual products including heat dried residual pellets, fertilizer, mulch, and soil amendments. While concerns related to the transportation and application of residual and related products have limited their use, creating markets for these products could result in additional revenue streams for compost, wastewater treatment, and new AD facilities and should be considered a priority for State and local incentives related to market research and incentives. The size of the additional revenue stream depends on the specific products and market development, but could be on par with revenues generated from LCFS credits.

[66] http://nepis.epa.gov/Adobe/PDF/P100LDEL.pdf.

g. New Anaerobic Digesters

Table 30 outlines the estimated costs and revenue potential for an illustrative new anaerobic digester that has a throughput capacity of 100,000 tons per year and produces approximately 385 million scf of biomethane per year.[67] In this scenario, the biomethane is injected into the natural gas pipeline for use as transportation fuel and receives RINs and LCFS credits for the CNG005 pathway with a carbon intensity of -22.93.[68] For this illustrative scenario it is assumed that 50 percent of AD digestate is utilized at no cost and 50 percent is processed and shipped to compost facilities. While concerns related to the transportation and application of residual and related products have limited their use, creating markets for digestate could result in large additional revenue streams for new AD facilities and should be considered a priority for State and local incentives related to market research and incentives.

The realized costs of an anaerobic digester may vary greatly based on geographic location and concerns related to odor, permitting difficulty, and existing infrastructure. This illustrative facility outlines the revenue potential as well as the significant capital costs that are required to construct a new anaerobic digester.

[67] Biomethane calculation assumes 100,000 tons per year of food waste or 644,464,440 ft^3 of biogas per facility per year, converted to biomethane assuming the conversions outline in Table 33. The calculation is based on EPA's CoEAT tool available at: https://archive.epa.gov/region9/organics/web/html/index-2.html.

[68] The CI for CNG005 is outlined in Table 6 of the LCFS Regulation available at: www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf.

Table 30: Estimated Cost and Revenue per New Anaerobic Digester[69]

Component	Capital Cost	Average Annual O&M Cost	Average Annual Revenue
Anaerobic Digester	$20,000,000[70]	$2,000,000	
Organic Processing Facility	$12,000,000	$1,200,000	
CNG Vehicles (2)	$500,000	$50,000	
Organic Waste Transportation		$900,000	
Digestate Processing		$975,000	
Digestate Transportation		$420,000	
Pipeline	$3,000,000	$150,000	
Pipeline Interconnection	$3,000,000	$150,000	
Biogas Upgrading		$2,500,000	
Tipping Fee			$6,500,000
Fuel Sales			$1,300,000
LCFS Credits (CNG005)			$4,800,000
RINs			$9,500,000
Total	**$38,500,000**	**$8,345,000**	**$22,100,000**
10-Year Net Present Value	**$65,700,000**		

The calculations outlined in Table 30 are highly sensitive to assumptions regarding the price of LCFS credits and RINs. To further explore sensitivity to LCFS credit and RIN pricing, Table 15 presents the 10-year net present value of diverting food waste to new AD facilities under a range of LCFS credit and RIN prices.

[69] Capital costs are amortized over 10 years with 7% interest. The discount rate is 5% and all values are rounded.
[70] Digester cost for facility with 100,000 tons per year throughput obtained at: https://fortress.wa.gov/ecy/publications/publications/1207036.pdf.

Table 31: Net Present Value of Anaerobic Digester Facility Organic Diversion under Varying LCFS Credit Prices and RIN Credit Prices (Million Dollars)

		New AD Facility				
		LCFS credit price				
		$0	$50	$100	$150	$200
Cellulosic RIN credit prices	$0.00	-$44.8	-$26.4	-$8.0	$10.3	$28.7
	$0.50	-$24.9	-$6.5	$11.9	$30.2	$48.6
	$1.00	-$5.0	$13.4	$31.8	$50.2	$68.6
	$1.85	$28.9	$47.3	$65.7	$84.1	$102.5
	$2.50	$54.8	$73.2	$91.6	$110.0	$128.4
	$3.00	$74.7	$93.1	$111.5	$129.9	$148.3
	$3.50	$94.7	$113.0	$131.5	$149.8	$168.2
	$4.00	$114.6	$133.0	$151.4	$169.8	$188.2

As outlined in Table 31, there is the potential for very large revenue streams from the sale of LCFS credits and RINs. However, these revenue streams are necessary to make the illustrative facility in Table 31 viable. Without revenue from RINs or LCFS credits, an upfront grant of $41 million would be required in order for this illustrative facility to breakeven over a 10-year financing period. While the revenue potential from RINs and LCFS credits is high, it is also uncertain which may present difficulty in obtaining financing. Alternatively, facilities can generate electricity for use on-site as well as sale to the grid, which has lower, but potentially more stable, potential revenue. On-site transportation fuel use is another feasible revenue option for facilities located large distances from the pipeline. On site criteria co-pollutant emissions are generally higher for electricity generation then for pipeline injection.

4. Estimated Cost and Revenue by Scenario

There are many potential ways to divert and utilize organic waste in California, and high uncertainty surrounding future compliance responses, costs, and markets. This analysis outlines three scenarios that achieve the organic diversion target by focusing on one type of facility for the handling of food waste and some grasses and leaves. While the pathway to compliance is unknown, the scenarios outline the potential range of capital costs, potential revenue, and uncertainty that exists in the treatment and diversion of organic waste. Regulatory, technological, political, financial, and market uncertainty must be considered in additional to the direct costs and potential revenue outlined in this analysis.

The three scenarios in this analysis indicate that achieving the organic diversion target could require an estimated capital investment of $800 million to $2.1 billion dollars and with potential cumulative revenue ranging from $1.6 to $8.3 billion over a 10-year period. The wide range in revenues highlight the value in existing, yet uncertain, revenue streams when biomethane is used for transportation fuel. High capital costs, as well as significant O&M also may discourage investment in facilities that could result in positive economic gains and highlights the need for State incentives, funding, and regulations to achieve the organic waste diversion targets.

Table 32 presents the state wide cumulative capital costs, O&M costs, and revenue for each scenario, across all facilities needed to achieve the 2020 and 2025 organic diversion target. In this analysis, the organic diversion and food recovery targets are met linearly over time, with new facilities coming on-line as additional capacity is needed. Projects are financed over 10 years assuming a 7 percent cost of capital and a 5 percent discount rate.

The scenario costs in Table 32 are estimated through 2025. Additional amortized capital payments continue through 2034 (as facilities are phased in over time) and annual O&M costs and revenues continue beyond 2025 for all three scenarios. O&M costs and revenues remain constant through 2025 this analysis. Scenario 1 and 2 show positive returns through 2025 due to biomethane generation, LCFS credit, and RIN credit generation. Despite the potential value of organic waste diversion, there are significant upfront capital costs that may prevent long-term revenue streams.

Variable revenue streams, such as RIN and LCFS credits, while lucrative, do not facilitate easy access to capital. The State must work with both public and private lenders to eliminate barriers to obtain capital for these projects through grants, reducing lender risk and lowering interest rates, or making regulatory changes.

Table 32: Cumulative Estimated Costs and Revenues by Scenario Over 10-Year Accounting Period (Million Dollars)

Scenario 1: New AD	Component	Capital Cost	O&M	Revenue
New AD New Compost	47 Facilities 26 Facilities	$1,700 $400	$2,600 $700	$7,000 $1,300
Total		**$2,100**	**$3,300**	**$8,300**
10-Year Net Present Value		**$2,700**		
Scenario 2: WWTP	**Component**	**Capital Cost**	**O&M**	**Revenue**
New Compost	35 Facilities	$600	$900	$1,800
Existing Wastewater Treatment	104 Facilities	$1,600	$2,800	$5,700
Total		**$2,200**	**$3,700**	**$7,500**
10-Year Net Present Value		**$1,400**		
Scenario 3: Compost	**Component**	**Capital Cost**	**O&M**	**Revenue**
New Compost	65 Facilities	$800	$800	$1,600
Total		**$800**	**$800**	**$1,600**
10-Year Net Present Value		**-$100**		

Despite the uncertainty, existing facilities are able to obtain financing to handle diverted organic materials through public and private partnerships with encouraging results. US EPA analyzed six wastewater treatment facilities, two located in California that upgraded to accept food waste and had estimated pay back periods ranging from zero to 12 years.[71] These facilities received funding assistance from $250,000 to $35 million and produce energy and fuel for revenue.

Altogether, this analysis suggests that the diversion of organic waste can result in environmental and economic value to California. There are important uncertainties associated with facility costs and potential revenues, however, which may limit project development without additional support. In the absence of revenue from LCFS credits and RINs, significant financial support may be required to achieve the targets identified in this SLCP Strategy and deliver other environmental benefits.

5. Cost Assumptions Used for All Scenarios

Table 33 contains the assumptions used in each scenario, along with references.

[71] http://nepis.epa.gov/Adobe/PDF/P100LDEL.pdf

Table 33: Organic Diversion Scenario Assumptions

Organic Diversion Scenario Assumptions			
Costs	**Capital**	**O&M**	**References**
Natural gas transmission pipeline or urban low pressure pipeline ($/mile)	$1,000,000	5%	http://www.suscon.org/news/pdfs/GHG_Mitigation_for_Dairies_Final_July2015.pdf
On-site biogas upgrading system ($/1000 scf)		$7	Upper bound of range provided by CASA in public comment
Centralized biogas upgrading system ($/1000 scf)		$6	http://www.suscon.org/news/pdfs/GHG_Mitigation_for_Dairies_Final_July2015.pdf
On-site utility natural gas pipeline interconnection ($)	$3,000,000	5%	
Cost per acre of California farm land for compost facility ($/acre)	$7,700		http://www.usda.gov/nass/PUBS/TODAYRPT/land0815.pdf
Gore Positive Aerated Static Pile (ASP) compost facility	$16,500,000	10%	Cost estimates from CalRecycle assumes 25 acre facility processing 100,000 tpy
Organic processing station including pre-processing and facility upgrades	$12,000,000	10%	Mid-range of estimated costs based on information from East Bay MUD, CMSA, and LACSD. Information provided by CASA in public comment. References available at: http://nepis.epa.gov/Adobe/PDF/P100LDEL.pdf.
Anaerobic digester (100,00 TPY capacity)	$20,000,000	10%	Estimated cost of San Jose ZNW Facility
Low NOx CNG truck	$250,000	10%	Estimate from ARB Staff, Vision 2.0 assumes CNG heavy duty vehicle costs $250k in 2016 and costs reduce to $144 by 2030
Waste transport ($/ton-mile)		$0.18	https://archive.epa.gov/region9/organics/web/html/index-2.html
Average mileage for transportation of organics to WWTF (miles)		50	Assumption informed by geo-spatial analysis
Average mileage for transportation of organics to AD (miles)		50	Assumption informed by geo-spatial analysis of waste location
Average mileage for transportation of biosolids (miles)		130	http://scap1.org/Biosolids%20Reference%20Library/2014%20SCAP%20Biosolids%20Trends%20Update.pdf

Cost of biosolid disposal ($/ton)		54	http://scap1.org/Biosolids%20Reference%20Library/2014%20SCAP%20Biosolids%20Trends%20Update.pdf
Average mileage for transportation of organics to compost (miles)		40	Assumption informed by geo-spatial analysis of waste location
Revenues			
Biogas price ($/ 1000 cubic feet)		$3.46	
Tipping fee at compost facilities ($/ton)		$45	http://www.calrecycle.ca.gov/publications/Documents/1520%5C20151520.pdf.
Tipping fee at AD facilities ($/ton)		$65	-
Tipping fee at wastewater treatment facilities ($/ton)		$65	
Low Carbon Fuel Standard credits ($/ton)		$100	
RINs, $/77,000 BTU		$1.85	Internal ARB calculation based on public RIN values.
Conversion Factors			
Biogas per wet ton food waste	6,444		https://archive.epa.gov/region9/organics/web/html/index-2.html
Biogas to biomethane conversion	0.6		https://archive.epa.gov/region9/organics/web/html/index-2.html
scf to BTU	1,028		http://www.arb.ca.gov/cc/inventory/doc/docs1/1a3b_onroad_fuelcombustion_naturalgas_ch4_2013.htm
Food total solids (fraction)	0.3		https://archive.epa.gov/region9/organics/web/pdf/ebmudfinalreport.pdf
Biosolids from food waste digestion (fraction)	0.36		https://archive.epa.gov/region9/organics/web/pdf/ebmudfinalreport.pdf
Financial parameters			
Interest rate	7%		
Loan period, years	10		-
Discount rate	5%		

C. Hydrofluorocarbon (HFC) Emission Reductions

Note: The following HFC section was written before the global phasedown of HFCs was agreed to on October 15, 2016 (the “Kigali Amendment”). ARB is currently evaluating the Kigali Amendment’s impact upon HFC emissions in California; this section will be further updated to reflect changes in BAU emissions, additional needed reductions, and the cost and benefit of HFC reductions measures.

As described in Section VI, HFCs are the fastest-growing source of GHG emissions globally and in California. California is among the world's leaders in reducing HFC emissions, with existing actions leading to significant reductions in HFC emissions in California through 2030, compared to where they would be otherwise.

The SLCP Strategy describes a set of four potential measures that can reduce HFC emissions by 40 percent in California by 2030. The proposed measures are anticipated to reduce cumulative HFC emissions by 260 $MMTCO_2E$ (20-year global warming potential (GWP)) by 2030 to meet the SLCP emission reduction target. This section estimates the potential costs and savings of the four proposed HFC emission reduction measures which are:

1. Prohibition on New Equipment with High-GWP Refrigerants
2. HFC Supply Phasedown (now covered by the global HFC phasedown)
3. Financial Incentive Program for Low-GWP Refrigeration Early Adoption
4. Sales Ban of Very-High GWP Refrigerants

The potential costs and cost savings of the four proposed HFC emission reduction measures are based on the three main variables: the incremental equipment cost of low-GWP units, gains or losses in energy efficiency and resulting change in energy consumption, and the projected price of HFCs relative to the price of replacement of natural refrigerants and the new generation of synthetic refrigerants, hydrofluoro-olefins (HFOs).

The proposed HFC measures would require new stationary refrigeration and AC equipment to use refrigerants with a lower-GWP than the current high-GWP HFC refrigerants. In many cases, there is an incremental cost to lower-GWP equipment relative to the cost of high-GWP equipment. The higher capital cost is often offset by energy efficiency gains and subsequent decreased energy costs over the equipment lifetime. Although it is anticipated that the incremental cost of low-GWP equipment will decline over time, this learning effect is not accounted for in this analysis with all costs and savings assumed to remain constant through 2030. In all tables, annual and cumulative costs are presented in 2016 dollars.

This analysis assumes that the growth in refrigeration and AC equipment is correlated with projected population growth in California through 2050, projected at 0.746% annually, according to California Department of Finance.[72]

Pending an evaluation to determine if specific California HFC reductions measures are needed in addition to the global HFC phasedown, measures are listed as originally proposed in April 2016.

[72] http://www.dof.ca.gov/research/demographic/projections/

1. Prohibition on New Equipment with High-GWP Refrigerants

This proposed measure prohibits the use of high-GWP refrigerants in new stationary refrigeration and air-conditioning equipment. For the stationary refrigeration sector, refrigerants with a 100-year GWP of 150 or greater would be prohibited for new equipment for non-residential refrigeration, and also for residential refrigerator-freezers. The proposed measure also prohibits refrigerants with a 100-year GWP of 750 or greater for new air-conditioning equipment in the stationary air-conditioning, for both residential and non-residential. (Start dates for measures have not yet been determined, pending the completion of the impact evaluation of the Kigali Amendment.)

a. Initial Added Cost of Low-GWP Refrigeration and AC Equipment

Table 34 shows the incremental cost of low-GWP refrigeration and air-conditioning equipment. Due to the lack of low-GWP equipment currently in operation, cost estimates were obtained through a survey of industry stakeholders for the average cost of baseline business-as-usual equipment using high-GWP HFCs, and new low-GWP equipment using natural refrigerants or new low-GWP (synthetic refrigerants HFOs). The incremental capital cost of low-GWP equipment varied greatly across respondents, ranging from slightly less to more than double the cost of high-GWP equipment. For air-conditioning, less data is available relative to refrigeration as low-GWP air-conditioning is still in development and is not widely used. In this analysis, it is assumed that the incremental cost of lower-GWP air-conditioning ranges from 5 to 15 percent higher than the business-as-usual, or BAU, high-GWP refrigerant equipment.

Table 34: Estimated Initial Added Cost of Low-GWP Refrigeration and Air-Conditioning Equipment

Equipment Sector	General Description of Sector	Average Equipment Cost per Unit[73]	Incremental Cost of Low-GWP Unit
Stationary Refrigeration Sectors			
Large Commercial Large Centralized System (2,000+ lbs)	Centralized system with 2000 or more lbs of refrigerant charge (average charge 2,485 lbs). Generally, one system can be used per large retail facility such as a supermarket.	$1,000,000	$200,000
Medium Commercial Medium Centralized System (200 – 2,000 lbs)	Distributed type equipment with more than one unit. Average charge size 700 lbs, three or four units may be used in a supermarket.	$250,000	$50,000
Large Cold Storage	Charge size is 2000 lbs or more per facility.	$3,500,000	$500,000

[73] Assumes the BAU baseline is high-GWP.

Equipment Sector	General Description of Sector	Average Equipment Cost per Unit[73]	Incremental Cost of Low-GWP Unit
Medium Cold Storage	Average charge size of 565 lbs per facility	$1,750,000	$250,000
Industrial Process Cooling	Average charge size of 4,440 lbs per facility for Industrial processing such as manufacturing or food processing.	$2,500,000	$250,000
Refrigerated Condensing Units (50-200 lbs)	Used in retail food and other cooling, average charge 122 lbs per system.	$75,000	$15,000
Refrigerated Condensing Units (Under 50 lbs)	Used in convenience stores, other smaller refrigeration needs. Average charge 31 lbs per system.	$37,500	$7,500
Standalone (Self-Contained) Refrigeration Units	Smaller self-contained equipment average charge 7 lbs or less. Does not include refrigerated vending machines already covered by U.S. EPA requirements.	$5,000	$1,000
Residential-Type Refrigerator Freezer	Average charge of 0.34 lbs per normal domestic appliance.	$1,165	$150
Stationary Air-Conditioning Sectors			
Centrifugal Large Chiller (2000+ lbs)	Chiller with 2000 lbs refrigerant or more. Typically used for large building AC. Average charge size of 3,978 lbs	$300,000	$30,000
Medium Centrifugal Chiller (200-2000 lbs)	Chiller containing 200 to 2000 lbs refrigerant. Average charge of 1,007 lbs	$200,000	$20,000
Medium Packaged Chiller (200-2000 lbs)	Chiller containing 200 to 2000 lbs refrigerant, generally smaller than centrifugal type. Average charge size of 526 lbs	$200,000	$20,000
Commercial Unitary AC (50-200 lbs)	AC system contains on average 100 lbs of refrigerant.	$13,000	$1,300
Commercial Unitary AC (Less Than 50 lbs Charge)	Smaller AC systems contain on average 15 lbs of refrigerant.	$4,000	$400
Commercial Window AC Units	Window units contain an average of 1.5 lbs refrigerant.	$900	$90
Residential Unitary AC	Residential AC systems contain on average 7.5 lbs refrigerant.	$4,000	$400
Residential Window AC Units	Window units contain an average of 1.5 lbs refrigerant.	$800	$80

b. Savings from Energy Efficiency

The added cost of low-GWP equipment is generally offset by reduced energy usage from using low-GWP refrigerants. Table 35 shows the energy efficiency savings used in this cost analysis. The change in energy efficiency is relative to HFC equipment currently being manufactured. In this analysis, the ozone-depleting substance (ODS) refrigerant HCFC-22 has the same or better energy efficiency relative to most low-GWP refrigerants. However, new HCFC-22 equipment has been prohibited since January 1, 2010, and therefore cannot be considered as baseline for new equipment.

Refrigerant systems using only CO_2 as the refrigerant are known as transcritical CO_2 systems. Compared to baseline HFC refrigeration, transcritical CO_2 systems have shown energy efficiency gains of 10 to 18 percent in climates where the ambient temperature is less than 87 °F. In higher ambient temperatures, energy penalties can be incurred compared to baseline refrigerant systems, although significant research and development is occurring to manufacture transcritical systems that work efficiently in higher ambient temperatures.[74, 75] For example, transcritical CO2 systems have been installed in warm weather climates in Louisiana, Alabama, Georgia, and Florida; and also in Brazil; Indonesia, Australia, and Spain, showing energy efficiencies equivalent or better than HFC refrigeration systems. In California, more than 20 transcritical systems have been installed, several of them in high-temperature ambient climates.[76]   Cooling a CO_2 secondary cooling loop or cascade system with an HFC refrigerant or ammonia as the primary refrigerant appear to operate at the same energy efficiency or better than all-HFC systems, including in very hot ambient temperatures.[77]

Ammonia refrigeration has long-established energy efficiency benefits compared to fluorinated refrigerants including HFCs. Typical energy efficiency gains of using ammonia refrigerant range from 3 to 10 percent or greater, depending upon the specific type of equipment.[78, 79, 80]

[74] ASHRAE, 2015. "System Efficiency for Natural Refrigerants" Anatolii Mikhailov and Hans Ole Matthiesen, Technical Feature in ASHRAE Journal, August 2015. Available at: https://www.ashrae.org/File%20Library/docLib/eNewsletters/Mikhailov-082013--05142015feature.pdf (accessed 9 April 2016).

[75] UNEP, 20115. "Montreal Protocol on Substances that Deplete the Ozone Layer UNEP 2014 Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee 2014 Assessment". February 2015. United Nations Environment Programme (UNEP). Available at: http://ozone.unep.org/en/assessment-panels/technology-and-economic-assessment-panel (accessed 11 July 2016).

[76] Shecco, 2015. Guide to Natural Refrigerants in North America - State of the Industry 2015. Shecco publications, 17 September 2015. Available at: http://publication.shecco.com/publications/lists (accessed 6 July 2016).

[77] Mycom-Mayekawa, 2015. "Low Refrigerant Charge Ammonia/CO_2 Chiller in a Supermarket Application" case study. Available at: http://www.ammonia21.com/web/assets/link/4091_GUIDE_NA_Case%20Study_MYCOM_1.pdf (accessed 11 July 2016).

[78] ASHRAE, 2010. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). ASHRAE Position Document on Ammonia as a Refrigerant. June 30, 2010. Available at: https://www.ashrae.org/File%20Library/docLib/About%20Us/PositionDocuments/Ammonia-as-a-Refrigerant-PD-2014.pdf (accessed 16 June 2016).

[79] AMIC, 2014. Australian Meat Industry Council (AMIC) Fact Sheet 3 "Out with the Old & In with the New: Freon vs. Ammonia & Glycol Refrigeration Systems". Available at: http://www.amic.org.au/SiteMedia/W3SVC116/Uploads/Documents/Freon%20vs%20Ammonia%20&%20Glycol%20Refrigeration.docx (accessed 13 July 2016).

[80] Industrial Refrigeration Handbook, Wilbert F. Stoecker. McGraw-Hill, 1998. ISBN 0-07-061623-X

Hydrocarbon refrigerants are more energy efficient than HFC refrigerants in all end-use sectors for which they have been approved for use by the U.S. EPA. Energy efficiency gains of more than 30 percent have been shown for some smaller refrigeration equipment, with efficiency gains of 2 to 5 percent for residential refrigerator-freezers, and 5 to 10 percent for air-conditioning.[81, 82, 83, 84, 85]

Hydrofluoro-olefin (HFO) refrigerant blends are new and energy efficiency data is limited, although several studies indicate that they are equivalent to slightly more energy-efficient than HFCs used in refrigeration and air-conditioning, ranging from the same efficiency as HFC-134a or R-410A (an HFC blend), to nine percent greater energy efficiency than R-404A, a relatively energy-inefficient HFC blend used widely in retail food.[86, 87, 88, 89]

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[81] EIA, 2014. "Putting the Freeze on HFCs: A Global Digest of Available Climate-Friendly Refrigeration and Air-Conditioning Technologies", May 2014. Environmental Investigation Agency (2014). Available at: http://eia-global.org/images/uploads/Putting_the_Freeze_on_HFCs_Final.pdf. (Accessed 17 March 2016).

[82] DOE, 2011. Department of Energy, Technical Support Document of Final Rule for Residential Refrigeration Products, September 3, 2011. Available at: https://www1.eere.energy.gov *(accessed 12 February 2016).*

[83] "Comparative Performance of Hydrocarbon Refrigerants", I.L Maclaine-cross and E.Leonardi, School of Mechanical and Manufacturing Engineering, The University of New South Wales. Available at: http://www.academia.edu/9496884/Comparative_Performance_of_Hydrocarbon_Refrigerants (accessed 28 January, 2016).

[84] Sattar, et. al, 2007. "Performance Investigation of Domestic Refrigerator Using Pure Hydrocarbons and Blends of Hydrocarbons as Refrigerants", M. A. Sattar, R. Saidur, and H. H. Masjuki. World Academy of Science, Engineering and Technology, Number 29, 2007. Available at: http://citeseerx.ist.psu.edu (accessed 12 February 2016).

[85] DOE, 2015. "Alternative Refrigerant Evaluation for High-Ambient-Temperature Environments: R-22 and R-410A Alternatives for Mini-Split Air Conditioners", Report ORNL/TM-2015/536, October 2015. Oak Ridge National Laboratory managed by UT-Batelle for Department of Energy. Available at: http://energy.gov/sites/prod/files/2015/10/f27/bto_pub59157_101515.pdf (accessed 11 January 2016).

[86] Ibid.

[87] Dupont (Chemours), 2015. "Opteon Product Information Bulletin Low GWP Replacement for R-134a", and "Opteon Product Information Bulletin for Stationary Refrigeration", technical data literature available at: https://www.chemours.com/businesses-and-products/fluoroproducts/opteon-refrigerant/ (accessed 13 July 2016).

[88] Honeywell, 2015. "R410A and R22 low GWP alternatives for A/C - Focus on high ambient performances" by Dr. Jean de Bernardi and Dr. Abdenacer Achaichia; and Solstice refrigerants technical data literature. Available at: http://www.honeywell-refrigerants.com/ (accessed 13 July 2016).

[89] UNEP 2016. "Promoting Low-GWP Refrigerants for Air-Conditioning Sectors in High-Ambient Temperature Countries (PRAHA)", United Nations Environment Program (UNEP), document number UNEP/OzL.Pro/ExCom/76/10 April 16, 2016. Available at: http://www.multilateralfund.org/76/pages/English.aspx (accessed 12 March 2016).

Table 35: Estimated Added Energy Efficiency of Low-GWP Refrigerants

Equipment Sector	Added Energy Efficiency of Low-GWP Refrigerants	Mix of Low-GWP Refrigerants Used in Analysis[90]
Centralized System Large (2,000+ lbs)	7.5%	50% carbon dioxide (CO_2), 45% HFO blends, 5% ammonia (NH_3)
Centralized System Medium (200-2,000 lbs)	7.5%	
Cold Storage Large (2,000+ lbs)	8.0%	80% NH_3, 20% CO_2
Cold Storage Medium (200-2,000 lbs)	8.0%	
Process Cooling Large (2,000+ lbs)	7.5%	50% CO_2, 50% NH_3
Refrigerated Condensing Units Small (50-200 lbs)	7.5%	33% CO_2, 33% NH_3, 33% HFOs[91] or HFO blends
Refrigerated Condensing Units (less than 50 lbs)	7.5%	
Stand-Alone Refrigerator Display Cases	6.1%	50% CO_2, 50% hydrocarbons
Residential Refrigerator-Freezer	3.0%	100% hydrocarbons
Centrifugal Chiller Large (2,000+ lbs)	1.0%	50% HFC-32[92], 50% HFOs
Centrifugal Chiller Medium (200-2,000 lbs)	1.0%	
Chiller - Packaged Medium (200-2,000 lbs)	1.0%	
Unitary A/C Small (50-200 lbs)	2.0%	HFC-32
Unitary A/C Central (less than 50 lbs)	2.0%	
Window AC units commercial	2.0%	
Residential AC Central	2.0%	
Window AC Units Residential	2.0%	

[90] Improved energy efficiency of CO_2 refrigeration systems is dependent upon the ambient air temperature, with energy efficiency decreasing as the temperature increases. Below the critical temperature of CO_2 at 87 °F, energy efficiency of 2-6 percent has been measured (ASHRAE, 2009 www.ashrae.org), (Australian GCC, 2008) http://www.r744.com/files/news/green-cooling-council_montreal_apr08.pdf., and (Emerson, 2015) http://www.emersonclimate.com/en-us/Market_Solutions/By_Solutions/CO2_solutions/Documents/Commercial-CO2-Refrigeration-Systems-Guide-to-Subcritical-and-Transcritical-CO2-Applications.pdf.

[91] Energy efficiency of HFOs is generally the same as the HFC refrigerants they replace, although manufacturers have tested HFO equipment and concluded that it is three percent more energy efficient than HFC equipment (Danfoss, 2014) available at: http://turbocor.danfoss.com. Hydrocarbons, with GWPs less than 20 have demonstrated energy efficiency in refrigeration and AC equipment, with average efficiency improvements between 6 and 15 percent compared to HFCs (A.D. Little, 2001) Energy Consumption Characteristics of Commercial Building HVAC Systems. Volume I: Chillers, Refrigerant Compressors, and Heating Systems Prepared by Detlef Westphalen and Scott Koszalinski of Arthur D. Little, Inc. for Office of Building Equipment, Office of Building Technology State and Community Programs, U.S. Department of Energy. April 2001., (Wang, et al., 2009) https://www.energystar.gov/ia/partners/manuf_res/downloads/Appliance_and_Recycling_Quick_Start_Guide.pdf.

[92] HFC-32 has a 100-year GWP of 675, and a 20-year GWP of 2330 and would be used instead of the standard HFC refrigerant R-410A. DOE research indicates that HFC-32 is 2 percent to 13 percent more energy efficient than baseline R-410A in AC equipment (DOE, 2015) http://www.osti.gov/scitech/.

In this analysis, an ARB uses an electricity cost of 14 cents per kWh for commercial customers, and a cost of 17 cents per kWh for residential customers, based on recent California electricity prices posted by the Energy Information Administration (EIA, 2016).[93] The analysis assumes no relative increase or decrease in future electricity prices.

c. Savings or Added Cost from low and lower-GWP Refrigerants

High-GWP HFC refrigerants cost more per pound than the low-GWP refrigerants CO_2 and ammonia, but less per pound than hydrocarbon refrigerants and the new HFO refrigerants. The costs used in this analysis are based on a survey of average refrigerant prices and are as follows:

- HFCs (average of the six most commonly used HFCs): $6.90/lb.
- CO_2: $2.00/lb.
- Ammonia: $3.00/lb.
- Hydrocarbons: $9.00/lb.
- HFOs and HFO blends: $15.00/lb.

Due to the non-patented status of the natural refrigerants CO_2, ammonia, and hydrocarbons, it is assumed that their prices remain constant through 2030. HFOs are currently made in small quantities, and prices could be reduced in the future as HFO production increases. However, as some HFOs may be more cost-intensive to manufacture than HFCs, it is assumed that the cost will remain constant through 2030. This analysis assumes that the cost of high-GWP HFC refrigerants will double by 2030 due to an HFC phasedown or other regulatory pressures that will decrease the supply of high-GWP HFCs. The doubling of high-GWP HFC costs by 2030 is conservative, as previous phasedowns of ozone-depleting refrigerants have resulting in a five to six-fold increase in prices. The cost of lower-GWP HFCs such as HFC-32 is expected to remain constant, as they are not affected by HFC phasedowns. Table 36 shows the projected savings resulting from the use of low-GWP equipment

[93] EIA, 2016. U.S. Energy Information Administration. Electric Power Monthly, Table 5.6.A. “Average Price of Electricity to Ultimate Customers by End-Use Sector”. By State, January 2015 and January 2016. Cents per Kilowatthour. https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a.

Table 36: Estimated Low-GWP Equipment Savings[94]

Sector	Low-GWP Added Energy Efficiency	Annual Electricity Savings	Annual Refrigerant (lbs)	Annual Refrigerant Savings[95]	Annual Total Savings
Centralized System Large (2,000+ lbs)	7.5%	$ 12,000	600	$ 3,000	$ 15,000
Centralized System Medium (200-2,000 lbs)	7.5%	$ 3,000	200	$ 1,000	$ 4,000
Cold Storage Large (2,000+ lbs)	8.0%	$ 15,0000	1,200	$ 10,000	$ 25,000
Cold Storage Medium (200-2,000 lbs)	8.0%	$ 8,000	150	$ 1,000	$ 9,000
Process Cooling Large (2,000+ lbs)	7.5%	$ 11,000	350	$ 3,000	$ 13,665
Refrigerated Condensing Small (50-200 lbs)	7.5%	$ 1,000	25	$ 100	$ 1,000
Refrigerated Condensing Units (Less than 50 lbs)	7.5%	$ 500	5	$ 25	$ 500
Stand-Alone Refrigerated Display Cases	6.1%	$ 50	0.5	$ 2	$ 50
Centrifugal Chiller Large (2,000+ lbs)	1.0%	$ 500	150	($ 250)	$ 200
Centrifugal Chiller Medium (200-2,000 lbs)	1.0%	$ 532	24	($ 45)	$ 487
Chiller Packaged Medium (200-2,000 lbs)	1.0%	$ 319	42	($ 77)	$ 242
Unitary A/C Small (50-200 lbs)	2.0%	$ 174	13	$ 0	$ 174
Unitary A/C Central (Less than 50 lbs)	2.0%	$ 27	2	$ 0	$ 27

[94] Numbers may not add due to rounding.
[95] Refrigerant cost increases for chillers used in air-conditioning, therefore, savings are shown as negative.

Sector	Low-GWP Added Energy Efficiency	Annual Electricity Savings	Annual Refrigerant (lbs)	Annual Refrigerant Savings[95]	Annual Total Savings
Window AC Units Commercial	2.0%	$ 1	0.2	$ 0	$ 1
Residential AC Central	2.0%	$ 6	1.2	$ 0	$ 6
Window AC Units Residential	2.0%	$ 2	0.2	$ 0	$ 2
Residential Refrig Freezer	3.0%	$ 3	0.02	$ 0.05	$ 3

d. Added Cost and Savings: Net Cost of Low-GWP Equipment

Table 37 presents the added cost and savings are added together to show a net cost per year of equipment life. We then multiply the net cost per year of equipment life by the total number of new equipment each year, to show a theoretical annual cost if all new equipment is manufactured as low-GWP to meet the high-GWP refrigerant prohibitions.

Table 37: Estimated Net Cost of Low-GWP Equipment, Prohibition Measure[96]

Sector	Average Lifetime (yr)	Added Equipment Cost ($/yr)[97]	Annual Cost (Savings) ($/unit)	Estimated Units Replaced per Year[98]	Estimated Annual Net Cost (Savings)[99]
Centralized System Large (2,000+ lbs)	15	$13,000	$15,000	50	($114,000)
Centralized System Medium (200-2,000 lbs)	15	$3,000	$4,000	1,600	($549,000)
Cold Storage Large (2,000+ lbs)	20	$25,000	$25,000	10	($2,000)
Cold Storage Medium (200-2,000 lbs)	20	$12,500	$9,000	20	$81,000

[96]Numbers may not add due to rounding.
[97] The added equipment cost per year is calculated by taking the total added initial cost of the equipment, and dividing by the average years of equipment lifetime. The annual savings has been calculated by determining all annual savings and dividing by the average years of equipment cost. All costs and savings are shown in today's dollars; no discounted cost has been used.
[98] The estimated number of new units is derived from research and analysis conducted for the ARB Refrigerant Management Program regulation, equipment data registered through the Refrigerant Management Program data, and additional analysis used in the ARB Greenhouse Gas Emissions Inventory as developed by Gallagher, et al. 2014.
[99] Net Cost or savings is equal to the cost per unit multiplied by the number of units produced, by model year or cohort.

Sector	Average Lifetime (yr)	Added Equipment Cost ($/yr)[97]	Annual Cost (Savings) ($/unit)	Estimated Units Replaced per Year[98]	Estimated Annual Net Cost (Savings)[99]
Process Cooling Large (2,000+ lbs)	20	$12,500	$14,000	5	($6,000)
Refrigerated Condensing Units Small (50-200 lbs)	15	$1,000	$1,000	4,000	$78,000
Refrigerated Condensing Units (Less than 50 lbs)	20	$400	$500	15,700	($2,200,000)
Stand-Alone Refrigerant Display Cases	20	$50	$50	34,000	$618,000
Centrifugal Chiller Large (2,000+ lbs)	20	$1,500	$800	300	$176,000
Centrifugal Chiller Medium (200-2,000 lbs)	20	$1,000	$500	100	$42,000
Chiller – Packaged Medium (200-2,000 lbs)	20	$1,000	$200	500	$387,000
Unitary A/C Small (50-200 lbs)	15	$100	$200	5,000	($426,000)
Unitary A/C Central (Less than 50 lbs)	15	$50	$50	169,000	$0
Window AC Units Commercial	12	$10	$0	54,000	$325,000
Residential AC Central	15	$50	$10	482,000	$10,123,000
Window AC Units Residential	12	$10	$5	310,000	$1,552,000
Residential Refrigerator Freezer	15	$10	$5	1,266,000	$10,125,000
Total Annual Cost of Equipment Model Year[100]					**$20,225,000**

[100] The annual cost would be applied for each year of the model year or cohort's lifetime. Table 37 shows the cost if the prohibition were the only proposed HFC measure implemented. The cumulative costs of the four proposed HFC measures are shown in Table 34 of the Appendix.

Due to the very high number of new residential appliances per year, and their net added cost, residential AC and refrigerator-freezers account for virtually all of the added net cost of low-GWP equipment. The current best estimate for added cost per unit ($400 for central AC, and $150 for refrigerator-freezers) may decrease in the future as production of lower-GWP equipment increases and economies of scale are realized. The added cost of low-GWP residential refrigerator-freezers could also be reduced due to a March 29, 2016 Federal proposal by the U.S. EPA that will prohibit high-GWP refrigerants in new units as of January 1, 2021. Presumably, a national requirement would result in greater production of low-GWP appliances than a California-only requirement, with greater cost savings due to a nation-wide transition resulting in mass production or import of low-GWP equipment. The U.S. EPA proposed regulation had not been adopted as of April 2016.

2. HFC Supply Phasedown

The HFC supply phasedown measure is no longer specific to California, but is international in scope and all developed countries, including the U.S., will follow the same phasedown schedule. Although the phasedown measure is no longer attributed to ARB, the cost and benefit analysis summarized below is still an accurate representation of the impact on businesses and residents in California.

The methodology used to estimate the cost and savings of a global HFC supply phasedown as it affects California is the same as that used for high-GWP refrigerant prohibitions, with one exception; the incremental equipment is estimated to be ten percent less than the cost used for the prohibitions measure. Analysis conducted for the European Union F-gas regulation concluded that non-prescriptive measures in which HFCs can be used in conjunction with a gradually decreasing HFC supply are approximately ten percent less costly than sector specific high-GWP prohibitions (Oko Recherche, 2011). Additionally, trade organizations such as the Alliance for Responsible Atmospheric Policy (ARAP), representing more than 100 equipment manufacturers and refrigerant manufacturers, state that an HFC phasedown could be met with a much lower added cost than specific high-GWP prohibitions. The costs of the high-GWP phasedown are shown in Table 38.

Table 38: Estimated Net Cost of Low-GWP Equipment, HFC Phasedown Measure[101]

Sector	Average Lifetime (yrs)	Added Equipment Cost ($/yr)[102]	Annual Cost Savings ($/unit)	Estimated New Units[103] and Equipment	Estimated Annual Net Cost (Savings) ($/yr)[104]
Centralized System Large (2,000+ lbs)	15	$12,000	($15,000)	50	($189,000)
Centralized System Medium (200-2,000 lbs)	15	$3,000	($4,000)	1,600	($1,076,000)
Cold Storage Large (2,000+ lbs)	20	$22,000	($25,000)	10	($22,000)
Cold Storage Medium (200-2,000 lbs)	20	$11,000	($9,000)	25	$55,000
Process Cooling Large (2,000+ lbs)	20	$11,000	($14,000)	10	($12,000)
Refrigerated Condensing Units Small (50-200 lbs)	15	$1,000	($1,000)	3,900	($311,000)
Refrigerated Condensing Units (Less than 50 lbs)	20	$500	($500)	15,700	($2,772,000)
Stand-Alone Refrig Display Cases	20	$10	($50)	34,300	$420,000
Centrifugal Chiller Large (2,000+ lbs)	20	$1,000	($800)	200	$137,000
Centrifugal Chiller Medium (200-2,000 lbs)	20	$1,000	($500)	100	$34,000
Chiller Packaged Medium (200-2,000 lbs)	20	$1,000	($200)	500	$336,000

101 Numbers may not add due to rounding.
102 The added equipment cost per year is calculated by taking the total added initial cost of the equipment, and dividing by the average years of equipment lifetime. The annual savings has been calculated by determining all annual savings and dividing by the average years of equipment cost. All costs and savings are shown in today's dollars; no discounted cost has been used.
103 The estimated number of new units is derived from research and analysis conducted for the ARB Refrigerant Management Program regulation, equipment data registered through the Refrigerant Management Program data, and additional analysis used in the ARB Greenhouse Gas Emissions Inventory as developed by Gallagher, et al. 2014.
104 The annual cost would be applied for each year of the model year or cohort's lifetime. Table 43 shows the cost if the HFC phasedown were the only proposed HFC measure implemented. The cumulative costs of the four proposed HFC measures are shown in Table 27 of the Appendix.

Sector	Average Lifetime (yrs)	Added Equipment Cost ($/yr)[102]	Annual Cost Savings ($/unit)	Estimated New Units[103] and Equipment	Estimated Annual Net Cost (Savings) ($/yr)[104]
Unitary A/C Small (50-200 lbs)	15	$100	($200)	4,900	($469,000)
Unitary A/C Central (Less than 50 lbs)	15	$50	($25)	169,000	($586,000)
Window AC Units Commercial	10	$25	($10)	54,000	$289,000
Residential AC Central	15	$25	($10)	482,000	$8,709,000
Window AC Units Residential	10	$25	($10)	310,000	$1,345,000
Residential Refrigerator-Freezer	15	$10	($10)	1,266,000	$8,227,000
Total Annual Cost of Equipment Model Year[105]					**$14,115,000**

3. Financial Incentive Program for Low-GWP Refrigeration Early Adoption

In order to incentivize low-GWP refrigeration prior to any mandatory regulatory measures, ARB has requested funding from the Greenhouse Gas Reduction Fund (GGRF) to use as a financial incentive, as a grant, loan, or other payment to be determined, to encourage new retail food facilities to use low-GWP refrigeration. Additionally, current stores using high-GWP equipment with remaining useful life could use funding to replace the high-GWP refrigerant in existing equipment, with low-GWP refrigerant, in a process known as a retrofit.

Table 39 shows the estimated incremental equipment cost of an incentive program for new equipment and retrofits. The cost assumptions in Table 39 are the same as those used for high-GWP prohibitions outlined in Table 37. This analysis assumes that the entire incremental cost of low-GWP equipment is covered by the incentive. However, the cost-effectiveness of this proposed measure could be improved if the necessary incentive is less than the incremental cost of low-GWP equipment.

[105] The annual cost would be applied for each year of the model year or cohort's lifetime. Table 22 shows the cost if the prohibition were the only proposed HFC measure implemented. The cumulative costs of the four proposed HFC measures are shown in Table 43 of the Appendix.

Table 39: Estimated Cost and Savings of Incentive Program for New Low-GWP Equipment (Per Piece of Equipment)

Sector	Average Lifetime (yrs)	Baseline Average Cost of Equipment	Incremental Cost for Low-GWP Equipment	Lifetime Cost	Annual Cost	Net Cost (Savings) ($/yr)
Centralized System Large[106] (2,000+ lbs)	15	$1,000,000	$200,000	($231,000)	($15,000)	($2,000)
Centralized System Medium[107] (200-2,000 lbs)	15	$250,000	$50,000	($55,000)	($4,000)	($500)
Refrigerated Condensing Units Small[108] (50-200 lbs)	15	$75,000	$15,000	($15,000)	($1,000)	$25
Refrigerated Condensing Units[109] (Less than 50 lbs)	20	$37,500	$7,500	($10,000)	($500)	($250)
Stand-Alone Refrigerated Display Cases[110]	20	$5,000	$1,000	($1,000)	($25)	$50

In addition to incentivizing new low-GWP equipment, existing high-GWP equipment could be converted to using lower-GWP refrigerants in a process known as a retrofit, where the high-GWP refrigerant is removed, and new lower-GWP refrigerant is added, along with minor modifications such as replacing seals and the refrigerant oil. Table 40 shows the cost of an incentive program to retrofit existing high-GWP equipment and Table 41 presents the cost of a voluntary retrofit program.

The relative high cost savings of are due to the inherent inefficiency of the refrigerant being replaced, which is R-404A, a high-GWP blend of HFCs. Almost any refrigerant replacement will result in significant energy efficiencies compared to R-404A. In this analysis, we assume that the replacement refrigerant is an HFO-HFC blend, either R-448A, or R-449A, each with a 10 percent greater efficiency than R-404A. The same kWh and electricity cost from the Prohibition analysis is used here. The total cost of an incentive program is limited by available funds, and is not known. The following shows a theoretical net cost of an incentive program for one year for new equipment, if 80% of new large and medium centralized systems are incentivized, four percent of smaller

[106] The analysis assumes one per supermarket.
[107] The analysis assumes three to four per supermarket and one to two per grocery store.
[108] The analysis assumes one to three per grocery store.
[109] The analysis assumes up to several per small market.
[110] The analysis assumes several per small market and more for larger markets.

units (50 to 200 lbs charge size), two percent of refrigeration units with less than 50 lbs charge size, and one percent of stand-alone (self-contained equipment). For existing equipment, we assume that a number equal to one-year's turnover rate could be retrofitted. For equipment with a 20-year lifetime, the retrofit rate would be 5% of all equipment, and for equipment with a 15-year lifetime, the retrofit rate would be 6.7%. The cost of the following analysis assumes that approximately $240 million dollars in incentive funds could be available. Although the funding would be one-time and at the time of the new low-GWP equipment installation, or retrofit activity, the cost is shown on an annualized basis over the lifetime of the equipment to be consistent with cost analysis by year of equipment life.

Table 40: Estimated Cost and Savings of Incentive Program for Retrofit of Existing Low-GWP Equipment (Per Piece of Equipment)[111]

Sector	Post-Retrofit Remaining Life[112] (yrs)	One-Time Retrofit Cost ($/unit)	Lifetime Cost (Savings)	Added Annual Cost	Number of Equipment (unit/yr)	Net Cost (Savings) ($/yr)
Centralized System Large[113] (2,000+ lbs)	10	$80,000	($141,000)	$8,000	($14,000)	($6,000)
Centralized System Medium[114] (200-2,000 lbs)	10	$30,000	($31,000)	$3,000	($3,000)	($100)
Refrigerated Condensing Units Small[115] (50-200 lbs)	13	$6,000	($10,000)	$500	($1,000)	($300)
Refrigerated Condensing Units[116] (Less than 50 lbs)	13	$3,000	($7,000)	$250	($50)	($300)
Stand-Alone Refrigerated Display Cases[117]	13	$250	($500)	$50	($50)	($25)

[111] Numbers may not add due to rounding.
[112] Assumed to be 2/3 of total equipment lifetime.
[113] The analysis assumes one per supermarket.
[114] This analysis assumes three to four per supermarket and one to two per grocery store.
[115] This analysis assumes one to three per grocery store.
[116] This analysis assumes up to several per small market.
[117] This analysis assumes several per small market and more for larger markets.

Table 41: Estimated Annual Costs and Savings of Voluntary Incentive Program (Per Piece of Equipment) [118]

Sector	Incentive: New Equipment or Retrofit Existing	Added Annual Cost	Annual Cost (Savings)	Net Cost (Savings)	Pieces of Equipment (unit/yr)	Net Cost (Savings) ($/yr)
Centralized System Large (2,000+ lbs)[119]	New	$13,000	($15,000)	($2,000)	45	($91,000)
	Retrofit	$8,000	($14,000)	($6,000)	56	($340,000)
Centralized System Medium[120] (200-2,000 lbs)	New	$3,000	($4,000)	($500)	1,300	($439,000)
	Retrofit	$3,000	($3,000)	($100)	1,600	($202,000)
Refrigerated Condensing Units Small[121] (50-200 lbs)	New	$1,000	($1,000)	$25	150	$3,000
	Retrofit	$500	($750)	($300)	3,800	($1,107,000)
Refrigerated Condensing Units[122] (Less than 50 lbs)	New	$500	($500)	($100)	300	($44,000)
	Retrofit	$250	($500)	($300)	16,000	($4,545,000)
Stand-Alone Refrigerated Display Cases[123]	New	$50	($25)	$25	300	$6,000
	Retrofit	$25	($25)	($25)	34,000	($480,000)
Total Estimated Annual Net Cost (Saving)						**($7,239,000)**

4. Sales Ban of Very-High GWP Refrigerants

To determine the incremental cost of complying with a sales ban of very high-GWP refrigerant (100-year GWP > 2500), this analysis assumes that a sales ban of refrigerant with a GWP > 2500 can be met by replacing the old refrigerant (if necessary) with new refrigerant, in a process called a retrofit. It is not anticipated that a sales ban of very-high GWP refrigerants will require purchasing new equipment sooner than the normal expected lifetime of the existing equipment, although some equipment owners may choose to purchase new low-GWP equipment rather than replace the existing refrigerant. Air-conditioning equipment, residential refrigeration, and residential AC do

[118] Numbers may not add due to rounding. Estimated costs and savings are for participating businesses only.
[119] The analysis assumes one per supermarket.
[120] This analysis assumes three to four per supermarket and one to two per grocery store.
[121] This analysis assumes one to three per grocery store.
[122] This analysis assumes up to several per small market.
[123] This analysis assumes several per small market and more for larger markets.

not use very-high GWP refrigerants and would not be affected by the sales ban. The retrofit cost shown in Table 42 is an average of quotes from technicians who conduct refrigeration retrofits. There are estimated significant savings over equipment lifetime resulting from the reduced energy usage of lower-GWP refrigerants, similar to the retrofit cost outlined in the proposed incentive program measure.

Table 42: Estimated Cost and Savings of Sales Ban of Very-High GWP Refrigerants (Per Piece of Equipment)[124]

Sector	Post-Retrofit Remaining Life[125] (yrs)	One-Time Retrofit Cost ($/unit)	Lifetime Cost (Savings)	Added Annual Cost	Cost (Savings) ($/yr)	Cost (Savings) ($/yr)
Centralized System Large (2,000+ lbs)	10	$80,000	($141,000)	$8,000	($14,000)	($6,000)
Centralized System Medium (200-2,000 lbs)	10	$20,000	($31,000)	$3,000	($3,000)	($100)
Cold Storage Large (2,000+ lbs)	13	$200,000	($230,000)	$15,000	($17,000)	($2,000)
Cold Storage Medium (200-2,000 lbs)	13	$100,000	($115,000)	$7,500	($9,000)	($1,000)
Process Cooling Large (2,000+ lbs)	13	$100,000	($182,000)	$7,500	($14,000)	($6,000)
Refrigerated Condensing Units Small (50-200 lbs)	10	$6,000	($10,000)	$1,000	($1,000)	($500)
Refrigerated Condensing Units (Less than 50 lbs)	13	$3,000	($7,000)	$250	($500)	($500)
Stand-Alone Refrigerated Display Cases	13	$250	($500)	$25	($50)	($25)

The total equipment cost of a sales ban is dependent upon the numbers of equipment undergoing a retrofit, which would not necessarily be required if the equipment did not require new refrigerant, as is common in many self-contained equipment. Also, stockpiled or recycled refrigerant would still be available during a sales ban on new production.

[124] Numbers may not add due to rounding.
[125] Assumed to be 2/3 of total equipment lifetime.

Table 43 is a continuation of the cost for a sales ban measure. In addition to showing the cost per unit, the number of units affected by the measure is estimated. Table 41 shows the cost per year of a scenario where the retrofit rate is approximately 10 percent of existing very-high GWP equipment.

Table 42: Estimated Cost and Saving of a Very-High GWP Sales Ban (Per Year of Measure)[126]

Sector	Added Unit Cost	Cost or (Savings)	Net Costs per Unit	Number of Equipment (unit/yr)	Net Cost (Savings)
Centralized System Large (2,000+ lbs)	$8,000	(-$14,000)	(-$6,000)	10	(-$523,000)
Centralized System Medium (200-2,000 lbs)	$3,000	(-$3,000)	(-$250)	2,500	(-$310,400)
Cold Storage Large (2,000+ lbs)	$15,000	(-$17,000)	(-$2,000)	25	(-$34,000)
Cold Storage Medium (200-2,000 lbs)	$7,500	(-$9,000)	(-$1000)	50	(-$48,000)
Process Cooling Large (2,000+ lbs)	$7,500	(-$14,000)	(-$6,000)	10	(-$68,000)
Refrigerated Condensing Units Small (50-200 lbs)	$600	(-$1,000)	(-$500)	8,000	(-$3,019,000)
Refrigerated Condensing Units (Less than 50 lbs)	$250	(-$500)	(-$500)	32,000	(-$9,294,000)
Stand-Alone Refrigerated Display Cases	$25	(-$50)	(-$25)	70,000	(-$982,000)
Estimated Annual Cost (Savings)					**(-$14,278,000)**

5. Cumulative Cost of All Measures

This analysis estimates a net cost as a result of the proposed prohibition and phasedown measures and net savings from the proposed incentive and sales ban measures. This analysis also finds that all four measures are estimated to contribute to HFC emission reductions. As new equipment can only be built as low-GWP once, new equipment can be assigned to only one of the four reduction measures. Existing equipment can also be retrofitted to lower-GWP refrigerants, which will increase HFC emission reductions faster than waiting for natural equipment turn over. As existing equipment can be retrofitted, the estimated annual percentage of new low-GWP

[126] Numbers may not add due to rounding.

equipment (new and retrofit) can equal more than 100 percent of estimated unit turn over per year.

The following section outlines the assumptions that were used to determine the combination of measures contributing to both cost and savings as well as HFC emission reductions and are presented by proposed measure.

Incentive Program

From 2017 through 2020, an incentive program could incentive a switch to low-GWP refrigeration for up to 80 new large and medium refrigeration systems. The analysis also assumes an additional four percent of new refrigerated condensing units (50 to 200 lbs of refrigerant), two percent of new refrigerated condensing units less than 50 lbs, and one percent of new stand-alone (self-contained) refrigerated display cases could be incentivized to switch to low-GWP refrigerant.

Sales Ban

For existing units, the analysis estimates that approximately five to seven percent of refrigeration units could be retrofit to lower-GWP refrigerants each year, from 2019 through 2025. The analysis assumes that the sales ban could also be responsible for five to six percent of all new low-GWP refrigeration equipment. The sales ban would not apply to refrigerants used in air-conditioning.

HFC Phasedown

A phasedown in the supply of new HFC refrigerant will begin in 2019 and continue with a gradual phasedown in the supply through 2036 until the new total allocation (as measured in CO_2e) will be 85 percent less than baseline. By 2025, we estimate that up to half of all new equipment could be low-GWP due to an HFC phasedown.

High-GWP Refrigerant Prohibitions in New Equipment

Prohibition measures would take place immediately after measures implementation and would result in an estimated 80 to 90 percent turnover to low-GWP equipment until implementation of HFC phasedowns. The percent of equipment becoming low-GWP as a result of the prohibitions would gradually decrease, and by 2025, the analysis estimates 37 percent of all new equipment will be low-GWP due to the prohibitions.

Given the transition towards low-GWP refrigeration and AC equipment as modeled in this analysis, Table 43 shows the estimated cost, by year, and also aggregated cost and savings through 2030.

Table 43: Cumulative Cost of all Measures (Million Dollars)

Measure		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Incentive Program	Added Cost	$5	$11	$17	$18	$18	$18	$18	$18	$18	$19	$19	$19	$19	$19
	Savings	($6)	($12)	($19)	($20)	($20)	($20)	($20)	($20)	($20)	($21)	($21)	($21)	($21)	($21)
	Net Cost or (Savings)	($1)	($1)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)
Sales Ban	Added Cost	$0	$0	$16	$40	$64	$89	$115	$136	$150	$151	$152	$147	$141	$148
	Savings	$0	$0	($26)	($65)	($105)	($146)	($187)	($224)	($246)	($248)	($249)	($237)	($232)	($240)
	Net Cost or (Savings)	$0	$0	($11)	($26)	($41)	($57)	($73)	($88)	($96)	($97)	($97)	($90)	($90)	($92)
HFC Phasedown (through global Kigali Amendment)	Added Cost	$0	$0	$0	$2	$4	$11	$28	$56	$91	$124	$160	$198	$237	$276
	Savings	$0	$0	($0)	($1)	($3)	($7)	($19)	($39)	($63)	($87)	($113)	($140)	($168)	($196)
	Net Cost or (Savings)	$0	$0	$0	$0	$1	$4	$9	$18	$28	$37	$47	$58	$69	$80
High-GWP HFC Prohibitions	Added Cost	$0	$0	$0	$19	$73	$123	$164	$194	$218	$246	$273	$299	$325	$352
	Savings	$0	$0	$0	($21)	($55)	($87)	($113)	($132)	($147)	($165)	($181)	($198)	($215)	($233)
	Net Cost or (Savings)	$0	$0	$0	($2)	$18	$36	$51	$62	$71	$82	$91	$101	$110	$120

All Measures Combined	**Cumulative Cost**	$5	$16	$50	$128	$287	$528	$852	$1,257	$1,734	$2,274	$2,877	$3,540	$4,262	$5,058
	Cumulative Savings	($6)	($18)	($64)	($171)	($354)	($613)	($952)	($1366)	($1843)	($2363)	($2927)	($3524)	($4159)	($4849)
	Cumulative Net Cost or (Savings)	**($1)**	**($2)**	**($14)**	**($43)**	**($67)**	**($85)**	**($100)**	**($110)**	**($109)**	**($89)**	**($50)**	**$16**	**$103**	**$209**

Appendix F: Supporting Documentation for the Economic Assessment of Measures in the SLCP Strategy

Supporting Documentation for the Economic Assessment of Measures in the SLCP Strategy

This Appendix presents technical information and calculations that support the economic analysis in Chapter VIII of the SLCP Strategy. Appendix F contains information for three measures for which there is great potential for low-cost emission reductions. Reducing methane from dairy manure, diversion of landfilled organic waste, and hydrofluorocarbon (HFC) emission reductions all have large economic and environmental potential as outlined in the subsequent sections.

A. Methane Emission Reductions from Dairy Manure

The dairy economic analysis presented in Section VIII of the SLCP Strategy, examined five mitigation pathways and two sector wide cost bounding scenarios to achieve a 22 MMTCO2e (20-yr GWP) reduction in dairy manure methane in 2030. This appendix provides more detail about the assumptions and calculation methodologies used for these analyses. First, each pathway is described along with a summary of the assumptions used to calculate capital costs, annual operations and maintenance (O&M), and annual revenue (Table 1 through Table 8). Next, a more detailed breakout of the total capital costs, annual O&M, and annual revenue for an example 2,000 cow dairy are provided for each pathway (Table 9 through Table 16). Finally, additional detail is provided for the two sector-wide economic analyses that we used to bound the estimate for total costs to reduce dairy manure methane by 22 MMTCO2e (20-yr GWP) in 2030 (Table 17 through Table 19).

List of Tables Related to Methane Emission Reductions from Dairy Manure

1. Cost Analysis Methodology

Five potential pathways to reduce manure methane emissions were analyzed. Not every pathway may be feasible for every dairy, and a variety of pathways will be employed to reach the targets. These pathways do not represent an exhaustive list of mitigation options and variations may be used by some dairies. The assumptions used to analyze these pathways are subject to uncertainty and any actual project cost will vary from the estimate here. The five pathways include:

1) Scrape conversion and onsite manure digestion producing:
   a) electricity or
   b) pipeline-injected renewable natural gas vehicle fuel
2) Scrape conversion and transport of manure offsite for centralized digestion producing:
   a) electricity or
   b) pipeline injected renewable natural gas as a vehicle fuel
3) Retain existing manure lagoon management with onsite covered lagoon digestion producing:
   a) electricity or
   b) pipeline-injected renewable natural gas vehicle fuel
4) Conversion of dairy operations to pasture-based management
5) Scrape conversion, collection and open solar drying of manure onsite

Pathway 1 assumes solid manure management, which includes solid scrape and vacuum systems. There is a cost for dairies that use anaerobic lagoons to convert to solid systems. Each dairy uses an above ground tank or plug-flow digester to produce biogas. The biogas use was analyzed for two sub-pathways: 1a assumed electricity production, and 1b assumed biogas was converted to transportation fuel. In pathway 1a, electricity was produced by a microturbine with the intention to emit less local NOx emissions compared to an internal combustion reciprocating engine generator. In pathway 1b biogas is injected into the transmission pipeline. Table 1 contains a summary of costs and revenues for Pathway 1a and Table 2 contains a summary of costs and revenue for Pathway 1b.

Table 1: Summary of Assumptions for Dairy Pathway 1a - Scrape Conversion and Onsite Manure Digestion Producing Electricity

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion[1]	$350 per milking head	3%	ARB Estimated Value
Digester and Microturbine with Electricity Equipment	Cost per head = 18,431*[# milking head]^-0.275	8.5%	UC Davis Report
Interconnection	$1,000,000	5%	Suscon Report
Biogas Upgrading	Included in O&M	$6 per 1,000 SCF biogas[2]	

Revenue		
Item	**Value**	**Reference**
Electricity Generation	0.123 kW per milking cow	UC Davis Report and ARB Inventory assuming 100% methane utilization
SB1122 Electricity Tariff Price	$ 0.1263 per kWh	SB1122 Feed in Tariff Price[3]
Mitigatable methane (lagoon management)	7.38 metric tons CO_2e per milking head per year (100-yr GWP)	ARB GHG Inventory
Mitigatable methane (other management)	2.13 metric tons CO_2e per milking head per year (100-yr GWP)	ARB GHG Inventory
Cap-and-Trade Offset	$13 per ton CO_2e mitigated (100-yr GWP)	Estimate
Soil Amendment	$0[4]	

[1] Scrape conversion costs were only assumed for lagoon manure management. Other manure management types were assumed to require no capital to convert to solid manure management.
[2] These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
[3] https://www.pge.com/en_US/for-our-business-partners/floating-pages/biomat/biomat.page
[4] Soil amendments were assumed to have zero value due to uncertainty in future markets, but could provide additional revenue.

Table 2: Summary of Assumptions for Dairy Pathway 1b - Scrape Conversion and Onsite Manure Digestion Producing Pipeline-Injected Renewable Natural Gas

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion[5]	$350 per milking head	3%	ARB Estimated Value
Digester without Electricity Equipment	Cost per head = 64% * 18,431*[# milking head]^-0.275	6%	UC Davis Report and Suscon Report[6]
Interconnection	$2,000,000	5%	Suscon Report
Pipeline	$200,000 per mile	5%	Suscon Report[7]
Biogas Upgrading	Included in O&M	$8 per 1,000 SCF biogas[8]	Suscon Report

Revenue		
Item	**Value**	**Reference**
Biomethane production	21,601 cubic feet per milking cow per year	UC Davis Report[9]
Biogas price	$ 3.46 per 1,000 cubic feet	
RIN Credits (above ground or plug-flow digester)	145 RINS per cow per year	LCFS LHV for CA ULSD of 127,460 Btu and 77,500 Btu per RIN under RFS2
RIN Credit Price	$1.85 per RIN credit	Estimate
LCFS Credit Price	$100	Estimate
Soil Amendment	$0[10]	

Pathway 2 is similar to Pathway 1, except centralized digesters are used instead of individual digesters on each dairy, and only dairies using anaerobic lagoon manure management are included in the analysis. ARB staff selected 55 centralized locations that would pull from 1.05 million dairy cows to digest manure and inject it into the pipeline. The number and location of centralized facilities was estimated, but not optimized, and there may be configurations that could reduce collective costs among clustered dairy farmers more than shown here. As modeled, the statewide scenario required building approximately 200 miles of low-pressure pipeline and 55 miles of new natural gas transmission pipeline. The average centralized digester was fed by approximately 40 truckloads of manure per day, with the trucks traveling an average round-trip distance of approximately 7 miles per load. This analysis includes assumed costs for new low-NOx CNG trucks, a small fleet refueling station for each cluster, and hauling costs. The number of trucks needed was estimated assuming 1 roundtrip per hour running 7.5 hours per day hauling 33.2 tons of manure per trip. The central digesters are assumed to be plug-flow or above ground tank digester types. The biogas use was analyzed for two sub-pathways: 2a assumed electricity production, and 2b

5 Scrape conversion costs were only assumed for lagoon manure management. Other manure management types were assumed to require no capital to convert to solid manure management.
6 O&M assumed to be lower than electricity generating pathways because there is no electricity generating equipment
7 Low pressure rural pipeline
8 These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
9 Above ground tank or plug flow with uncovered effluent pond, adjusted to assume 100% of manure volatile solids reached the digester.
10 Soil amendments were assumed to have zero value due to uncertainty in future markets but could provide additional revenue.

assumed biogas was converted to transportation fuel. In pathway 2a, electricity was produced by a microturbine with the intention to emit less local NOx emissions compared to an internal combustion reciprocating engine generator. In pathway 2b, a portion of the transportation fuel was used in a small local station to fuel manure hauling trucks and a portion was injected into the transmission pipeline. Costs and revenue are distributed among the dairies in a cluster according to milking population. Table 3 contains a summary of costs and revenues for Pathway 2a and Table 4 contains a summary of costs and revenue for Pathway 2b.

Table 3: Summary of Assumptions for Dairy Pathway 2a - Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Electricity

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion	$350 per milking head	3%	ARB Estimated Value
Digester and Microturbine with Electricity Equipment	Cost per head = 18,431*[# milking head]^-0.275	8.5%	UC Davis Report
Interconnection	$5,500,000 per cluster	3.5%	Suscon Report
Biogas Upgrading	Included in O&M	$2 per 1,000 SCF biogas[11]	
Low NOx Natural Gas Truck Purchase	$250,000 each	Assumed to be included in trucking costs below	Suscon Report
Manure transport cost		$2 per mile plus $15 per trip	Compilation[12]
Constants			
Manure trips	1 truckload per hour 7.5 hours per day	Estimate based on average trip distance from GIS analysis	
Manure per cow	140 lbs per day (wet)	UC Davis[13]	
Manure hauling capacity	33.2 tons (wet) per trip	Calculation[14]	

Revenue		
Item	**Value**	**Reference**
Electricity Generation	0.123 kW per milking cow	UC Davis Report and ARB Inventory assuming 100% methane utilization
SB1122 Electricity Tariff Price	$ 0.1263 per kWh	SB1122 Feed in Tariff Price[15]
Mitigatable methane (lagoon management)	7.38 metric tons CO_2e per milking head per year (100-yr GWP)	ARB GHG Inventory
Cap-and-Trade Offset	$13 per ton CO_2e mitigated (100-yr GWP)	Estimate
Soil Amendment	$0[16]	

[11] These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
[12] $2 per mile is based on California rates from http://www.dat.com/resources/trendlines/van/west-regional-rates and rounded up to assume it includes added incremental cost of ultra-low NOx natural gas truck. $15 per trip covers future minimum wage, assuming 1 trip per hour. Trip costs were calculated using the amount of manure produced, the number of truckloads needed and the round trip distance to the central digester.
[13] http://energy.ucdavis.edu/files/09-16-2014-08_Biomass_Resource-and-Facilities-Database-Update.pdf
[14] Assuming a truck can haul 40 cubic yards and manure is 62 pounds per cubic foot (wet) from http://pss.uvm.edu/vtcrops/articles/ManureCalibration.pdf, http://www.mastersonloam.com/trucks/ and http://www.calrecycle.ca.gov/SWFacilities/Directory/38-AA-0020/Document/298055
[15] https://www.pge.com/en_US/for-our-business-partners/floating-pages/biomat/biomat.page
[16] Soil amendments were assumed to have zero value due to uncertainty in future markets but could provide additional revenue.

Table 4: Summary of Assumptions for Dairy Pathway 2b
- Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Pipeline-Injected Renewable Natural Gas

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion	$350 per milking head	3%	ARB Estimated Value
Digester with No Electricity Equipment	Cost per head = 64% * 18,431*[# milking head]^-0.275	6%	UC Davis Report and Suscon Report[17]
Interconnection	$5,500,000 per cluster	3.5%	Suscon Report
Biogas Upgrading	Included in O&M	$6 per 1,000 SCF biogas[18]	
Low NOx Natural Gas Truck Purchase	$250,000 each	Assumed to be included in trucking costs below	Suscon Report
Manure transport cost		$2 per mile plus $15 per trip	Compilation[19]
Pipeline	$200,000 per mile	5%	Suscon Report[20]
Transmission Pipeline	$1,000,000 per mile	5%	SoCal Gas[21]
Small CNG Station	$150,000 each, 1 per cluster	10%	Suscon Report
Constants			
Manure trips	1 truckload per hour 7.5 hours per day	Estimate based on average trip distance from GIS analysis	
Manure per cow	140 lbs per day (wet)	UC Davis[22]	
Manure hauling capacity	33.2 tons (wet) per trip	Calculation[23]	

Revenue		
Item	**Value**	**Reference**
Biomethane production	21,601 cubic feet per milking cow per year	UC Davis Report[24]
Biogas price	$ 3.46 per 1,000 cubic feet	
RIN Credits (above ground or plug-flow digester)	145 RINS per cow per year	LCFS LHV for CA ULSD of 127,460 Btu and 77,500 Btu per RIN under RFS2
RIN Credit Price	$1.85 per RIN credit	Estimate
LCFS Credit Price	$100	Estimate
Soil Amendment	$0[25]	

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17 O&M assumed to be lower than electricity generating pathways because there is no electricity generating equipment
18 These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
19 $2 per mile is based on California rates from http://www.dat.com/resources/trendlines/van/west-regional-rates and rounded up to assume it includes added incremental cost of ultra-low NOx natural gas truck. $15 per trip covers future minimum wage, assuming 1 trip per hour. Trip costs were calculated using the amount of manure produced the number of truckloads needed and the round trip distance to the central digester.
20 Low pressure rural pipeline connecting central digester to the transmission pipeline.
21 SoCal Gas suggests pipelines might cost $200-300 per foot near roadways (http://americanbiogascouncil.org/webinars/22may14_pipelineBiogasCA.pdf), which would translate to about $1-$1.5 million per mile. 55 miles of transmission pipeline extensions are assumed to be needed, and costs are divided among all clusters by milking population.
22 http://energy.ucdavis.edu/files/09-16-2014-08_Biomass_Resource-and-Facilities-Database-Update.pdf
23 Assuming a truck can haul 40 cubic yards and manure is 62 pounds per cubic foot (wet) from http://pss.uvm.edu/vtcrops/articles/ManureCalibration.pdf, http://www.mastersonloam.com/trucks/ and http://www.calrecycle.ca.gov/SWFacilities/Directory/38-AA-0020/Document/298055
24 Above ground tank or plug flow with uncovered effluent pond, adjusted to assume 100% of manure volatile solids reached the digester.
25 Soil amendments were assumed to have zero value due to uncertainty in future markets but could provide additional revenue.

Pathway 3 assumes individual dairies retain existing anaerobic lagoon manure management and collect biogas from the covered lagoons. Only dairies already using anaerobic lagoon manure management are included in this scenario. Biogas use was analyzed for two sub-pathways: 3a assumed electricity production, and 3b assumed biogas was converted to transportation fuel. In pathway 3a, electricity was produced by a micro turbine to reduce local NOx emissions. In pathway 3b, transportation fuel was injected into the transmission pipeline. Pipeline injection of renewable natural gas avoids new onsite NOx generation that would occur from on-site electricity generation. Table 5 contains a summary of costs and revenues for Pathway 3a and Table 6 contains a summary of costs and revenue for Pathway 3b.

Table 5: Summary of Assumptions for Dairy Pathway 3a – Covered Lagoon Manure Management with Collected Methane Producing Electricity

Costs			
Item	**Capital**	**O&M**	**Reference**
Covered Lagoon Digester	Cost per head = 12,146*[# milking head]^-0.25	6%	UC Davis Report
Interconnection	$1,000,000	5%	Suscon Report
Biogas Upgrading	Included in O&M	$6 per 1,000 SCF biogas[26]	

Revenue		
Item	**Value**	**Reference**
Electricity Generation	0.066 kW per milking cow	UC Davis Report[27]
SB1122 Electricity Tariff Price	$ 0.1263 per kWh	SB1122 Feed in Tariff Price[28]
Mitigatable methane (lagoon management)	7.38 metric tons CO_2e per milking head per year (100-yr GWP)	ARB GHG Inventory
Cap-and-Trade Offset	$13 per ton CO_2e mitigated (100-yr GWP)	Estimate
Soil Amendment	$0[29]	

[26] These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
[27] Adjusted to match biogas production assumptions. Covered lagoon digesters are approximately 11 percent less efficient at biogas production per pound of manure based on the UC Davis Report, and 40% of manure volatile solids are assumed to be lost during solids separation.
[28] https://www.pge.com/en_US/for-our-business-partners/floating-pages/biomat/biomat.page
[29] Soil amendments were assumed to have zero value due to uncertainty in future markets, but could provide additional revenue.

Table 6: Summary of Assumptions for Dairy Pathway 3b – Covered Lagoon Manure Management with Collected Methane Producing Pipeline-Injected Renewable Natural Gas

Costs			
Item	**Capital**	**O&M**	**Reference**
Covered Lagoon Digester	Cost per head = 12,146*[# milking head]^-0.25	6%	UC Davis Report
Interconnection	$2,000,000	5%	Suscon Report
Pipeline	$200,000 per mile	5%	Suscon Report[30]
Biogas Upgrading	Included in O&M	$8 per 1,000 SCF biogas[31]	Suscon Report

Revenue		
Item	**Value**	**Reference**
Biomethane production	11,520 cubic feet per milking cow per year	UC Davis Report[32]
Biogas price	$ 3.46 per 1,000 cubic feet	
RIN Credits (covered lagoon)	77.4 RINS per cow per year	Calculation[33]
RIN Credit Price	$1.85 per RIN credit	Estimate
LCFS Credit Price	$100	Estimate
Soil Amendment	$0[34]	

Pathway 4 assumed some dairies could convert to a pasture-based model where manure decays aerobically in the field and emits a negligible amount of methane. GIS analysis was used to analyze existing land area associated with dairies and to estimate the remaining amount of land purchase needed to meet the target cow density. Resulting diet changes are assumed to increase enteric emissions and reduce milk production. The impact of these effects on cost effectiveness was assessed by assuming manure methane reductions were partially offset by a 35 percent increase in enteric emissions. Revenue loss from decreased milk production was not directly accounted for due to a lack of information on this effect. Little information is available on the economics associated with converting to pasture, and most of the capital and operations and maintenance costs are assumptions based on ARB staff best estimates, review of limited studies, or direct calls to manufacturers. Table 7 contains a summary of assumptions used to calculate costs for Pathway 4; the pathway does not produce any new revenue.

[30] Low pressure rural pipeline
[31] These costs are represented as annual O&M costs, and are assumed to include amortized capital costs.
[32] Lagoon digester, assumes 60% of manure volatile solids reaches digester because 40% are lost in solids separation.
[33] Uses the same assumptions as for above ground tank or plug-flow (LCFS LHV for CA ULSD of 127,460 Btu and 77,500 Btu per RIN under RFS2) but adjusted for the 11% reduction in biogas efficiency for covered lagoon compared to above ground or plug-flow digesters based on UC Davis report and 40% reduction in volatile solids reaching the lagoon due to solids separation
[34] Soil amendments were assumed to have zero value due to uncertainty in future markets but could provide additional revenue.

Table 7: Summary of Assumptions for Dairy Pathway 4 – Conversion to Pasture

Costs			
Item	**Capital**	**O&M**	**Reference**
Land Purchase	$7,700 per acre	n/a	USDA[35]
Fencing	$1.07 per foot	2.5%	ARB Analysis[36]
Irrigation	$5,000 per acre	10%	ARB Analysis
Shade Structures	$6,500 per structure	2.5%	ARB Analysis
Water Troughs	$180 per parcel	1%	ARB Analysis

Constants		
Item	**Value**	**Reference**
Milking Cow Density	3 cows per acre	
Parcel Size	5 acres	
Additional Acres to Purchase	200,000 acres	ARB GIS Analysis
Fencing per Parcel	1,980 feet	
Water Troughs per Parcel	1	
Shade Structures per Parcel	1	

Pathway 5 assumes all dairies use open solar drying of manure for 8 months of the year. This pathway may be an option for dairy operations not suitable for digestion or not near natural gas pipelines or transportation corridors to sell fuel, or for dairy farmers that wish to avoid the complexity of digester operation, power purchase agreements, and utility interconnections. This method could reduce methane emissions by minimizing anaerobic manure processing and storage. Dairies that used anaerobic lagoons require conversion to solid scrape or vacuum manure management. This process can potentially produce compost for sale, but costs and revenues associated with that operation are not included here. Table 8 contains a summary of assumptions used to calculate costs for Pathway 5.

Table 8: Summary of Assumptions for Dairy Pathway 5 – Scrape Conversion and Solar Drying

Costs			
Item	**Capital**	**O&M**	**Reference**
Scrape Conversion[37]	$350 per milking head	3%	ARB Estimated Value
Land and concrete drying pads	$400 per milking head	4.5%	UC Davis Report[38]

[35] USDA Land Values 2015 Summary http://usda.mannlib.cornell.edu/usda/nass/AgriLandVa//2010s/2015/AgriLandVa-08-05-2015.pdf

[36] ARB staff determined typical costs from studies and calls to manufacturers for estimates. Operations and maintenance was estimated based on the complexity of the system.

[37] Scrape conversion costs were only assumed for lagoon manure management. Other manure management types were assumed to require no capital to convert to solid manure management.

[38] Capital cost per cow represents interpolated value between 1,500 and 3,000 cow values for scrape to open solar drying (8 months) pathway in UC Davis study. O&M based on O&M as a function of total average cost in UC Davis pathway.

2. Costs and Revenues for an Example 2,000 Milking Cow Dairy

An economic analysis was performed for each pathway on a dairy-by-dairy basis to account for cost differences between dairies of different sizes. However, to provide an overview comparison by pathway, the costs and revenues for an example 2,000 cow dairy that manages manure using anaerobic lagoons were analyzed. The effect of regulation on this theoretical project was also analyzed. The pre regulation scenario assumes the project is operating before regulation that would affect revenue, and all revenue is available for the full 10 year analysis timeframe. The post regulation scenario assumes the project begins operating after regulation, which affects some revenue streams. Once a regulation to control manure emissions is in place, LCFS credits for new dairy digester projects no longer include credit for capturing and utilizing methane that would have otherwise been emitted into the atmosphere, which reduces the LCFS revenue by approximately 90 percent. The negative carbon intensity, or "negative CI" LCFS credit prices are more valuable, as they include additional credit for capturing and utilizing methane that would have otherwise been emitted into the atmosphere.[39] Additionally, cap and trade offset credits would no longer be available after regulation.

Tables 9 through Table 16 provide a detailed breakdown of costs and revenues for the example 2,000 cow dairy for each pathway. Total capital costs, annual operations and maintenance (O&M) costs, and annual revenues are provided for each pathway, considering the two regulation scenarios. Two values are listed for revenues affected by regulation; one if the project began operating before regulation ("Pre reg") and one if the project began operating after regulation ("Post reg").

The net present value (NPV) is calculated assuming capital costs are amortized over 10 years with 7% interest, and includes 10 years of annual O&M and revenue. All costs and revenues used for NPV calculations are discounted at 5% per year. If applicable, NPV is calculated for two scenarios: a project that begins operating before regulation, and a project that begins operating after regulation. If a project begins operating before regulation is in place, revenue is assumed to be at the "Pre reg" value for all 10-years of the analysis. If the project begins operating after regulation is in place, revenue is assumed to be at the "Post reg" value for all 10-years.

Assumptions used to calculate these costs are summarized by pathway in Table 1 through Table 8. Note that the values in Table 9 through Table 16 may not add precisely due to rounding.

[39] The negative carbon intensity, or "negative CI" LCFS credits are available for projects that begin operating before regulation and are more valuable because they include additional revenue for capturing and utilizing methane that would have otherwise been emitted into the atmosphere. The positive carbon intensity or "positive CI" LCFS credits are available for projects that begin operating after regulation and are less valuable because the capture and destruction of methane. Any sources with a regulatory requirement to reduce emissions cannot receive credits for those reductions.

Table 9: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 1a - Scrape Conversion and Onsite Manure Digestion Producing Electricity

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Digester with Microturbine	$4,538,000	$386,000	
Interconnection	$1,000,000	$50,000	
Biogas Upgrading		$86,000	
Electricity Generation			$271,000
Cap-and-Trade Offset			Pre reg: $191,000 Post reg: $0
Total	**$6,234,000**	**$543,000**	**Pre reg: $461,000 Post reg: $271,000**
NPV Pre-Regulation (10yrs)	**-$7,481,000**		
NPV Post-Regulation (10yrs)	**-$8,954,000**		

Table 10: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 1b - Scrape Conversion and Onsite Manure Digestion Producing Pipeline-Injected Renewable Natural Gas

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Digester	$2,905,000	$174,000	
Pipeline	$914,000	$46,000	
Interconnection	$2,000,000	$100,000	
Biogas Upgrading		$344,000	
Fuel			$149,000
RINs			$533,000
LCFS Credits			Pre reg: $865,000 Post reg: $110,000
Total	**$6,514,000**	**$684,000**	**Pre reg:$1,547,000 Post reg: $792,000**
NPV Pre-Regulation (10yrs)	**-$503,000**		
NPV Post-Regulation (10yrs)	**-$6,333,000**		

Table 11: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 2a - Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Electricity

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Digester with Microturbine*	$4,538,000	$386,000	
Low NOx Truck Purchase*	$140,000		
Manure Hauling		$95,000	
Interconnection*	$849,000	$30,000	
Biogas Upgrading*		$86,000	
Electricity			$271,000
Cap-and-Trade Offsets			Pre reg: $191,000 Post reg: $0
Total	**$6,223,000**	**$617,000**	**Pre reg: $461,000** **Post reg: $271,000**
NPV Pre-Regulation (10yrs)	**-$8,042,000**		
NPV Post-Regulation (10yrs)	**-$9,515,000**		

*Costs are shared among dairies in the cluster, these costs represent a share of the total

Table 12: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 2b - Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Pipeline-Injected Renewable Natural Gas

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Digester without Microturbine*	$2,905,000	$174,000	
Low NOx Truck Purchase*	$140,000		
Manure Hauling		$95,000	
Interconnection*	$849,000	$30,000	
Pipeline (rural low pressure)*	$75,000	$4,000	
Pipeline (transmission)*	$103,000	$5,000	
Biogas Upgrading*		$258,000	
CNG Station (small)*	$23,000	$2,000	
Fuel			$149,000
RIN Credits			$533,000
LCFS Credits			Pre reg: $865,000 Post reg: $ 110,000
Total	**$4,792,000**	**$588,000**	**Pre reg: $1,547,000** **Post reg: $792,000**
NPV Pre-Regulation (10yrs)	**$2,132,000**		
NPV Post-Regulation (10yrs)	**-$3,698,000**		

*Costs are shared among dairies in the cluster, these costs represent a share of the total

Table 13: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 3a – Covered Lagoon Manure Management with Collected Methane Producing Electricity

Component	Total Capital	Annual O&M	Annual Revenue
Covered Lagoon Digester	$3,616,000	$217,000	
Interconnection	$1,000,000	$50,000	
Biogas Upgrading		$258,000	
Electricity			$144,000
Cap-and-Trade Offsets			Pre reg: $191,000 Post reg: $0
Total	**$4,616,000**	**$525,000**	**Pre reg: $335,000** **Post reg: $144,000**
NPV Pre-Regulation (10yrs)	**-$6,538,000**		
NPV Post-Regulation (10yrs)	**-$8,010,000**		

Table 14: Estimated Costs and Revenues for a 2,000 Cow Dairy: Pathway 3b – Covered Lagoon Manure Management with Collected Methane Producing Pipeline-Injected Renewable Natural Gas

Component	Total Capital	Annual O&M	Annual Revenue
Covered Lagoon Digester	$3,616,000	$217,000	
Interconnection	$2,000,000	$100,000	
Rural Low Pressure Pipeline	$914,000	46,000	
Fuel			$79,000
RIN Credits			$285,000
LCFS Credits			Pre reg: $831,000 Post reg: $ 59,000
Total	**$4,792,000**	**$588,000**	**Pre reg: $1,195,000** **Post reg: $423,000**
NPV Pre-Regulation (10yrs)	**-$3,404,000**		
NPV Post-Regulation (10yrs)	**-$9,369,000**		

Table 15: Estimated Costs for a 2,000 Cow Dairy: Pathway 4 – Conversion to Pasture

Component	Total Capital	Annual O&M	Annual Revenue
Land Purchase	$2,041,000		
Fencing	$281,000	$7,000	
Irrigation	$3,313,000	$331,000	
Water Troughs	$24,000	$200	
Shade	$861,000	$22,000	
Total	**$6,520,000**	**$360,000**	**$0**
NPV* (10yrs)	**-$9,949,000**		

*NVP is the same regardless of regulation

Table 16: Estimated Costs for a 2,000 Cow Dairy: Pathway 5 – Scrape Conversion and Solar Drying

Component	Total Capital	Annual O&M	Annual Revenue
Scrape Conversion	$696,000	$21,000	
Concrete Drying Pads and Land	$795,000	$36,000	
Total	**$1,491,000**	**$57,000**	**$0**
NPV* (10yrs)		**-$2,077,000**	

*NVP is the same regardless of regulation

3. Costs and Revenues for Sector-Wide Scenarios

Two pathways were selected to bound potential sector-wide cost and revenue from mitigation of dairy manure. Dairy operations were assumed to choose the pathway with the highest net present value if LCFS and RIN credits were available (2b – central digestion producing transportation fuels), or the lowest cost option in the absence of revenue (5 – scrape conversion). This provides a likely cost bounding considering scenarios with and without LCFS and RIN credits. It is important to note that these scenarios were selected as an economic bounding exercise, and they are not intended to suggest a preferred or expected path forward. Actual implementation of any regulatory requirements will likely include a suite of potential mitigation options.

The sector-wide scenarios use the same assumptions as the individual pathways, but aggregate cumulative costs and revenues from 2017 through 2030, based on individual dairy economics assuming a model build out timeline. There are additional costs and benefits after 2030, but these are not included in the analysis. The effect of regulation timing on revenue was also analyzed. Regulation affects the value of LCFS credits and cap-and-trade offsets, thus has an impact on the overall economics of pathway 2b, but not pathway 5, which has no revenue. Specific assumptions used for each sector-wide scenario can be found in Table 17 and Table 19.

A summary of cluster implementation schedule, costs, and revenues for sector-wide scenario 2b can be found in Table 17. All costs and revenues through 2030 were included in the calculation, though there would be additional costs, revenue and methane mitigation after 2030. Upfront capital represents the amount of capital needed to finance the new projects in a given year. This upfront capital is paid back as annual loan amortized over 10 years at 7 percent interest and a 5 percent discount rate. The annual capital spent by all dairies represents the total loan payment in a given year across all dairies. Annual O&M and revenue were assessed for each dairy and each year through 2030, with 5% discounting.

Table 17: Annual Build Out Schedule, Costs, and Revenue for Sector-Wide Scenario 2b - Scrape Conversion and Transport of Manure Offsite for Centralized Digestion Producing Pipeline-Injected Renewable Natural Gas [40]

Year	New Clusters	Dairies in New Clusters	Milking Head in New Clusters	Upfront Capital for New Clusters	Annual Capital Spent, All Dairies	Annual O&M Spent, All Dairies	Annual LCFS Revenue, All Dairies			RIN Credit Revenue	Other Revenue
							No Reg	2026 Reg	2024 Reg		
2017	1	7	32,070	$58	$8	$8	$14	$14	$14	$9	$2
2018	3	21	79,018	$143	$28	$25	$46	$46	$46	$28	$8
2019	4	31	89,109	$164	$50	$44	$79	$79	$79	$49	$14
2020	3	36	75,430	$138	$67	$59	$104	$104	$104	$64	$18
2021	4	42	96,136	$166	$88	$76	$133	$133	$133	$82	$23
2022	4	32	59,584	$108	$99	$85	$147	$147	$147	$91	$25
2023	4	37	88,521	$140	$114	$98	$169	$169	$169	$104	$29
2024	5	38	86,974	$136	$128	$110	$188	$188	$164	$116	$32
2025	4	50	94,631	$140	$142	$121	$207	$207	$160	$127	$35
2026	4	45	71,722	$108	$151	$128	$217	$199	$155	$134	$37
2027	4	52	73,207	$107	$154	$134	$217	$184	$141	$139	$39
2028	4	34	53,875	$77	$145	$136	$201	$157	$116	$141	$39
2029	6	52	75,503	$105	$139	$141	$188	$130	$91	$146	$41
2030	5	66	76,712	$104	$135	$146	$179	$109	$72	$150	$42
Total	**55**	**543**	**1,052,492**	**$1,694**	**$1,448**	**$1,312**	**$2,087**	**$1,863**	**$1,591**	**$1,379**	**$384**

LCFS revenue was assessed for three regulation scenarios: 1) no regulation, 2) 2026 regulation, and 3) 2024 regulation. Regulation effective dates were assumed to be January 1st of the regulation year. A summary of LCFS calculation for each regulation scenario can be found in Table 18. Any project started before the effective date of the regulation receives LCFS credits at the "negative CI" including methane destruction for 10 years. After 10 years the dairy no longer receives credit for methane destruction which reduces LCFS revenue for any remaining year through 2030. Some dairies could potentially reapply for LCFS methane destruction credits for an additional 10 years. This option was excluded for simplicity, and due to uncertainty in the number of projects that would reapply. Projects established after regulation receive the positive CI LCFS price for all years through 2030. In the no regulation case, all projects receive LCFS credits including methane destruction for up to10 years then drop down to the lower LCFS revenue for any remaining years through 2030.

[40] All costs and revenue in millions of dollars, and discounted at 5% per year.

Table 18: LCFS Revenue Assumptions for Three Regulation Scenarios[41]

	No Regulation	Regulation 2026	Regulation 20204
Cluster Established Before Regulation	Up to 10-years of LCFS credit at negative CI, remaining years through 2030 at positive CI	Up to 10-years of LCFS credit at negative CI, remaining years through 2030 at positive CI	Up to 10-years of LCFS credit at negative CI, remaining years through 2030 at positive CI
Cluster Established After Regulation	n/a	LCFS credit for all years at positive CI	LCFS credit for all years at positive CI

A summary of dairy implementation schedule, costs, and revenues for sector-wide scenario 5 can be found in Table 19. As in Table 17, upfront capital represents the amount of capital needed to finance the new projects in a given year. This upfront capital is paid back as annual loan amortized over 10 years at 7 percent interest and a 5 percent discount rate. The annual capital spent by all dairies represents the total loan payment in a given year across all dairies. Annual O&M and revenue were assessed for each dairy and each year through 2030, with 5% discounting.

[41] The negative carbon intensity, or "negative CI" LCFS credits are available for projects that begin operating before regulation and are more valuable because they include additional revenue for capturing and utilizing methane that would have otherwise been emitted into the atmosphere. The positive carbon intensity or "positive CI" LCFS credits are available for projects that begin operating after regulation and are less valuable because the capture and destruction of methane. Any sources with a regulatory requirement to reduce emissions cannot receive credits for those reductions.

Table 19: Annual Build Out Schedule, Costs, and Revenue for Sector-Wide Scenario 5 - Scrape Conversion and Solar Drying

Year	New Scrape Conversion Projects	Milking Head in New Projects	Upfront Capital for New Projects	Annual Capital Spent, All Dairies	Annual O&M Spent, All Dairies
2017	4	34,363	$26	$4	$1
2018	14	78,714	$56	$11	$3
2019	18	85,430	$58	$19	$5
2020	20	81,038	$53	$26	$7
2021	26	90,865	$56	$33	$9
2022	19	59,383	$35	$36	$10
2023	33	91,977	$51	$42	$11
2024	35	86,682	$46	$46	$12
2025	44	94,306	$48	$51	$14
2026	40	73,957	$36	$53	$14
2027	45	71,123	$33	$53	$15
2028	40	53,114	$23	$49	$15
2029	65	73,293	$31	$46	$15
2030	90	78,488	$31	$44	$16
Total	**493**	**1,052,733**	**$583**	**$513**	**$147**

B. Methane Emission Reductions from Landfill Organic Waste Diversion

Achieving California's methane reduction targets requires optimizing the use and disposal of methane generating organic materials. To that end, the SLCP Strategy recommends reducing organics deposited to landfills 50 percent from 2014 levels by 2020 and 75 percent from 2014 levels by 2025, consistent with SB 1383. These ambitious targets require putting organic materials to the highest feasible use and developing infrastructure and markets to optimize the economic and environmental value of California's waste streams across sources.

When considering waste diversion options it is essential to balance environmental and economic benefits with any potential impacts on criteria pollutant emissions and ecosystem and human health, especially in disadvantaged communities. Avoiding organic waste generation entirely is the best option to reduce emissions, protect health, and minimize costs. However, once generated, there are many options for creating environmental and economic benefit through the appropriate utilization organic waste. Organics can be diverted to waste facilities with existing excess capacity, including composting facilities, stand-alone anaerobic digesters, and wastewater treatment anaerobic digesters. New facilities can also be built in optimized locations.

This analysis attempts to bound the potential cost of achieving the organic diversion targets outlined in this SLCP Strategy by exploring the use of three types of facilities for the handling of diverted materials. The scenarios are illustrative and do not represent a preferred strategy or technology or the realized mixture of voluntary and regulatory actions that may achieve the organic diversion targets. The final mix of strategies used to meet the organic diversion target cannot be predicted, but will likely involve a variety of facility types analyzed in the three illustrative scenarios.

The analysis begins with the methodology used to estimate the organic waste targets through 2025 and feasible diversion paths. These waste diversion targets and diversion options are then used to develop three scenarios by which California can achieve the targets in SB 1383. The estimated costs and potential revenue streams for each strategy are then discussed.

1. Organic Waste Diversion Targets

SB 1383 requires a 50 percent reduction in the level of statewide disposal of organic waste from the 2014 level by 2020, and a 75 percent reduction from the 2014 level by 2025. The organic diversion targets were calculated using the composition of California's waste stream in 2014,[42] as outlined in Table 4. Organic waste, as defined by AB 1826, includes food waste, green waste, landscape and pruning waste, nonhazardous wood waste, and food-soiled paper waste that is mixed in with food waste.[43] This analysis relies upon existing definitions of what types of materials are considered organics. CalRecycle, in consultation with ARB and stakeholders, will be establishing a definition of organics that is specific to addressing the novel requirements of SB 1383. As such, the targets in this chapter are for illustrative purposes and are subject to change.

Not all paper is included in the AB 1826 definition of organic waste. Compostable paper in Table 20 includes two subcategories that approximate food-soiled paper waste: compostable other miscellaneous paper and compostable remainder/composite paper.[44] The remaining paper in California landfills, while not included in this analysis, is a critical component in achieving the goals of AB 341 and must also be diverted to the highest value usage, including source reduction, reuse, and recycling. To meet the targets required by SB 1383, 50 percent of 2014 organic waste in Table 20 must be diverted by 2020 and 75 percent by 2025.

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[42] The 2014 Disposal-Facility-Based Characterization of Solid Waste in California was produced under contract by Cascadia Consulting Group and released by CalRecycle on October 6, 2015. For the waste characterization utilized in this analysis, see Table 7 in the Significant Tables and Figures document available at: http://www.calrecycle.ca.gov/wastechar/PubExtracts/2014/SigTableFig.pdf.

[43] AB 1826 text available at: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201320140AB1826&search_keywords.

[44] These subcategories are estimated from the 2014 Disposal-Facility-Based Characterization of Solid Waste in California by CalRecycle.

Table 20: 2014 Organic Waste Characterizations

Waste Type	2014 (wet tons)
Compostable Paper*	2,093,462
Food	5,591,179
Leaves and Grasses	1,172,925
Prunings and Trimmings	962,262
Branches and Stumps	528,493
Lumber	3,676,710
Remainder/Composite Organic	1,323,465
TOTAL	**15,348,496**
2020 Organic Waste Diversion Target	***7,674,248***
2025 Organic Waste Diversion Target	***11,511,372***

a. Waste Diversion or Recovery Pathways

Organic waste in landfills is not homogeneous, and represents different sources, composition, methane generating potential, and challenges for recycling and diversion. As such, not all organic waste can, or should, be handled through the same processes. ARB and CalRecycle collaborated to outline potential diversion strategies by organic waste subcategory to meet the waste diversion targets. For each organic waste subcategory, Table 21 and Table 22 estimate the percentage of material diverted to each type of facility over time to achieve the 2020 or 2025 organic diversion targets, respectively. These diversion options are illustrative and do not represent all pathways that may be employed.

Table 21: Possible Organic Waste Diversion Pathway to Meet 2020 Target

Waste Type	2014 Waste (Wet Tons)	Estimated Distribution of Organic Waste (Wet Tons)					
		Landfill	Reduction or Recycle	Food Recovery	Compost	AD or Compost	Chip & Grind
Compostable Paper	2,093,462	628,039	209,346		1,256,077		
Food	5,591,179	1,146,192		559,118		3,885,869	
Leaves and Grasses	1,172,925	879,694			293,231		
Prunings and Trimmings	962,262	721,697			240,566		
Branches and Stumps	528,493	396,370					132,123
Lumber	3,676,710	2,573,697	183,836				919,178
Remainder/Composite Organic	1,323,465	1,323,465					
2014 TOTAL	**15,348,496**	**7,669,152**	**393,182**	**559,118**	**1,789,874**	**3,885,869**	**1,051,301**
Percent of 2014 Waste		**50%**	**50%**				

Table 22: Possible Organic Waste Diversion Pathway to Meet 2025 Target

Waste Type	2014 Waste (Wet Tons)	Estimated Distribution of Organic Waste (Wet Tons)					
		Landfill	Reduction or Recycle	Food Recovery	Compost	AD or Compost	Chip & Grind
Compostable Paper	2,093,462	628,039	209,346		1,256,077		
Food	5,591,179	385,791		1,118,236		4,087,152	
Leaves and Grasses	1,172,925				586,463	586,463	
Prunings and Trimmings	962,262				962,262		
Branches and Stumps	528,493	396,370					132,123
Lumber	3,676,710	1,103,013	367,671				2,206,026
Remainder/Composite Organic	1,323,465	1,323,465					
2014 TOTAL	**15,348,496**	**3,836,678**	**577,017**	**1,118,236**	**2,804,802**	**4,673,614**	**2,338,149**
Percent of 2014 Waste		**25%**	**75%**				

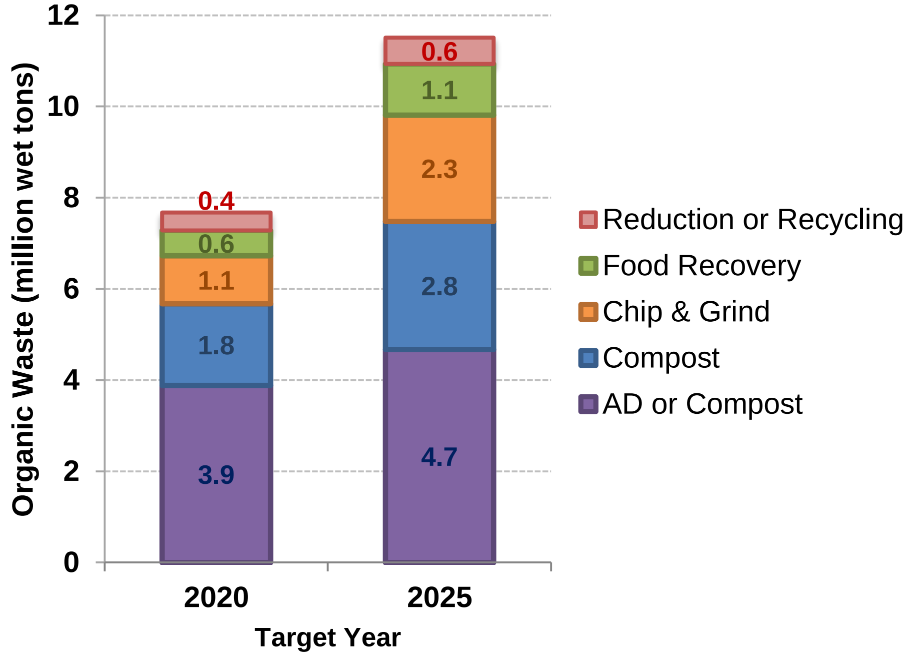
Conventional waste diversion options outlined in Tables 21 and 22 include composting, anaerobic digestion (AD), and chipping or grinding materials (Chip & Grind). In addition, reduction or recycling can be used to avoid waste generation or reuse and recycle the waste before it reaches the landfill. Food recovery is another important strategy that can remove potent methane-generating waste from landfills while minimizing nutritional loss in the food system. The US Department of Food and Agriculture estimates that approximately one-third of all food produced in the United States is not consumed, representing 1,249 calories per person per day.[45] In addition to generalized waste diversion goals, under SB 1383 20 percent of the edible food waste must be recovered for human consumption by 2025. In this SLCP Strategy, food recovery includes:

- Source Reduction - reducing the volume of surplus food generated in households and businesses
- Feeding the Hungry - donating appropriately safe extra food to food banks and shelters

Figure 1 outlines the organic waste diversion by pathway from Tables 21 and 22.

[45] USDA (2014). The Estimated Amount, Value, and Calories of Postharvest Food Losses at the Retail and Consumer Levels in the United States. Available at: http://www.ers.usda.gov/media/1282296/eib121.pdf.

Figure 1: Proposed Organic Waste Utilization Pathways by Year



Diverting a significant fraction of organic waste from landfills will cause a sharp decline in tipping fee revenue for landfills, which includes governmental fee revenue for both local governments and the State. In 2015, CalRecycle estimated the median tipping fee at California landfills as $45 per ton.[46] Holding this tipping fee constant through 2025 and assuming the organic diversion targets are met, revenue to California landfills could decrease by $345 million in 2020 and $520 million in 2025. This loss in revenue could impact the State's ability to meet existing statutory obligations and thus as California optimizes reduction, diversion, and disposal of waste, additional funding options should be explored that are not solely reliant on landfill fees.

b. Existing Excess Capacity at Waste Treatment Facilities

Leveraging existing excess capacity at California's waste treatment facilities can dramatically reduce the number of new facilities that may be required to handle diverted organic waste and help maximize the environmental and economic potential of organic waste diversion. Existing facilities that may accept organics from landfill include compost facilities, wastewater treatment facilities with anaerobic digestion, and Chip & Grind facilities. Table 23 presents the estimated excess capacity currently available at California wastewater treatment plants with anaerobic digesters and compost facilities. Though Chip & Grind excess capacity is not included in Table 22, CalRecycle estimates that existing Chip & Grind facilities will have sufficient capacity (and there will be

[46] Tipping fees vary by geographic region, type of waste, operational factors and consumer type. The median tipping fee is utilized to reflect the state mass balance of the waste characterization, www.calrecycle.ca.gov/publications/Documents/1520%5C20151520.pdf.

sufficient product demand) to handle all diverted organic materials in this analysis through 2025.

Table 23: Estimated Current Excess Capacity

Facility Type	Estimated Annual Excess Capacity (Wet Tons)
Compost	1,000,000
Wastewater Treatment	7,000,000
Total	**8,000,000**

CalRecycle estimates the excess capacity at existing compost facilities based on the 2014 Disposal-Facility-Based Characterization of Solid Waste in California. To meet the 2025 diversion target, California's compost needs are estimated to range from 3 and 8 million wet tons per year.[47] Therefore, current excess composting capacity of 1 million wet tons per year is insufficient to handle future diversion needs.

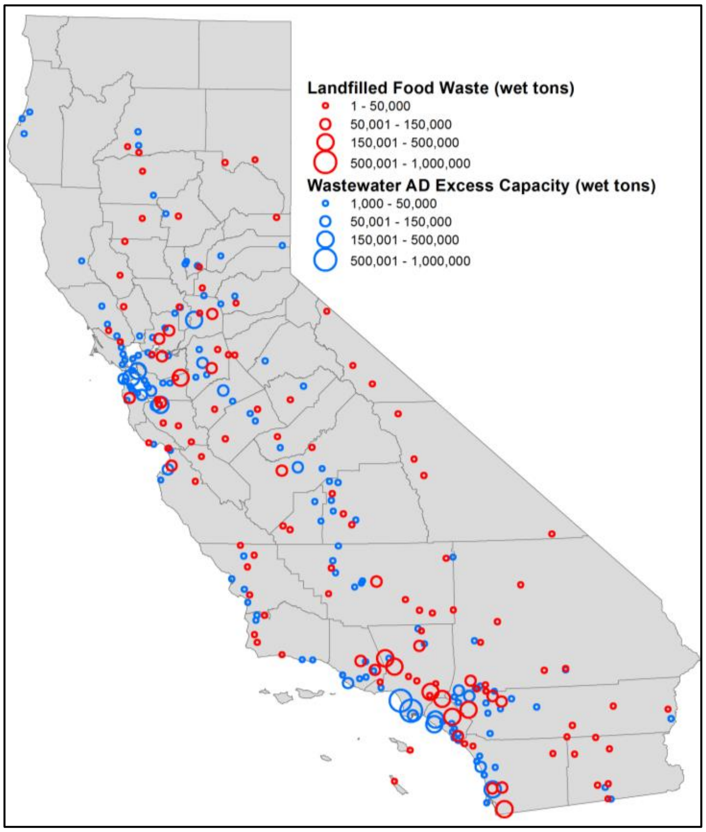
US EPA estimates that the nearly 140 wastewater treatment facilities with anaerobic digesters in California have an estimated excess capacity of 15 – 30 percent.[48] The California Association of Sanitation Agencies (CASA) estimates existing excess capacity at wastewater treatment facilities for food waste and fats, oils, and grease is approximately 7 million wet tons per year (Table 23),[49] which could theoretically handle the 4 million wet tons of food waste diverted to AD in 2025 (Table 22) as well as the 600,000 wet tons of leaves and grasses that can be diverted to AD facilities.[50]

Additionally, a geospatial analysis carried out by ARB indicates that food waste and wastewater treatment excess capacity are spatially correlated throughout California, as highlighted in Figure 2. The analysis compared the location of landfilled food waste and wastewater treatment excess capacity to estimate the additional distance food waste would travel from landfill to wastewater treatment plant. The analysis found that all food waste from landfills could theoretically be consumed by wastewater treatment plants within 30 miles. In this analysis, the landfill is treated as the source of waste (including food waste); therefore waste is transported to the nearest landfill where organics are separated, processed, and transported to their final destination including centralized digester, wastewater treatment plant, or compost facility. Alternatively, though this option was not analyzed, food waste could be separated by households, and travel

[47] Figure 2, depends on the assumptions for how much waste is utilized by AD.
[48] US EPA (2016). https://www3.epa.gov/region9/waste/features/foodtoenergy/wastewater.html.
[49] Assuming a MCRT of 15 days, CASA estimates that 17 facilities have an existing excess capacity of 5,805,000 gallons per day. The total estimate, when expanded across all facilities in California handling at least a million gallons a day, is estimated as 8,000,000 gallons per day. Applying mass loading for food waste and fats, oils, and grease results in an excess capacity for food waste of 6,035 dry tons per day or 7,342,500 wet tons per year. This information was provided by CASA on November 9, 2015.
[50] Does not include additional facilities needed to handle the potential increase in residual biosolids and assumes that co-digestion at wastewater treatment plans is both technologically and economically feasible for food waste as well as grasses and leaves. This analysis assumes that 100 percent of food waste can feasibly be diverted from landfills.

directly to pre-processing locations, then to wastewater treatment plants with excess capacity. Each of these options results in economic and environmental trade-offs that should be analyzed at the regional level to identify the best course of action. It is likely that a combination of these methods will be utilized, depending on the region.

Figure 2: Co-Location of Landfilled Food Waste and Wastewater Treatment Excess Capacity



2. Scenarios

The three scenarios are based on the potential organic waste diversion options outlined in Tables 21 and 22. All scenarios include the following assumptions:

- Existing excess compost capacity is fully utilized
- New compost facilities are constructed to handle all materials listed under the 'compost' heading in Tables 21 and 22
- Each new compost facility has a throughput of 100,000 wet tons per year
- Existing Chip & Grind facilities have capacity to handle all materials projected to be diverted to 'Chip & Grind' in Tables 21 and 22
- Food recovery targets are reached (10 percent in 2020 and 20 percent in 2025)

Therefore, the only difference between the scenarios is the waste utilization of food waste and grass and leaves ('Compost or AD' in Tables 21 and 22). The three scenarios are described below. The actual future utilization of food waste and grass and leaves will most likely be some mix of these options. Since it is not possible to predict the exact mix of utilization pathways, these three scenarios were developed to bound potential costs and revenues.

Scenario 1 - New Centralized AD Facilities

All ‘Compost or AD’ food waste, grass and leaves in Tables 21 and 22 are handled by new centralized AD treatment facilities, and the methane is injected to pipelines. It is assumed that there is a modest market for AD digestate, which represents 36 percent of the digested waste. 50 percent of AD digestate are assumed to be disposed of at no cost; i.e., the cost to process and ship the digestate is offset by any potential revenue. The other 50 percent of AD digestate is processed and shipped to compost facilities, and AD facilities pay the cost for transportation and compost tipping fees. This composted digestate requires construction of additional compost facilities. New centralized AD facilities are assumed to accept 100,000 tons of organic material, including both food waste and grass and leaves, per year on average.

Scenario 2 - Existing Wastewater Treatment Plant AD

Scenario 2 assumes that all ‘Compost or AD’ materials in Tables 21 and 22 are diverted to existing wastewater treatment facilities with AD, utilizing a majority of the estimated existing excess capacity. Upgrading and permitting costs are included for each facility, which could include digester expansion to allow for additional capacity. The scenario assumes there is no market for AD biosolids, which represents 36 percent of total digested waste, and new compost facilities are constructed to handle the residual biosolids. There is a cost to process the biosolids at wastewater treatment plants, and the materials are trucked to new compost facilities. The wastewater treatment plants pay for the cost to transport biosolids to compost facilities and pays tipping fees. It is assumed that, with modification, existing wastewater treatment facilities can accept 50,000 tons of organic material per year on average by 2025, with some facilities accepting more or less depending on size. The 50,000 capacity includes 45,000 wet tons of food waste and up to 5,000 wet tons of grasses and leaves.

Scenario 3 - New Compost Facilities

Scenario 3 assumes that all ‘Compost or AD’ materials in Tables 21 and 22 are composted at new facilities, after filling existing excess capacity at compost facilities.

Waste Diversion By Scenario

Table 24 estimates the organic waste diverted by pathway for the two target years. The overall waste diverted from landfills is the same in each scenario, but the pathway for diversion differs. Scenarios 1 and 2 require processing of more total organic material, because some portion of AD material is processed twice: once for the AD process and once to compost the biosolids or digestate. This double counting is necessary to accurately predict the number of new composting facilities needed, however, no additional organic material is diverted from the landfill in these scenarios.

Table 24: Organic Waste Utilization by Scenario

Diversion Target Year	Waste Diversion Pathway		Scenario		
			1. New AD	2. Existing WWTP	3. Compost Only
			(Million Wet Tons of Waste)		
2020	Reduction, Recycle, Food Rescue		1.0	1.0	1.0
	Compost	Existing Excess Capacity	1.0	1.0	1.0
		New Facilities	0.8	0.8	4.7
		New Facilities for Biosolids	0.7	1.4	--
	Anaerobic Digestion		3.9	3.9	--
	Chip and Grind		1.1	1.1	1.1
2025	Reduction, Recycle, Food Rescue		1.7	1.7	1.7
	Compost	Existing Excess Capacity	1.0	1.0	1.0
		New Facilities	1.8	1.8	6.5
		New Facilities for Biosolids	0.8	1.7	--
	Anaerobic Digestion		4.7	4.7	--
	Chip and Grind		2.3	2.3	2.3

A principal difference in outcomes from these three scenarios is the number of new facilities needed to achieve the organic diversion targets. Table 25 shows the number of new compost or AD facilities needed for each scenario.

Table 25: Estimated Number of New Facilities

Scenario	Estimated Number of New Compost Facilities		Estimated Number of New AD Facilities	
	2020	2025	2020	2025
1. New AD	15	26	39	47
2. Existing WWTP	22	35	--	--
3. Compost Only	47	65	--	--

3. Facility-Level Cost and Revenue Calculations

This section outlines the facility-specific costs and revenues that underlie the three statewide scenarios for organic diversion. Cost estimates rely on information obtained from California agencies, academic researchers, and industry estimates. This analysis estimates the incremental impact of the scenarios, therefore, only the impact associated with the diverted material is considered. Net present value calculations are used to determine the profitability of the three potential scenarios. By calculating the present value of future cost and organic diversion over a 10-year financing period, the net present value calculation provides insight into the feasibility of projects at the facility level.

There is uncertainty regarding the costs, savings, and potential revenue streams associated with organic waste diversion. Social welfare impacts, including those related to health, noise, odor, ecosystem benefit, and water impacts, are not included in this analysis but require additional consideration and analysis prior to the implantation of any organic diversion measure. Additional uncertainty related to existing infrastructure and technology development may also create economic impacts not analyzed in this analysis, which relies on available data to estimate the direct economic impact, including costs, fuel and energy savings, and potential revenue streams, of achieving California's organic waste diversion target.

This analysis assumes that organic waste is handled through existing collection routes for households, businesses, and industrial entities and no additional costs are incurred from curbside to arrival at the landfill. This assumption, while simplifying, may ignore both costs and efficiencies that result from optimized organic waste disposal within a geographic region.

The costs of diverting organic materials to existing facilities are assumed to be equal across all three scenarios. This analysis assumes that there is no net economic impact from reducing organic waste or diverting organics to existing facilities as detailed in the sections below. Scenario costs vary based on the relative cost of new AD and compost facilities as well as costs associated with retrofitting existing wastewater treatment plants to accept food waste.

a. Education and Outreach

Education and outreach is helpful to support any major change to public systems. While not quantified in this analysis, State and federal funds could contribute to awareness of California's organic waste diversion goals and provide support for organic waste reduction, recycling, and food recovery. Given the uncertainty surrounding measure implementation, these costs are not included in the analysis but represent the potential use of State and federal funding to achieve the organic diversion targets.

b. Food Recovery

The food recovery target in this SLCP Strategy can be achieved through source reduction, diverting food to feed the hungry, and utilizing food scraps as animal feed. A 2016 report estimates that achieving a national 20 percent reduction in food waste by 2025 will require an investment of $18 billion, but results in a societal benefit of $100 billion and the creation of 15,000 jobs per year.[51] The report finds that the most cost-effective way to reduce food waste is through food waste prevention and recovery. Scaling the investments to California (assuming the State comprises 12 percent of the US population in 2025) achieving a 20 percent food recovery target could require investments of $1.8 billion, or $200 million a year from 2016 through 2025.[52] These investment requirements are mitigated by an estimated annual business profit potential of $228 million in food waste savings. These figures do not include benefits that arise from household savings and food donations, which could result in an estimated annual economic value of $1.2 billion for California. Food recovery will also generate cost savings in avoided tipping fees, estimated at $25 million in 2020 and increasing to $50 million in 2025 (assuming a tipping fee of $45).

Given the variability in methods that can be used to achieve California's food recovery targets and the uncertainty surrounding costs and scalability, the analysis assumes that food recovery will have no net impact on the California economy. Because potential revenues and avoided tipping fees outweigh costs of achieving a 20 percent food recovery target (as estimated at a national level), this is a conservative approach.

c. Chip & Grind

The location of Chip & Grind facilities may require additional transportation of materials, resulting in increased fuel and vehicle costs. However, Chip & Grind facilities also produce salable products including mulch, and woodchips, and compost.[53] In the analysis, revenue from the increased sale of materials is assumed to offset any costs from transportation and processing of lumber and branches and stumps, resulting in no net economic impact.

d. Existing Compost Facilities

The analysis assumes that existing compost facilities are permitted and able to operable at full capacity and that no there are no additional operating and maintenance costs associated with filling excess capacity. It is assumed there is no cost for the transportation of organic materials, as material is already traveling to the existing compost facility from the landfill and the material represents a small fraction of the total compost amount.

[51] A Roadmap to Reduce U.S. Food Waste by 20 percent is available for download at: http://www.refed.com/download. The 20 percent reduction in food waste includes 27 strategies to reduce food waste including prevention, recovery, and recycling.

[52] See the marginal food waste abatement cost curve on page 23 of A Roadmap to Reduce U.S. Food Waste by 20 percent for additional information. The required investment of $14.9 billion includes food waste prevention and recovery only. The additional investments outlined by ReFED are captured through the AD or compost pathway.

[53] An example of the products produced at one Chip & Grind facility in San Diego is available at: http://www.sandiego.gov/environmental-services/miramar/greenery/cmw.shtml.

e. New Compost Facilities

New compost facilities are required in all three scenarios. To comply with federal, State, and local air quality requirements, the analysis assumes that all facilities are Gore positive aerated static pile (ASP) compost facilities with costs outlined in Table 26.[54] Gore ASP compost facilities have demonstrated the ability to meet strict VOC emission controls set by the San Joaquin Valley Air Pollution Control District and the South Coast Air Quality Management District and significantly reduce odor, making them a feasible option across California.

Table 26: Estimated Cost of a Representative New Compost Facilities

Gore Positive Aerated Static Pile (ASP) Compost Facility	
Facility Component	**Capital Investment**
Permitting	$900,000
Infrastructure	$11,500,000
Equipment	$3,900,000
Land	$200,000[55]
Total Cost	**$16,500,000**

Table 27 presents the estimated costs and revenue stream for a representative new compost facility over a 10-year period.. Transportation of organic materials from the centralized processing point (either landfill or materials recovery facilities) to the compost facility are included in the analysis, although these costs may not be explicitly born by the compost facility. In the Co-Digestion Economic Analysis Tool (CoEAT), US EPA estimates a waste hauling cost of $0.18 per ton-mile.[56] This analysis assumes that waste is transported 40-miles round trip between landfills and new compost facilities. This allows for location flexibility in geographic regions where permitting of new compost facilities may be difficult. In this analysis, each new facility purchases one low NOx compressed natural gas (CNG) truck to transport organic materials.

[54] Costs estimates based on information provided by CalRecycle.
[55] Assumes 25 acre facility with a cost of $7,700 per acre, the average value of an acre of farm land in California, http://www.usda.gov/nass/PUBS/TODAYRPT/land0815.pdf.
[56] https://archive.epa.gov/region9/organics/web/html/index-2.html

Table 27: Estimated Costs and Revenue per Compost Facility Through 2030[57]

Component	Capital Cost	Average Annual O&M Cost	Average Annual Revenue
Gore ASP Compost Facility	$16,500,000	$1,650,000	
CNG Vehicles	$250,000	$25,000	
Transportation		$720,000	
Tipping Fee			$4,500,000
Total	**$16,750,000**	**$2,395,000**	**$4,500,000**
10-Year Net Present Value	**-$2,200,000**		

The net present value assumes a 10-year finance period with 7 percent interest and a discount rate of 5 percent. This representative compost facility has a net present value of - $2.2 million over the 10-year period, therefore is not economically viable without additional funding sources. An upfront grant of $2 million would allow this project to break even, highlighting the need for incentives and State action to achieve the organic diversion goals.

This analysis does not include the sale of compost products,[58] because there is large variation and uncertainty in the processing costs and demand for compost products. In the analysis any revenue generated from compost materials is assumed to mitigate costs associated with processing and transporting the final products, resulting in no net economic impact. However, this may underestimate future revenue at compost facilities. A 2014 analysis of the economic impact of composting found that over 30 percent of compost revenues were related to the sale of soil, compost, and mulch,[59] while the sale of compost in San Francisco and Palo Alto has been recorded at $12 to $26 per ton.[60]

f. Upgrading Existing Wastewater Treatment Facilities with Anaerobic Digesters

Costs for diverting organic waste to existing wastewater treatment facilities is estimated as the incremental costs and benefits that result from the addition of organic waste to the wastewater facility anaerobic digester. While wastewater treatment facilities have significant revenue potential, difficulty in securing financing, potential restrictions in permitting and land use, and aging facilities may restrict the ability of facilities to receive new organic waste streams. For facilities that are able to secure financing and accept organic waste, costs include facility improvements, construction of pre-processing facilities, transportation costs, costs associated with biosolid processing transportation

[57] Capital costs are amortized over 10 years with 7% interest. The discount rate is 5% and all values are rounded.
[58] http://www.calrecycle.ca.gov/publications/Documents/1520%5C20151520.pdf
[59] http://www.mncompostingcouncil.org/uploads/1/5/6/0/15602762/economic_impact_study_final-2-2-15.pdf
[60] http://www.sfgate.com/bayarea/article/S-F-s-scraps-bring-joy-to-area-farmers-3246412.php and http://www.cityofpaloalto.org/civicax/filebank/documents/15113

and disposal, and costs associated with biogas generation, cleaning, and injection into pipelines.

The analysis assumes that all biogas generated through organic waste diversion will be used as transportation fuel, as this represents the highest value use of biomethane. There are 118 wastewater treatment facilities located less than 8 miles from a natural gas pipeline. These facilities represent 95 percent of the existing excess capacity and it is assumed in this analysis that these facilities can upgrade to allow food waste generated biogas to be pipeline injected. Assuming each wastewater treatment facility can accept 45,000 wet tons of food waste a year, meeting the SB 1383 targets will require diversion of organic food waste to 86 facilities in 2020 and 104 facilities in 2025. Three miles of pipeline is apportioned to each facility in the cost calculation, assuming that facilities greater than 3 miles from a pipeline are not economically feasible options for pipeline injection.

The analysis only considers the incremental biogas produced from the addition of food waste to the wastewater treatment facility, and excludes any potential biogas production from anaerobic digestion of grass and leaves. While capital costs include upgrades to the entire wastewater treatment facility, the analysis assumes that any biogas produced by the facilities prior to the addition of food waste continues to be used in the same capacity to satisfy existing contractual obligations. However, it is possible that some or all facilities would inject all biogas into the pipeline, resulting in additional revenue.

The costs associated with processing food waste at wastewater treatment facilities can vary greatly by facility and are subject to a great degree of technological and regulatory uncertainty. While costs and potential revenue will vary by facility, Table 28 represents an illustrative facility that processes 45,000 tons of food waste[61] and produces approximately 175 million standard cubic feet (scf) of biomethane each year for injection into the natural gas pipeline.[62] This generates revenues streams from sale of CNG fuel, LCFS credits, and RINs as outlined in Table 28.

[61] This limit is subject to permitting but is within the range of East Bay MUD's limit of 250 tons of food waste per day (91,250 tons per year) and Central Marin Sanitation Agency's limit of 5,474 tons per year. http://nepis.epa.gov/Adobe/PDF/P100LDEL.pdf.

[62] Biomethane calculation assumes 45,000 tons per year of food waste or 291,655,440 ft^3 of biogas per facility per year, converted to biomethane assuming the conversions outlined in Table 33. The calculation is based on EPA's CoEAT tool available at: https://archive.epa.gov/region9/organics/web/html/index-2.html.

Table 28: Estimated Cost and Revenue per Existing Wastewater Treatment Facility[63]

Component	Capital Cost	Average Annual O&M Cost	Average Annual Revenue
Organic Processing Facility and Facility Upgrades	$12,000,000	$1,200,000	
CNG Vehicles (2)	$500,000	$50,000	
Organic Waste Transportation		$450,000	
Biosolid Processing		$975,000	
Biosolid Transportation		$425,000	
Pipeline	$3,000,000	$150,000	
Pipeline Interconnection	$3,000,000	$150,000	
Biogas Upgrading		$1,400,000	
Tipping Fee			$3,250,000
Fuel Sales			$600,000
LCFS Credits (CNG020)			$1,350,000
RINs			$4,300,000
Total	**$18,500,000**	**$4,600,000**	**$9,500,000**
10-Year Net Present Value	**$17,600,000**		

The calculations outlined in Table 28 are highly sensitive to assumptions regarding the price of LCFS credits and RINs. It is assumed that wastewater treatment facilities generate LCFS credits through the CNG020 pathway with a proposed biomethane carbon intensity of 7.75,[64] assuming a LCFS credit price of $100 and a total RIN value of $1.85.[65] To further explore sensitivity to LCFS credit and RIN pricing, Table 29 presents the 10-year net present value of diverting organic waste to wastewater treatment facilities under a range of LCFS credit and RIN prices.

[63] Capital costs are amortized over 10 years with 7% interest. The discount rate is 5% and all values are rounded.

[64] This analysis assumes wastewater treatment facilities are medium to large as outlined in Alternative Case 2 in under the CNG020 pathway as outlined in Table 6 of the LCFS Regulation available at: www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf.

[65] The assumed cellulosic RIN credit value of $1.85 for biomethane includes a D5 RIN ($0.85), cellulosic waiver credit ($0.90) and value from the Blenders Tax Credit ($0.10 per D5 RIN). These assumptions for RIN credit prices are somewhat lower than current credit prices. The latest available information at the time of this writing (November 20, 2016), suggests that cellulosic RINs could be worth about $2.10.

Table 29: Net Present Value of Wastewater Treatment Facility Under Varying LCFS Credit and RIN Credit Prices (Million Dollars)

		Wastewater Treatment Facility				
		LCFS credit price				
		$0	$50	$100	$150	$200
Cellulosic RIN credit prices	$0.00	-$26.2	-$21.0	-$15.7	-$10.5	-$5.3
	$0.50	-$17.2	-$12.0	-$6.7	-$1.5	$3.7
	$1.00	-$8.2	-$2.9	$2.3	$7.5	$12.7
	$1.85	$7.1	$12.4	$17.6	$22.9	$28.0
	$2.50	$18.9	$24.1	$29.3	$34.6	$39.8
	$3.00	$27.9	$33.1	$38.4	$43.6	$48.8
	$3.50	$36.9	$42.1	$47.4	$52.6	$57.8
	$4.00	$45.9	$51.2	$56.4	$61.6	$66.9

For the facility outlined in Table 28, the 10-year net present value is positive across a wide combination of RIN and LCFS credit prices. However, in the absence of revenue generated from LCFS credits or RINs, the 10-year net present value is negative. If LCFS and RIN credit revenues do not materialize, State resources could be deployed to shore up financing of biomethane projects through mechanisms such as upfront grants, loan assistance programs, and tax incentives. For example, the illustrative facility in Table 12 would break even over a 10-year financing period with an upfront grant of $24 million. State agencies are collaborating to find solutions to the economic challenges associated with upfront capital costs and financing for wastewater treatment projects.

Wastewater treatment facilities are not limited to generating transportation fuels from diverted organic material. In 2013, 85 percent of wastewater treatment facilities with anaerobic digesters used biogas on site and 22 percent generated electricity.[66] Generating electricity for on-site use and selling excess electricity to the grid is an option for many facilities and can provide stable yet less lucrative potential revenue streams. However, these options generally emit criteria pollutants, including NOx, which might make operations unviable, especially in nonattainment areas. Additional revenue potential can be realized through the development of sustainable markets for residual products including heat dried residual pellets, fertilizer, mulch, and soil amendments. While concerns related to the transportation and application of residual and related products have limited their use, creating markets for these products could result in additional revenue streams for compost, wastewater treatment, and new AD facilities and should be considered a priority for State and local incentives related to market research and incentives. The size of the additional revenue stream depends on the specific products and market development, but could be on par with revenues generated from LCFS credits.

[66] http://nepis.epa.gov/Adobe/PDF/P100LDEL.pdf.

g. New Anaerobic Digesters

Table 30 outlines the estimated costs and revenue potential for an illustrative new anaerobic digester that has a throughput capacity of 100,000 tons per year and produces approximately 385 million scf of biomethane per year.[67] In this scenario, the biomethane is injected into the natural gas pipeline for use as transportation fuel and receives RINs and LCFS credits for the CNG005 pathway with a carbon intensity of -22.93.[68] For this illustrative scenario it is assumed that 50 percent of AD digestate is utilized at no cost and 50 percent is processed and shipped to compost facilities. While concerns related to the transportation and application of residual and related products have limited their use, creating markets for digestate could result in large additional revenue streams for new AD facilities and should be considered a priority for State and local incentives related to market research and incentives.

The realized costs of an anaerobic digester may vary greatly based on geographic location and concerns related to odor, permitting difficulty, and existing infrastructure. This illustrative facility outlines the revenue potential as well as the significant capital costs that are required to construct a new anaerobic digester.

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[67] Biomethane calculation assumes 100,000 tons per year of food waste or 644,464,440 ft^3 of biogas per facility per year, converted to biomethane assuming the conversions outline in Table 33. The calculation is based on EPA's CoEAT tool available at: https://archive.epa.gov/region9/organics/web/html/index-2.html.

[68] The CI for CNG005 is outlined in Table 6 of the LCFS Regulation available at: www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf.

Table 30: Estimated Cost and Revenue per New Anaerobic Digester[69]

Component	Capital Cost	Average Annual O&M Cost	Average Annual Revenue
Anaerobic Digester	$20,000,000[70]	$2,000,000	
Organic Processing Facility	$12,000,000	$1,200,000	
CNG Vehicles (2)	$500,000	$50,000	
Organic Waste Transportation		$900,000	
Digestate Processing		$975,000	
Digestate Transportation		$420,000	
Pipeline	$3,000,000	$150,000	
Pipeline Interconnection	$3,000,000	$150,000	
Biogas Upgrading		$2,500,000	
Tipping Fee			$6,500,000
Fuel Sales			$1,300,000
LCFS Credits (CNG005)			$4,800,000
RINs			$9,500,000
Total	**$38,500,000**	**$8,345,000**	**$22,100,000**
10-Year Net Present Value	**$65,700,000**		

The calculations outlined in Table 30 are highly sensitive to assumptions regarding the price of LCFS credits and RINs. To further explore sensitivity to LCFS credit and RIN pricing, Table 15 presents the 10-year net present value of diverting food waste to new AD facilities under a range of LCFS credit and RIN prices.

[69] Capital costs are amortized over 10 years with 7% interest. The discount rate is 5% and all values are rounded.
[70] Digester cost for facility with 100,000 tons per year throughput obtained at: https://fortress.wa.gov/ecy/publications/publications/1207036.pdf.

Table 31: Net Present Value of Anaerobic Digester Facility Organic Diversion under Varying LCFS Credit Prices and RIN Credit Prices (Million Dollars)

		New AD Facility				
		LCFS credit price				
		$0	$50	$100	$150	$200
Cellulosic RIN credit prices	$0.00	-$44.8	-$26.4	-$8.0	$10.3	$28.7
	$0.50	-$24.9	-$6.5	$11.9	$30.2	$48.6
	$1.00	-$5.0	$13.4	$31.8	$50.2	$68.6
	$1.85	$28.9	$47.3	$65.7	$84.1	$102.5
	$2.50	$54.8	$73.2	$91.6	$110.0	$128.4
	$3.00	$74.7	$93.1	$111.5	$129.9	$148.3
	$3.50	$94.7	$113.0	$131.5	$149.8	$168.2
	$4.00	$114.6	$133.0	$151.4	$169.8	$188.2

As outlined in Table 31, there is the potential for very large revenue streams from the sale of LCFS credits and RINs. However, these revenue streams are necessary to make the illustrative facility in Table 31 viable. Without revenue from RINs or LCFS credits, an upfront grant of $41 million would be required in order for this illustrative facility to breakeven over a 10-year financing period. While the revenue potential from RINs and LCFS credits is high, it is also uncertain which may present difficulty in obtaining financing. Alternatively, facilities can generate electricity for use on-site as well as sale to the grid, which has lower, but potentially more stable, potential revenue. On-site transportation fuel use is another feasible revenue option for facilities located large distances from the pipeline. On site criteria co-pollutant emissions are generally higher for electricity generation then for pipeline injection.

4. Estimated Cost and Revenue by Scenario

There are many potential ways to divert and utilize organic waste in California, and high uncertainty surrounding future compliance responses, costs, and markets. This analysis outlines three scenarios that achieve the organic diversion target by focusing on one type of facility for the handling of food waste and some grasses and leaves. While the pathway to compliance is unknown, the scenarios outline the potential range of capital costs, potential revenue, and uncertainty that exists in the treatment and diversion of organic waste. Regulatory, technological, political, financial, and market uncertainty must be considered in additional to the direct costs and potential revenue outlined in this analysis.

The three scenarios in this analysis indicate that achieving the organic diversion target could require an estimated capital investment of $800 million to $2.1 billion dollars and with potential cumulative revenue ranging from $1.6 to $8.3 billion over a 10-year period. The wide range in revenues highlight the value in existing, yet uncertain, revenue streams when biomethane is used for transportation fuel. High capital costs, as well as significant O&M also may discourage investment in facilities that could result in positive economic gains and highlights the need for State incentives, funding, and regulations to achieve the organic waste diversion targets.

Table 32 presents the state wide cumulative capital costs, O&M costs, and revenue for each scenario, across all facilities needed to achieve the 2020 and 2025 organic diversion target. In this analysis, the organic diversion and food recovery targets are met linearly over time, with new facilities coming on-line as additional capacity is needed. Projects are financed over 10 years assuming a 7 percent cost of capital and a 5 percent discount rate.

The scenario costs in Table 32 are estimated through 2025. Additional amortized capital payments continue through 2034 (as facilities are phased in over time) and annual O&M costs and revenues continue beyond 2025 for all three scenarios. O&M costs and revenues remain constant through 2025 this analysis. Scenario 1 and 2 show positive returns through 2025 due to biomethane generation, LCFS credit, and RIN credit generation. Despite the potential value of organic waste diversion, there are significant upfront capital costs that may prevent long-term revenue streams.

Variable revenue streams, such as RIN and LCFS credits, while lucrative, do not facilitate easy access to capital. The State must work with both public and private lenders to eliminate barriers to obtain capital for these projects through grants, reducing lender risk and lowering interest rates, or making regulatory changes.

Table 32: Cumulative Estimated Costs and Revenues by Scenario Over 10-Year Accounting Period (Million Dollars)

Scenario 1: New AD	Component	Capital Cost	O&M	Revenue
New AD New Compost	47 Facilities 26 Facilities	$1,700 $400	$2,600 $700	$7,000 $1,300
Total		**$2,100**	**$3,300**	**$8,300**
10-Year Net Present Value		**$2,700**		
Scenario 2: WWTP	**Component**	**Capital Cost**	**O&M**	**Revenue**
New Compost	35 Facilities	$600	$900	$1,800
Existing Wastewater Treatment	104 Facilities	$1,600	$2,800	$5,700
Total		**$2,200**	**$3,700**	**$7,500**
10-Year Net Present Value		**$1,400**		
Scenario 3: Compost	**Component**	**Capital Cost**	**O&M**	**Revenue**
New Compost	65 Facilities	$800	$800	$1,600
Total		**$800**	**$800**	**$1,600**
10-Year Net Present Value		**-$100**		

Despite the uncertainty, existing facilities are able to obtain financing to handle diverted organic materials through public and private partnerships with encouraging results. US EPA analyzed six wastewater treatment facilities, two located in California that upgraded to accept food waste and had estimated pay back periods ranging from zero to 12 years.[71] These facilities received funding assistance from $250,000 to $35 million and produce energy and fuel for revenue.

Altogether, this analysis suggests that the diversion of organic waste can result in environmental and economic value to California. There are important uncertainties associated with facility costs and potential revenues, however, which may limit project development without additional support. In the absence of revenue from LCFS credits and RINs, significant financial support may be required to achieve the targets identified in this SLCP Strategy and deliver other environmental benefits.

5. Cost Assumptions Used for All Scenarios

Table 33 contains the assumptions used in each scenario, along with references.

[71] http://nepis.epa.gov/Adobe/PDF/P100LDEL.pdf

Table 33: Organic Diversion Scenario Assumptions

Organic Diversion Scenario Assumptions			
Costs	**Capital**	**O&M**	**References**
Natural gas transmission pipeline or urban low pressure pipeline ($/mile)	$1,000,000	5%	http://www.suscon.org/news/pdfs/GHG_Mitigation_for_Dairies_Final_July2015.pdf
On-site biogas upgrading system ($/1000 scf)		$7	Upper bound of range provided by CASA in public comment
Centralized biogas upgrading system ($/1000 scf)		$6	http://www.suscon.org/news/pdfs/GHG_Mitigation_for_Dairies_Final_July2015.pdf
On-site utility natural gas pipeline interconnection ($)	$3,000,000	5%	
Cost per acre of California farm land for compost facility ($/acre)	$7,700		http://www.usda.gov/nass/PUBS/TODAYRPT/land0815.pdf
Gore Positive Aerated Static Pile (ASP) compost facility	$16,500,000	10%	Cost estimates from CalRecycle assumes 25 acre facility processing 100,000 tpy
Organic processing station including pre-processing and facility upgrades	$12,000,000	10%	Mid-range of estimated costs based on information from East Bay MUD, CMSA, and LACSD. Information provided by CASA in public comment. References available at: http://nepis.epa.gov/Adobe/PDF/P100LDEL.pdf.
Anaerobic digester (100,00 TPY capacity)	$20,000,000	10%	Estimated cost of San Jose ZNW Facility
Low NOx CNG truck	$250,000	10%	Estimate from ARB Staff, Vision 2.0 assumes CNG heavy duty vehicle costs $250k in 2016 and costs reduce to $144 by 2030
Waste transport ($/ton-mile)		$0.18	https://archive.epa.gov/region9/organics/web/html/index-2.html
Average mileage for transportation of organics to WWTF (miles)		50	Assumption informed by geo-spatial analysis
Average mileage for transportation of organics to AD (miles)		50	Assumption informed by geo-spatial analysis of waste location
Average mileage for transportation of biosolids (miles)		130	http://scap1.org/Biosolids%20Reference%20Library/2014%20SCAP%20Biosolids%20Trends%20Update.pdf

Cost of biosolid disposal ($/ton)		54	http://scap1.org/Biosolids%20Reference%20Library/2014%20SCAP%20Biosolids%20Trends%20Update.pdf
Average mileage for transportation of organics to compost (miles)		40	Assumption informed by geo-spatial analysis of waste location
Revenues			
Biogas price ($/ 1000 cubic feet)		$3.46	
Tipping fee at compost facilities ($/ton)		$45	http://www.calrecycle.ca.gov/publications/Documents/1520%5C20151520.pdf.
Tipping fee at AD facilities ($/ton)		$65	-
Tipping fee at wastewater treatment facilities ($/ton)		$65	
Low Carbon Fuel Standard credits ($/ton)		$100	
RINs, $/77,000 BTU		$1.85	Internal ARB calculation based on public RIN values.
Conversion Factors			
Biogas per wet ton food waste	6,444		https://archive.epa.gov/region9/organics/web/html/index-2.html
Biogas to biomethane conversion	0.6		https://archive.epa.gov/region9/organics/web/html/index-2.html
scf to BTU	1,028		http://www.arb.ca.gov/cc/inventory/doc/docs1/1a3b_onroad_fuelcombustion_naturalgas_ch4_2013.htm
Food total solids (fraction)	0.3		https://archive.epa.gov/region9/organics/web/pdf/ebmudfinalreport.pdf
Biosolids from food waste digestion (fraction)	0.36		https://archive.epa.gov/region9/organics/web/pdf/ebmudfinalreport.pdf
Financial parameters			
Interest rate	7%		
Loan period, years	10		-
Discount rate	5%		

C. Hydrofluorocarbon (HFC) Emission Reductions

Note: The following HFC section was written before the global phasedown of HFCs was agreed to on October 15, 2016 (the "Kigali Amendment"). ARB is currently evaluating the Kigali Amendment's impact upon HFC emissions in California; this section will be further updated to reflect changes in BAU emissions, additional needed reductions, and the cost and benefit of HFC reductions measures.

As described in Section VI, HFCs are the fastest-growing source of GHG emissions globally and in California. California is among the world's leaders in reducing HFC emissions, with existing actions leading to significant reductions in HFC emissions in California through 2030, compared to where they would be otherwise.

The SLCP Strategy describes a set of four potential measures that can reduce HFC emissions by 40 percent in California by 2030. The proposed measures are anticipated to reduce cumulative HFC emissions by 260 $MMTCO_2E$ (20-year global warming potential (GWP)) by 2030 to meet the SLCP emission reduction target. This section estimates the potential costs and savings of the four proposed HFC emission reduction measures which are:

1. Prohibition on New Equipment with High-GWP Refrigerants
2. HFC Supply Phasedown (now covered by the global HFC phasedown)
3. Financial Incentive Program for Low-GWP Refrigeration Early Adoption
4. Sales Ban of Very-High GWP Refrigerants

The potential costs and cost savings of the four proposed HFC emission reduction measures are based on the three main variables: the incremental equipment cost of low-GWP units, gains or losses in energy efficiency and resulting change in energy consumption, and the projected price of HFCs relative to the price of replacement of natural refrigerants and the new generation of synthetic refrigerants, hydrofluoro-olefins (HFOs).

The proposed HFC measures would require new stationary refrigeration and AC equipment to use refrigerants with a lower-GWP than the current high-GWP HFC refrigerants. In many cases, there is an incremental cost to lower-GWP equipment relative to the cost of high-GWP equipment. The higher capital cost is often offset by energy efficiency gains and subsequent decreased energy costs over the equipment lifetime. Although it is anticipated that the incremental cost of low-GWP equipment will decline over time, this learning effect is not accounted for in this analysis with all costs and savings assumed to remain constant through 2030. In all tables, annual and cumulative costs are presented in 2016 dollars.

This analysis assumes that the growth in refrigeration and AC equipment is correlated with projected population growth in California through 2050, projected at 0.746% annually, according to California Department of Finance.[72]

Pending an evaluation to determine if specific California HFC reductions measures are needed in addition to the global HFC phasedown, measures are listed as originally proposed in April 2016.

[72] http://www.dof.ca.gov/research/demographic/projections/

1. Prohibition on New Equipment with High-GWP Refrigerants

This proposed measure prohibits the use of high-GWP refrigerants in new stationary refrigeration and air-conditioning equipment. For the stationary refrigeration sector, refrigerants with a 100-year GWP of 150 or greater would be prohibited for new equipment for non-residential refrigeration, and also for residential refrigerator-freezers. The proposed measure also prohibits refrigerants with a 100-year GWP of 750 or greater for new air-conditioning equipment in the stationary air-conditioning, for both residential and non-residential. (Start dates for measures have not yet been determined, pending the completion of the impact evaluation of the Kigali Amendment.)

a. Initial Added Cost of Low-GWP Refrigeration and AC Equipment

Table 34 shows the incremental cost of low-GWP refrigeration and air-conditioning equipment. Due to the lack of low-GWP equipment currently in operation, cost estimates were obtained through a survey of industry stakeholders for the average cost of baseline business-as-usual equipment using high-GWP HFCs, and new low-GWP equipment using natural refrigerants or new low-GWP (synthetic refrigerants HFOs). The incremental capital cost of low-GWP equipment varied greatly across respondents, ranging from slightly less to more than double the cost of high-GWP equipment.
For air-conditioning, less data is available relative to refrigeration as low-GWP air-conditioning is still in development and is not widely used. In this analysis, it is assumed that the incremental cost of lower-GWP air-conditioning ranges from 5 to 15 percent higher than the business-as-usual, or BAU, high-GWP refrigerant equipment.

Table 34: Estimated Initial Added Cost of Low-GWP Refrigeration and Air-Conditioning Equipment

Equipment Sector	General Description of Sector	Average Equipment Cost per Unit[73]	Incremental Cost of Low-GWP Unit
Stationary Refrigeration Sectors			
Large Commercial Large Centralized System (2,000+ lbs)	Centralized system with 2000 or more lbs of refrigerant charge (average charge 2,485 lbs). Generally, one system can be used per large retail facility such as a supermarket.	$1,000,000	$200,000
Medium Commercial Medium Centralized System (200 – 2,000 lbs)	Distributed type equipment with more than one unit. Average charge size 700 lbs, three or four units may be used in a supermarket.	$250,000	$50,000
Large Cold Storage	Charge size is 2000 lbs or more per facility.	$3,500,000	$500,000

[73] Assumes the BAU baseline is high-GWP.

Equipment Sector	General Description of Sector	Average Equipment Cost per Unit[73]	Incremental Cost of Low-GWP Unit
Medium Cold Storage	Average charge size of 565 lbs per facility	$1,750,000	$250,000
Industrial Process Cooling	Average charge size of 4,440 lbs per facility for Industrial processing such as manufacturing or food processing.	$2,500,000	$250,000
Refrigerated Condensing Units (50-200 lbs)	Used in retail food and other cooling, average charge 122 lbs per system.	$75,000	$15,000
Refrigerated Condensing Units (Under 50 lbs)	Used in convenience stores, other smaller refrigeration needs. Average charge 31 lbs per system.	$37,500	$7,500
Standalone (Self-Contained) Refrigeration Units	Smaller self-contained equipment average charge 7 lbs or less. Does not include refrigerated vending machines already covered by U.S. EPA requirements.	$5,000	$1,000
Residential-Type Refrigerator Freezer	Average charge of 0.34 lbs per normal domestic appliance.	$1,165	$150
Stationary Air-Conditioning Sectors			
Centrifugal Large Chiller (2000+ lbs)	Chiller with 2000 lbs refrigerant or more. Typically used for large building AC. Average charge size of 3,978 lbs	$300,000	$30,000
Medium Centrifugal Chiller (200-2000 lbs)	Chiller containing 200 to 2000 lbs refrigerant. Average charge of 1,007 lbs	$200,000	$20,000
Medium Packaged Chiller (200-2000 lbs)	Chiller containing 200 to 2000 lbs refrigerant, generally smaller than centrifugal type. Average charge size of 526 lbs	$200,000	$20,000
Commercial Unitary AC (50-200 lbs)	AC system contains on average 100 lbs of refrigerant.	$13,000	$1,300
Commercial Unitary AC (Less Than 50 lbs Charge)	Smaller AC systems contain on average 15 lbs of refrigerant.	$4,000	$400
Commercial Window AC Units	Window units contain an average of 1.5 lbs refrigerant.	$900	$90
Residential Unitary AC	Residential AC systems contain on average 7.5 lbs refrigerant.	$4,000	$400
Residential Window AC Units	Window units contain an average of 1.5 lbs refrigerant.	$800	$80

b. Savings from Energy Efficiency

The added cost of low-GWP equipment is generally offset by reduced energy usage from using low-GWP refrigerants. Table 35 shows the energy efficiency savings used in this cost analysis. The change in energy efficiency is relative to HFC equipment currently being manufactured. In this analysis, the ozone-depleting substance (ODS) refrigerant HCFC-22 has the same or better energy efficiency relative to most low-GWP refrigerants. However, new HCFC-22 equipment has been prohibited since January 1, 2010, and therefore cannot be considered as baseline for new equipment.

Refrigerant systems using only CO_2 as the refrigerant are known as transcritical CO_2 systems. Compared to baseline HFC refrigeration, transcritical CO_2 systems have shown energy efficiency gains of 10 to 18 percent in climates where the ambient temperature is less than 87 °F. In higher ambient temperatures, energy penalties can be incurred compared to baseline refrigerant systems, although significant research and development is occurring to manufacture transcritical systems that work efficiently in higher ambient temperatures.[74, 75] For example, transcritical CO2 systems have been installed in warm weather climates in Louisiana, Alabama, Georgia, and Florida; and also in Brazil; Indonesia, Australia, and Spain, showing energy efficiencies equivalent or better than HFC refrigeration systems. In California, more than 20 transcritical systems have been installed, several of them in high-temperature ambient climates.[76] Cooling a CO_2 secondary cooling loop or cascade system with an HFC refrigerant or ammonia as the primary refrigerant appear to operate at the same energy efficiency or better than all-HFC systems, including in very hot ambient temperatures.[77]

Ammonia refrigeration has long-established energy efficiency benefits compared to fluorinated refrigerants including HFCs. Typical energy efficiency gains of using ammonia refrigerant range from 3 to 10 percent or greater, depending upon the specific type of equipment.[78, 79, 80]

[74] ASHRAE, 2015. “System Efficiency for Natural Refrigerants” Anatolii Mikhailov and Hans Ole Matthiesen, Technical Feature in ASHRAE Journal, August 2015. Available at: https://www.ashrae.org/File%20Library/docLib/eNewsletters/Mikhailov-082013--05142015feature.pdf (accessed 9 April 2016).

[75] UNEP, 20115. “Montreal Protocol on Substances that Deplete the Ozone Layer UNEP 2014 Report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee 2014 Assessment”. February 2015. United Nations Environment Programme (UNEP). Available at: http://ozone.unep.org/en/assessment-panels/technology-and-economic-assessment-panel (accessed 11 July 2016).

[76] Shecco, 2015. Guide to Natural Refrigerants in North America - State of the Industry 2015. Shecco publications, 17 September 2015. Available at: http://publication.shecco.com/publications/lists (accessed 6 July 2016).

[77] Mycom-Mayekawa, 2015. “Low Refrigerant Charge Ammonia/CO_2 Chiller in a Supermarket Application” case study. Available at: http://www.ammonia21.com/web/assets/link/4091_GUIDE_NA_Case%20Study_MYCOM_1.pdf (accessed 11 July 2016).

[78] ASHRAE, 2010. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE). ASHRAE Position Document on Ammonia as a Refrigerant. June 30, 2010. Available at: https://www.ashrae.org/File%20Library/docLib/About%20Us/PositionDocuments/Ammonia-as-a-Refrigerant-PD-2014.pdf (accessed 16 June 2016).

[79] AMIC, 2014. Australian Meat Industry Council (AMIC) Fact Sheet 3 “Out with the Old & In with the New: Freon vs. Ammonia & Glycol Refrigeration Systems”. Available at: http://www.amic.org.au/SiteMedia/W3SVC116/Uploads/Documents/Freon%20vs%20Ammonia%20&%20Glycol%20Refrigeration.docx (accessed 13 July 2016).

[80] Industrial Refrigeration Handbook, Wilbert F. Stoecker. McGraw-Hill, 1998. ISBN 0-07-061623-X

Hydrocarbon refrigerants are more energy efficient than HFC refrigerants in all end-use sectors for which they have been approved for use by the U.S. EPA. Energy efficiency gains of more than 30 percent have been shown for some smaller refrigeration equipment, with efficiency gains of 2 to 5 percent for residential refrigerator-freezers, and 5 to 10 percent for air-conditioning.[81, 82, 83, 84, 85]

Hydrofluoro-olefin (HFO) refrigerant blends are new and energy efficiency data is limited, although several studies indicate that they are equivalent to slightly more energy-efficient than HFCs used in refrigeration and air-conditioning, ranging from the same efficiency as HFC-134a or R-410A (an HFC blend), to nine percent greater energy efficiency than R-404A, a relatively energy-inefficient HFC blend used widely in retail food.[86, 87, 88, 89]

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[81] EIA, 2014. "Putting the Freeze on HFCs: A Global Digest of Available Climate-Friendly Refrigeration and Air-Conditioning Technologies", May 2014. Environmental Investigation Agency (2014). Available at: http://eia-global.org/images/uploads/Putting_the_Freeze_on_HFCs_Final.pdf. (Accessed 17 March 2016).

[82] DOE, 2011. Department of Energy, Technical Support Document of Final Rule for Residential Refrigeration Products, September 3, 2011. Available at: https://www1.eere.energy.gov *(accessed 12 February 2016).*

[83] "Comparative Performance of Hydrocarbon Refrigerants", I.L Maclaine-cross and E.Leonardi, School of Mechanical and Manufacturing Engineering, The University of New South Wales. Available at: http://www.academia.edu/9496884/Comparative_Performance_of_Hydrocarbon_Refrigerants (accessed 28 January, 2016).

[84] Sattar, et. al, 2007. "Performance Investigation of Domestic Refrigerator Using Pure Hydrocarbons and Blends of Hydrocarbons as Refrigerants", M. A. Sattar, R. Saidur, and H. H. Masjuki. World Academy of Science, Engineering and Technology, Number 29, 2007. Available at: http://citeseerx.ist.psu.edu (accessed 12 February 2016).

[85] DOE, 2015. "Alternative Refrigerant Evaluation for High-Ambient-Temperature Environments: R-22 and R-410A Alternatives for Mini-Split Air Conditioners", Report ORNL/TM-2015/536, October 2015. Oak Ridge National Laboratory managed by UT-Batelle for Department of Energy. Available at: http://energy.gov/sites/prod/files/2015/10/f27/bto_pub59157_101515.pdf (accessed 11 January 2016).

[86] Ibid.

[87] Dupont (Chemours), 2015. "Opteon Product Information Bulletin Low GWP Replacement for R-134a", and "Opteon Product Information Bulletin for Stationary Refrigeration", technical data literature available at: https://www.chemours.com/businesses-and-products/fluoroproducts/opteon-refrigerant/ (accessed 13 July 2016).

[88] Honeywell, 2015. "R410A and R22 low GWP alternatives for A/C - Focus on high ambient performances" by Dr. Jean de Bernardi and Dr. Abdenacer Achaichia; and Solstice refrigerants technical data literature. Available at: http://www.honeywell-refrigerants.com/ (accessed 13 July 2016).

[89] UNEP 2016. "Promoting Low-GWP Refrigerants for Air-Conditioning Sectors in High-Ambient Temperature Countries (PRAHA)", United Nations Environment Program (UNEP), document number UNEP/OzL.Pro/ExCom/76/10 April 16, 2016. Available at: http://www.multilateralfund.org/76/pages/English.aspx (accessed 12 March 2016).

Table 35: Estimated Added Energy Efficiency of Low-GWP Refrigerants

Equipment Sector	Added Energy Efficiency of Low-GWP Refrigerants	Mix of Low-GWP Refrigerants Used in Analysis[90]
Centralized System Large (2,000+ lbs)	7.5%	50% carbon dioxide (CO_2), 45% HFO blends, 5% ammonia (NH_3)
Centralized System Medium (200-2,000 lbs)	7.5%	
Cold Storage Large (2,000+ lbs)	8.0%	80% NH_3, 20% CO_2
Cold Storage Medium (200-2,000 lbs)	8.0%	
Process Cooling Large (2,000+ lbs)	7.5%	50% CO_2, 50% NH_3
Refrigerated Condensing Units Small (50-200 lbs)	7.5%	33% CO_2, 33% NH_3, 33% HFOs[91] or HFO blends
Refrigerated Condensing Units (less than 50 lbs)	7.5%	
Stand-Alone Refrigerator Display Cases	6.1%	50% CO_2, 50% hydrocarbons
Residential Refrigerator-Freezer	3.0%	100% hydrocarbons
Centrifugal Chiller Large (2,000+ lbs)	1.0%	50% HFC-32[92], 50% HFOs
Centrifugal Chiller Medium (200-2,000 lbs)	1.0%	
Chiller - Packaged Medium (200-2,000 lbs)	1.0%	
Unitary A/C Small (50-200 lbs)	2.0%	HFC-32
Unitary A/C Central (less than 50 lbs)	2.0%	
Window AC units commercial	2.0%	
Residential AC Central	2.0%	
Window AC Units Residential	2.0%	

[90] Improved energy efficiency of CO_2 refrigeration systems is dependent upon the ambient air temperature, with energy efficiency decreasing as the temperature increases. Below the critical temperature of CO_2 at 87 °F, energy efficiency of 2-6 percent has been measured (ASHRAE, 2009 www.ashrae.org), (Australian GCC, 2008) http://www.r744.com/files/news/green-cooling-council_montreal_apr08.pdf., and (Emerson, 2015) http://www.emersonclimate.com/en-us/Market_Solutions/By_Solutions/CO2_solutions/Documents/Commercial-CO2-Refrigeration-Systems-Guide-to-Subcritical-and-Transcritical-CO2-Applications.pdf.

[91] Energy efficiency of HFOs is generally the same as the HFC refrigerants they replace, although manufacturers have tested HFO equipment and concluded that it is three percent more energy efficient than HFC equipment (Danfoss, 2014) available at: http://turbocor.danfoss.com. Hydrocarbons, with GWPs less than 20 have demonstrated energy efficiency in refrigeration and AC equipment, with average efficiency improvements between 6 and 15 percent compared to HFCs (A.D. Little, 2001) Energy Consumption Characteristics of Commercial Building HVAC Systems. Volume I: Chillers, Refrigerant Compressors, and Heating Systems Prepared by Detlef Westphalen and Scott Koszalinski of Arthur D. Little, Inc. for Office of Building Equipment, Office of Building Technology State and Community Programs, U.S. Department of Energy. April 2001., (Wang, et al., 2009) https://www.energystar.gov/ia/partners/manuf_res/downloads/Appliance_and_Recycling_Quick_Start_Guide.pdf.

[92] HFC-32 has a 100-year GWP of 675, and a 20-year GWP of 2330 and would be used instead of the standard HFC refrigerant R-410A. DOE research indicates that HFC-32 is 2 percent to 13 percent more energy efficient than baseline R-410A in AC equipment (DOE, 2015) http://www.osti.gov/scitech/.

In this analysis, an ARB uses an electricity cost of 14 cents per kWh for commercial customers, and a cost of 17 cents per kWh for residential customers, based on recent California electricity prices posted by the Energy Information Administration (EIA, 2016).[93] The analysis assumes no relative increase or decrease in future electricity prices.

c. Savings or Added Cost from low and lower-GWP Refrigerants

High-GWP HFC refrigerants cost more per pound than the low-GWP refrigerants CO_2 and ammonia, but less per pound than hydrocarbon refrigerants and the new HFO refrigerants. The costs used in this analysis are based on a survey of average refrigerant prices and are as follows:

- HFCs (average of the six most commonly used HFCs): $6.90/lb.
- CO_2: $2.00/lb.
- Ammonia: $3.00/lb.
- Hydrocarbons: $9.00/lb.
- HFOs and HFO blends: $15.00/lb.

Due to the non-patented status of the natural refrigerants CO_2, ammonia, and hydrocarbons, it is assumed that their prices remain constant through 2030. HFOs are currently made in small quantities, and prices could be reduced in the future as HFO production increases. However, as some HFOs may be more cost-intensive to manufacture than HFCs, it is assumed that the cost will remain constant through 2030. This analysis assumes that the cost of high-GWP HFC refrigerants will double by 2030 due to an HFC phasedown or other regulatory pressures that will decrease the supply of high-GWP HFCs. The doubling of high-GWP HFC costs by 2030 is conservative, as previous phasedowns of ozone-depleting refrigerants have resulting in a five to six-fold increase in prices. The cost of lower-GWP HFCs such as HFC-32 is expected to remain constant, as they are not affected by HFC phasedowns. Table 36 shows the projected savings resulting from the use of low-GWP equipment

[93] EIA, 2016. U.S. Energy Information Administration. Electric Power Monthly, Table 5.6.A. “Average Price of Electricity to Ultimate Customers by End-Use Sector”. By State, January 2015 and January 2016. Cents per Kilowatthour. https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a.

Table 36: Estimated Low-GWP Equipment Savings[94]

Sector	Low-GWP Added Energy Efficiency	Annual Electricity Savings	Annual Refrigerant (lbs)	Annual Refrigerant Savings[95]	Annual Total Savings
Centralized System Large (2,000+ lbs)	7.5%	$ 12,000	600	$ 3,000	$ 15,000
Centralized System Medium (200-2,000 lbs)	7.5%	$ 3,000	200	$ 1,000	$ 4,000
Cold Storage Large (2,000+ lbs)	8.0%	$ 15,0000	1,200	$ 10,000	$ 25,000
Cold Storage Medium (200-2,000 lbs)	8.0%	$ 8,000	150	$ 1,000	$ 9,000
Process Cooling Large (2,000+ lbs)	7.5%	$ 11,000	350	$ 3,000	$ 13,665
Refrigerated Condensing Small (50-200 lbs)	7.5%	$ 1,000	25	$ 100	$ 1,000
Refrigerated Condensing Units (Less than 50 lbs)	7.5%	$ 500	5	$ 25	$ 500
Stand-Alone Refrigerated Display Cases	6.1%	$ 50	0.5	$ 2	$ 50
Centrifugal Chiller Large (2,000+ lbs)	1.0%	$ 500	150	($ 250)	$ 200
Centrifugal Chiller Medium (200-2,000 lbs)	1.0%	$ 532	24	($ 45)	$ 487
Chiller Packaged Medium (200-2,000 lbs)	1.0%	$ 319	42	($ 77)	$ 242
Unitary A/C Small (50-200 lbs)	2.0%	$ 174	13	$ 0	$ 174
Unitary A/C Central (Less than 50 lbs)	2.0%	$ 27	2	$ 0	$ 27

[94] Numbers may not add due to rounding.
[95] Refrigerant cost increases for chillers used in air-conditioning, therefore, savings are shown as negative.

Sector	Low-GWP Added Energy Efficiency	Annual Electricity Savings	Annual Refrigerant (lbs)	Annual Refrigerant Savings[95]	Annual Total Savings
Window AC Units Commercial	2.0%	$ 1	0.2	$ 0	$ 1
Residential AC Central	2.0%	$ 6	1.2	$ 0	$ 6
Window AC Units Residential	2.0%	$ 2	0.2	$ 0	$ 2
Residential Refrig Freezer	3.0%	$ 3	0.02	$ 0.05	$ 3

d. Added Cost and Savings: Net Cost of Low-GWP Equipment

Table 37 presents the added cost and savings are added together to show a net cost per year of equipment life. We then multiply the net cost per year of equipment life by the total number of new equipment each year, to show a theoretical annual cost if all new equipment is manufactured as low-GWP to meet the high-GWP refrigerant prohibitions.

Table 37: Estimated Net Cost of Low-GWP Equipment, Prohibition Measure[96]

Sector	Average Lifetime (yr)	Added Equipment Cost ($/yr)[97]	Annual Cost (Savings) ($/unit)	Estimated Units Replaced per Year[98]	Estimated Annual Net Cost (Savings)[99]
Centralized System Large (2,000+ lbs)	15	$13,000	$15,000	50	($114,000)
Centralized System Medium (200-2,000 lbs)	15	$3,000	$4,000	1,600	($549,000)
Cold Storage Large (2,000+ lbs)	20	$25,000	$25,000	10	($2,000)
Cold Storage Medium (200-2,000 lbs)	20	$12,500	$9,000	20	$81,000

96 Numbers may not add due to rounding.
97 The added equipment cost per year is calculated by taking the total added initial cost of the equipment, and dividing by the average years of equipment lifetime. The annual savings has been calculated by determining all annual savings and dividing by the average years of equipment cost. All costs and savings are shown in today's dollars; no discounted cost has been used.
98 The estimated number of new units is derived from research and analysis conducted for the ARB Refrigerant Management Program regulation, equipment data registered through the Refrigerant Management Program data, and additional analysis used in the ARB Greenhouse Gas Emissions Inventory as developed by Gallagher, et al. 2014.
99 Net Cost or savings is equal to the cost per unit multiplied by the number of units produced, by model year or cohort.

Sector	Average Lifetime (yr)	Added Equipment Cost ($/yr)[97]	Annual Cost (Savings) ($/unit)	Estimated Units Replaced per Year[98]	Estimated Annual Net Cost (Savings)[99]
Process Cooling Large (2,000+ lbs)	20	$12,500	$14,000	5	($6,000)
Refrigerated Condensing Units Small (50-200 lbs)	15	$1,000	$1,000	4,000	$78,000
Refrigerated Condensing Units (Less than 50 lbs)	20	$400	$500	15,700	($2,200,000)
Stand-Alone Refrigerant Display Cases	20	$50	$50	34,000	$618,000
Centrifugal Chiller Large (2,000+ lbs)	20	$1,500	$800	300	$176,000
Centrifugal Chiller Medium (200-2,000 lbs)	20	$1,000	$500	100	$42,000
Chiller – Packaged Medium (200-2,000 lbs)	20	$1,000	$200	500	$387,000
Unitary A/C Small (50-200 lbs)	15	$100	$200	5,000	($426,000)
Unitary A/C Central (Less than 50 lbs)	15	$50	$50	169,000	$0
Window AC Units Commercial	12	$10	$0	54,000	$325,000
Residential AC Central	15	$50	$10	482,000	$10,123,000
Window AC Units Residential	12	$10	$5	310,000	$1,552,000
Residential Refrigerator Freezer	15	$10	$5	1,266,000	$10,125,000
Total Annual Cost of Equipment Model Year[100]					**$20,225,000**

[100] The annual cost would be applied for each year of the model year or cohort's lifetime. Table 37 shows the cost if the prohibition were the only proposed HFC measure implemented. The cumulative costs of the four proposed HFC measures are shown in Table 34 of the Appendix.

Due to the very high number of new residential appliances per year, and their net added cost, residential AC and refrigerator-freezers account for virtually all of the added net cost of low-GWP equipment. The current best estimate for added cost per unit ($400 for central AC, and $150 for refrigerator-freezers) may decrease in the future as production of lower-GWP equipment increases and economies of scale are realized. The added cost of low-GWP residential refrigerator-freezers could also be reduced due to a March 29, 2016 Federal proposal by the U.S. EPA that will prohibit high-GWP refrigerants in new units as of January 1, 2021. Presumably, a national requirement would result in greater production of low-GWP appliances than a California-only requirement, with greater cost savings due to a nation-wide transition resulting in mass production or import of low-GWP equipment. The U.S. EPA proposed regulation had not been adopted as of April 2016.

2. HFC Supply Phasedown

The HFC supply phasedown measure is no longer specific to California, but is international in scope and all developed countries, including the U.S., will follow the same phasedown schedule. Although the phasedown measure is no longer attributed to ARB, the cost and benefit analysis summarized below is still an accurate representation of the impact on businesses and residents in California.

The methodology used to estimate the cost and savings of a global HFC supply phasedown as it affects California is the same as that used for high-GWP refrigerant prohibitions, with one exception; the incremental equipment is estimated to be ten percent less than the cost used for the prohibitions measure. Analysis conducted for the European Union F-gas regulation concluded that non-prescriptive measures in which HFCs can be used in conjunction with a gradually decreasing HFC supply are approximately ten percent less costly than sector specific high-GWP prohibitions (Oko Recherche, 2011). Additionally, trade organizations such as the Alliance for Responsible Atmospheric Policy (ARAP), representing more than 100 equipment manufacturers and refrigerant manufacturers, state that an HFC phasedown could be met with a much lower added cost than specific high-GWP prohibitions. The costs of the high-GWP phasedown are shown in Table 38.

Table 38: Estimated Net Cost of Low-GWP Equipment, HFC Phasedown Measure[101]

Sector	Average Lifetime (yrs)	Added Equipment Cost ($/yr)[102]	Annual Cost Savings ($/unit)	Estimated New Units[103] and Equipment	Estimated Annual Net Cost (Savings) ($/yr)[104]
Centralized System Large (2,000+ lbs)	15	$12,000	($15,000)	50	($189,000)
Centralized System Medium (200-2,000 lbs)	15	$3,000	($4,000)	1,600	($1,076,000)
Cold Storage Large (2,000+ lbs)	20	$22,000	($25,000)	10	($22,000)
Cold Storage Medium (200-2,000 lbs)	20	$11,000	($9,000)	25	$55,000
Process Cooling Large (2,000+ lbs)	20	$11,000	($14,000)	10	($12,000)
Refrigerated Condensing Units Small (50-200 lbs)	15	$1,000	($1,000)	3,900	($311,000)
Refrigerated Condensing Units (Less than 50 lbs)	20	$500	($500)	15,700	($2,772,000)
Stand-Alone Refrig Display Cases	20	$10	($50)	34,300	$420,000
Centrifugal Chiller Large (2,000+ lbs)	20	$1,000	($800)	200	$137,000
Centrifugal Chiller Medium (200-2,000 lbs)	20	$1,000	($500)	100	$34,000
Chiller Packaged Medium (200-2,000 lbs)	20	$1,000	($200)	500	$336,000

[101] Numbers may not add due to rounding.
[102] The added equipment cost per year is calculated by taking the total added initial cost of the equipment, and dividing by the average years of equipment lifetime. The annual savings has been calculated by determining all annual savings and dividing by the average years of equipment cost. All costs and savings are shown in today's dollars; no discounted cost has been used.
[103] The estimated number of new units is derived from research and analysis conducted for the ARB Refrigerant Management Program regulation, equipment data registered through the Refrigerant Management Program data, and additional analysis used in the ARB Greenhouse Gas Emissions Inventory as developed by Gallagher, et al. 2014.
[104] The annual cost would be applied for each year of the model year or cohort's lifetime. Table 43 shows the cost if the HFC phasedown were the only proposed HFC measure implemented. The cumulative costs of the four proposed HFC measures are shown in Table 27 of the Appendix.

Sector	Average Lifetime (yrs)	Added Equipment Cost ($/yr)[102]	Annual Cost Savings ($/unit)	Estimated New Units[103] and Equipment	Estimated Annual Net Cost (Savings) ($/yr)[104]
Unitary A/C Small (50-200 lbs)	15	$100	($200)	4,900	($469,000)
Unitary A/C Central (Less than 50 lbs)	15	$50	($25)	169,000	($586,000)
Window AC Units Commercial	10	$25	($10)	54,000	$289,000
Residential AC Central	15	$25	($10)	482,000	$8,709,000
Window AC Units Residential	10	$25	($10)	310,000	$1,345,000
Residential Refrigerator-Freezer	15	$10	($10)	1,266,000	$8,227,000
Total Annual Cost of Equipment Model Year[105]					**$14,115,000**

3. Financial Incentive Program for Low-GWP Refrigeration Early Adoption

In order to incentivize low-GWP refrigeration prior to any mandatory regulatory measures, ARB has requested funding from the Greenhouse Gas Reduction Fund (GGRF) to use as a financial incentive, as a grant, loan, or other payment to be determined, to encourage new retail food facilities to use low-GWP refrigeration. Additionally, current stores using high-GWP equipment with remaining useful life could use funding to replace the high-GWP refrigerant in existing equipment, with low-GWP refrigerant, in a process known as a retrofit.

Table 39 shows the estimated incremental equipment cost of an incentive program for new equipment and retrofits. The cost assumptions in Table 39 are the same as those used for high-GWP prohibitions outlined in Table 37. This analysis assumes that the entire incremental cost of low-GWP equipment is covered by the incentive. However, the cost-effectiveness of this proposed measure could be improved if the necessary incentive is less than the incremental cost of low-GWP equipment.

[105] The annual cost would be applied for each year of the model year or cohort's lifetime. Table 22 shows the cost if the prohibition were the only proposed HFC measure implemented. The cumulative costs of the four proposed HFC measures are shown in Table 43 of the Appendix.

Table 39: Estimated Cost and Savings of Incentive Program for New Low-GWP Equipment (Per Piece of Equipment)

Sector	Average Lifetime (yrs)	Baseline Average Cost of Equipment	Incremental Cost for Low-GWP Equipment	Lifetime Cost	Annual Cost	Net Cost (Savings) ($/yr)
Centralized System Large[106] (2,000+ lbs)	15	$1,000,000	$200,000	($231,000)	($15,000)	($2,000)
Centralized System Medium[107] (200-2,000 lbs)	15	$250,000	$50,000	($55,000)	($4,000)	($500)
Refrigerated Condensing Units Small[108] (50-200 lbs)	15	$75,000	$15,000	($15,000)	($1,000)	$25
Refrigerated Condensing Units[109] (Less than 50 lbs)	20	$37,500	$7,500	($10,000)	($500)	($250)
Stand-Alone Refrigerated Display Cases[110]	20	$5,000	$1,000	($1,000)	($25)	$50

In addition to incentivizing new low-GWP equipment, existing high-GWP equipment could be converted to using lower-GWP refrigerants in a process known as a retrofit, where the high-GWP refrigerant is removed, and new lower-GWP refrigerant is added, along with minor modifications such as replacing seals and the refrigerant oil. Table 40 shows the cost of an incentive program to retrofit existing high-GWP equipment and Table 41 presents the cost of a voluntary retrofit program.

The relative high cost savings of are due to the inherent inefficiency of the refrigerant being replaced, which is R-404A, a high-GWP blend of HFCs. Almost any refrigerant replacement will result in significant energy efficiencies compared to R-404A. In this analysis, we assume that the replacement refrigerant is an HFO-HFC blend, either R-448A, or R-449A, each with a 10 percent greater efficiency than R-404A. The same kWh and electricity cost from the Prohibition analysis is used here. The total cost of an incentive program is limited by available funds, and is not known. The following shows a theoretical net cost of an incentive program for one year for new equipment, if 80% of new large and medium centralized systems are incentivized, four percent of smaller

[106] The analysis assumes one per supermarket.
[107] The analysis assumes three to four per supermarket and one to two per grocery store.
[108] The analysis assumes one to three per grocery store.
[109] The analysis assumes up to several per small market.
[110] The analysis assumes several per small market and more for larger markets.

units (50 to 200 lbs charge size), two percent of refrigeration units with less than 50 lbs charge size, and one percent of stand-alone (self-contained equipment). For existing equipment, we assume that a number equal to one-year's turnover rate could be retrofitted. For equipment with a 20-year lifetime, the retrofit rate would be 5% of all equipment, and for equipment with a 15-year lifetime, the retrofit rate would be 6.7%. The cost of the following analysis assumes that approximately $240 million dollars in incentive funds could be available. Although the funding would be one-time and at the time of the new low-GWP equipment installation, or retrofit activity, the cost is shown on an annualized basis over the lifetime of the equipment to be consistent with cost analysis by year of equipment life.

Table 40: Estimated Cost and Savings of Incentive Program for Retrofit of Existing Low-GWP Equipment (Per Piece of Equipment)[111]

Sector	Post-Retrofit Remaining Life[112] (yrs)	One-Time Retrofit Cost ($/unit)	Lifetime Cost (Savings)	Added Annual Cost	Number of Equipment (unit/yr)	Net Cost (Savings) ($/yr)
Centralized System Large[113] (2,000+ lbs)	10	$80,000	($141,000)	$8,000	($14,000)	($6,000)
Centralized System Medium[114] (200-2,000 lbs)	10	$30,000	($31,000)	$3,000	($3,000)	($100)
Refrigerated Condensing Units Small[115] (50-200 lbs)	13	$6,000	($10,000)	$500	($1,000)	($300)
Refrigerated Condensing Units[116] (Less than 50 lbs)	13	$3,000	($7,000)	$250	($50)	($300)
Stand-Alone Refrigerated Display Cases[117]	13	$250	($500)	$50	($50)	($25)

[111] Numbers may not add due to rounding.
[112] Assumed to be 2/3 of total equipment lifetime.
[113] The analysis assumes one per supermarket.
[114] This analysis assumes three to four per supermarket and one to two per grocery store.
[115] This analysis assumes one to three per grocery store.
[116] This analysis assumes up to several per small market.
[117] This analysis assumes several per small market and more for larger markets.

Table 41: Estimated Annual Costs and Savings of Voluntary Incentive Program (Per Piece of Equipment) [118]

Sector	Incentive: New Equipment or Retrofit Existing	Added Annual Cost	Annual Cost (Savings)	Net Cost (Savings)	Pieces of Equipment (unit/yr)	Net Cost (Savings) ($/yr)
Centralized System Large (2,000+ lbs)[119]	New	$13,000	($15,000)	($2,000)	45	($91,000)
	Retrofit	$8,000	($14,000)	($6,000)	56	($340,000)
Centralized System Medium[120] **(200-2,000 lbs)**	New	$3,000	($4,000)	($500)	1,300	($439,000)
	Retrofit	$3,000	($3,000)	($100)	1,600	($202,000)
Refrigerated Condensing Units Small[121] **(50-200 lbs)**	New	$1,000	($1,000)	$25	150	$3,000
	Retrofit	$500	($750)	($300)	3,800	($1,107,000)
Refrigerated Condensing Units[122] **(Less than 50 lbs)**	New	$500	($500)	($100)	300	($44,000)
	Retrofit	$250	($500)	($300)	16,000	($4,545,000)
Stand-Alone Refrigerated Display Cases[123]	New	$50	($25)	$25	300	$6,000
	Retrofit	$25	($25)	($25)	34,000	($480,000)
Total Estimated Annual Net Cost (Saving)						**($7,239,000)**

4. Sales Ban of Very-High GWP Refrigerants

To determine the incremental cost of complying with a sales ban of very high-GWP refrigerant (100-year GWP > 2500), this analysis assumes that a sales ban of refrigerant with a GWP > 2500 can be met by replacing the old refrigerant (if necessary) with new refrigerant, in a process called a retrofit. It is not anticipated that a sales ban of very-high GWP refrigerants will require purchasing new equipment sooner than the normal expected lifetime of the existing equipment, although some equipment owners may choose to purchase new low-GWP equipment rather than replace the existing refrigerant. Air-conditioning equipment, residential refrigeration, and residential AC do

[118] Numbers may not add due to rounding. Estimated costs and savings are for participating businesses only.
[119] The analysis assumes one per supermarket.
[120] This analysis assumes three to four per supermarket and one to two per grocery store.
[121] This analysis assumes one to three per grocery store.
[122] This analysis assumes up to several per small market.
[123] This analysis assumes several per small market and more for larger markets.

not use very-high GWP refrigerants and would not be affected by the sales ban. The retrofit cost shown in Table 42 is an average of quotes from technicians who conduct refrigeration retrofits. There are estimated significant savings over equipment lifetime resulting from the reduced energy usage of lower-GWP refrigerants, similar to the retrofit cost outlined in the proposed incentive program measure.

Table 42: Estimated Cost and Savings of Sales Ban of Very-High GWP Refrigerants (Per Piece of Equipment)[124]

Sector	Post-Retrofit Remaining Life[125] (yrs)	One-Time Retrofit Cost ($/unit)	Lifetime Cost (Savings)	Added Annual Cost	Cost (Savings) ($/yr)	Cost (Savings) ($/yr)
Centralized System Large (2,000+ lbs)	10	$80,000	($141,000)	$8,000	($14,000)	($6,000)
Centralized System Medium (200-2,000 lbs)	10	$20,000	($31,000)	$3,000	($3,000)	($100)
Cold Storage Large (2,000+ lbs)	13	$200,000	($230,000)	$15,000	($17,000)	($2,000)
Cold Storage Medium (200-2,000 lbs)	13	$100,000	($115,000)	$7,500	($9,000)	($1,000)
Process Cooling Large (2,000+ lbs)	13	$100,000	($182,000)	$7,500	($14,000)	($6,000)
Refrigerated Condensing Units Small (50-200 lbs)	10	$6,000	($10,000)	$1,000	($1,000)	($500)
Refrigerated Condensing Units (Less than 50 lbs)	13	$3,000	($7,000)	$250	($500)	($500)
Stand-Alone Refrigerated Display Cases	13	$250	($500)	$25	($50)	($25)

The total equipment cost of a sales ban is dependent upon the numbers of equipment undergoing a retrofit, which would not necessarily be required if the equipment did not require new refrigerant, as is common in many self-contained equipment. Also, stockpiled or recycled refrigerant would still be available during a sales ban on new production.

[124] Numbers may not add due to rounding.
[125] Assumed to be 2/3 of total equipment lifetime.

Table 43 is a continuation of the cost for a sales ban measure. In addition to showing the cost per unit, the number of units affected by the measure is estimated. Table 41 shows the cost per year of a scenario where the retrofit rate is approximately 10 percent of existing very-high GWP equipment.

Table 42: Estimated Cost and Saving of a Very-High GWP Sales Ban (Per Year of Measure)[126]

Sector	Added Unit Cost	Cost or (Savings)	Net Costs per Unit	Number of Equipment (unit/yr)	Net Cost (Savings)
Centralized System Large (2,000+ lbs)	$8,000	(-$14,000)	(-$6,000)	10	(-$523,000)
Centralized System Medium (200-2,000 lbs)	$3,000	(-$3,000)	(-$250)	2,500	(-$310,400)
Cold Storage Large (2,000+ lbs)	$15,000	(-$17,000)	(-$2,000)	25	(-$34,000)
Cold Storage Medium (200-2,000 lbs)	$7,500	(-$9,000)	(-$1000)	50	(-$48,000)
Process Cooling Large (2,000+ lbs)	$7,500	(-$14,000)	(-$6,000)	10	(-$68,000)
Refrigerated Condensing Units Small (50-200 lbs)	$600	(-$1,000)	(-$500)	8,000	(-$3,019,000)
Refrigerated Condensing Units (Less than 50 lbs)	$250	(-$500)	(-$500)	32,000	(-$9,294,000)
Stand-Alone Refrigerated Display Cases	$25	(-$50)	(-$25)	70,000	(-$982,000)
Estimated Annual Cost (Savings)					**(-$14,278,000)**

5. Cumulative Cost of All Measures

This analysis estimates a net cost as a result of the proposed prohibition and phasedown measures and net savings from the proposed incentive and sales ban measures. This analysis also finds that all four measures are estimated to contribute to HFC emission reductions. As new equipment can only be built as low-GWP once, new equipment can be assigned to only one of the four reduction measures. Existing equipment can also be retrofitted to lower-GWP refrigerants, which will increase HFC emission reductions faster than waiting for natural equipment turn over. As existing equipment can be retrofitted, the estimated annual percentage of new low-GWP

[126] Numbers may not add due to rounding.

equipment (new and retrofit) can equal more than 100 percent of estimated unit turn over per year.

The following section outlines the assumptions that were used to determine the combination of measures contributing to both cost and savings as well as HFC emission reductions and are presented by proposed measure.

Incentive Program

From 2017 through 2020, an incentive program could incentive a switch to low-GWP refrigeration for up to 80 new large and medium refrigeration systems. The analysis also assumes an additional four percent of new refrigerated condensing units (50 to 200 lbs of refrigerant), two percent of new refrigerated condensing units less than 50 lbs, and one percent of new stand-alone (self-contained) refrigerated display cases could be incentivized to switch to low-GWP refrigerant.

Sales Ban

For existing units, the analysis estimates that approximately five to seven percent of refrigeration units could be retrofit to lower-GWP refrigerants each year, from 2019 through 2025. The analysis assumes that the sales ban could also be responsible for five to six percent of all new low-GWP refrigeration equipment. The sales ban would not apply to refrigerants used in air-conditioning.

HFC Phasedown

A phasedown in the supply of new HFC refrigerant will begin in 2019 and continue with a gradual phasedown in the supply through 2036 until the new total allocation (as measured in CO_2e) will be 85 percent less than baseline. By 2025, we estimate that up to half of all new equipment could be low-GWP due to an HFC phasedown.

High-GWP Refrigerant Prohibitions in New Equipment

Prohibition measures would take place immediately after measures implementation and would result in an estimated 80 to 90 percent turnover to low-GWP equipment until implementation of HFC phasedowns. The percent of equipment becoming low-GWP as a result of the prohibitions would gradually decrease, and by 2025, the analysis estimates 37 percent of all new equipment will be low-GWP due to the prohibitions.

Given the transition towards low-GWP refrigeration and AC equipment as modeled in this analysis, Table 43 shows the estimated cost, by year, and also aggregated cost and savings through 2030.

Table 43: Cumulative Cost of all Measures (Million Dollars)

Measure		2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Incentive Program	Added Cost	$5	$11	$17	$18	$18	$18	$18	$18	$18	$19	$19	$19	$19	$19
	Savings	($6)	($12)	($19)	($20)	($20)	($20)	($20)	($20)	($20)	($21)	($21)	($21)	($21)	($21)
	Net Cost or (Savings)	($1)	($1)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)	($2)
Sales Ban	Added Cost	$0	$0	$16	$40	$64	$89	$115	$136	$150	$151	$152	$147	$141	$148
	Savings	$0	$0	($26)	($65)	($105)	($146)	($187)	($224)	($246)	($248)	($249)	($237)	($232)	($240)
	Net Cost or (Savings)	$0	$0	($11)	($26)	($41)	($57)	($73)	($88)	($96)	($97)	($97)	($90)	($90)	($92)
HFC Phasedown (through global Kigali Amendment)	Added Cost	$0	$0	$0	$2	$4	$11	$28	$56	$91	$124	$160	$198	$237	$276
	Savings	$0	$0	($0)	($1)	($3)	($7)	($19)	($39)	($63)	($87)	($113)	($140)	($168)	($196)
	Net Cost or (Savings)	$0	$0	$0	$0	$1	$4	$9	$18	$28	$37	$47	$58	$69	$80
High-GWP HFC Prohibitions	Added Cost	$0	$0	$0	$19	$73	$123	$164	$194	$218	$246	$273	$299	$325	$352
	Savings	$0	$0	$0	($21)	($55)	($87)	($113)	($132)	($147)	($165)	($181)	($198)	($215)	($233)
	Net Cost or (Savings)	$0	$0	$0	($2)	$18	$36	$51	$62	$71	$82	$91	$101	$110	$120

All Measures Combined	**Cumulative Cost**	$5	$16	$50	$128	$287	$528	$852	$1,257	$1,734	$2,274	$2,877	$3,540	$4,262	$5,058
	Cumulative Savings	($6)	($18)	($64)	($171)	($354)	($613)	($952)	($1366)	($1843)	($2363)	($2927)	($3524)	($4159)	($4849)
	Cumulative Net Cost or (Savings)	**($1)**	**($2)**	**($14)**	**($43)**	**($67)**	**($85)**	**($100)**	**($110)**	**($109)**	**($89)**	**($50)**	**$16**	**$103**	**$209**