CALIFORNIA
AIR RESOURCES BOARD

California Greenhouse Gas Emissions for 2000 to 2016

Trends of Emissions and Other Indicators

Executive Summary

California uses the annual statewide greenhouse gas (GHG) emission inventory to track progress toward meeting statewide GHG targets. The inventory for 2016 shows that California's GHG emissions continue to decrease, a trend observed since 2007. In 2016, emissions from routine GHG emitting activities statewide were 429 million metric tons of CO2 equivalent (MMTCO2e), 12 MMTCO2e lower than 2015 levels. This puts total emissions just below the 2020 target of 431 million metric tons. Emissions vary from year-to-year depending on the weather and other factors, but California will continue to implement its greenhouse gas reductions program to ensure the state remains on track to meet its climate targets in 2020 and beyond. These reductions come while California's economy grows and continues to generate jobs. Compared to 2015, California's GDP grew 3% while the carbon intensity of its economy declined by 6%.

- The largest reductions came from the electricity sector which continues to see decreases as a result of the state's climate policies, which led to growth in wind generation and solar power, including growth in both rooftop and large solar array generation.
- The abundant precipitation in 2016 provided higher hydropower to the state.
- The industrial sector shows a slight decrease in emissions in the past two years.
- The transportation sector remains the largest source of GHG emissions in the state and saw a 2% increase in emissions in 2016.
- Emissions from the remaining sectors are relatively constant in recent years, although emissions from high Global Warming Potential (GWP) gases also continued to increase as they replace Ozone Depleting Substances (ODS) banned under the 1987 Montreal Protocol.

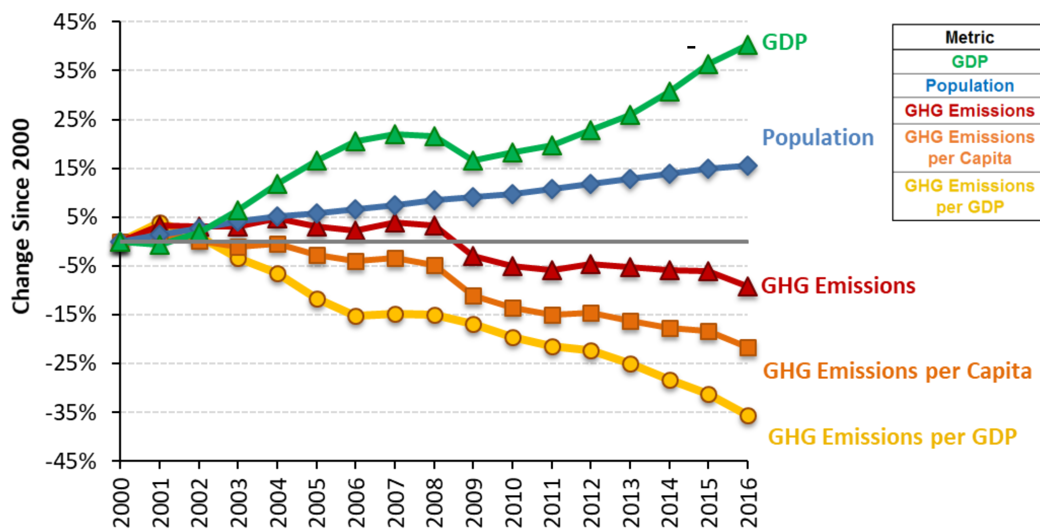
Introduction

The GHG inventory is a critical piece, in addition to data from various California Global Warming Solutions Act (AB 32) programs, in demonstrating the state's progress in achieving the statewide GHG targets established by AB 32 (reduce emissions to the 1990 levels by 2020) and Senate Bill 32 (SB 32) (reduce emissions to at least 40% below the 1990 levels by 2030). The 2018 edition of the GHG inventory includes the emissions of the seven GHGs identified in AB 32[1] for the years 2000 to 2016 and uses an inventory scope and framework consistent with international and national GHG inventory practices.[2] There are additional climate pollutants that are not included in AB 32 and are tracked separately outside of the GHG inventory. These climate pollutants include black carbon and sulfuryl fluoride (SO_2F_2), which are discussed in the Short-Lived Climate Pollutant (SLCP) Strategy[3], as well as ozone depleting substances (ODS) that are being phased out after a 1987 international treaty[7] and are now being substituted with hydrofluorocarbons, which are pollutants specified in AB 32.

Statewide Trends of Emissions and Indicators

California's GHG emissions have followed a declining trend since 2007. In 2016, emissions from routine emitting activities statewide were 429 million metric tons of CO_2 equivalent (MMTCO$_2$e), or 12 MMTCO$_2$e lower than 2015 levels, representing an overall decrease of 13% since peak levels in 2004 and 2 MMTCO$_2$e below the 1990 level and the state's 2020 GHG target. During the 2000 to 2016 period, per capita GHG emissions in California have continued to drop from a peak in 2001 of 14.0 tonnes per person to 10.8 tonnes per person in 2016, a 23% decrease.[4] Overall trends in the inventory also demonstrate that the carbon intensity of California's economy (the amount of carbon pollution per million dollars of gross domestic product (GDP)) is declining, representing a 38% decline since the 2001 peak, while the state's GDP has grown 41% during this period.[5] In 2016, GDP grew 3% while the emissions per GDP declined by 6% compared to 2015.

Figure 1a. Change in California GDP, Population, and GHG Emissions Since 2000



Metric	Associated 2016 Value
GDP	2.3 trillion (2009 $)
Population	39.3 million
GHG Emissions	429.33 $MMTCO_2e$
GHG Emissions per Capita	10.8 metric tons CO_2e per person
GHG Emissions per GDP	187 metric tons CO_2e per million dollars

Figure 1b. California Total and Per Capita GHG Emissions

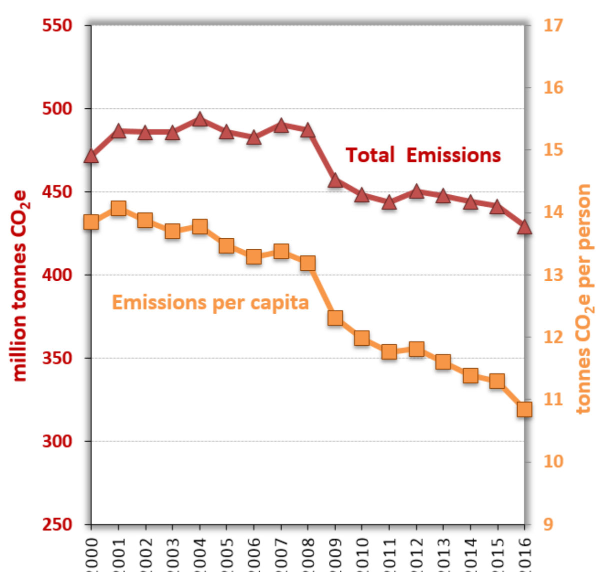
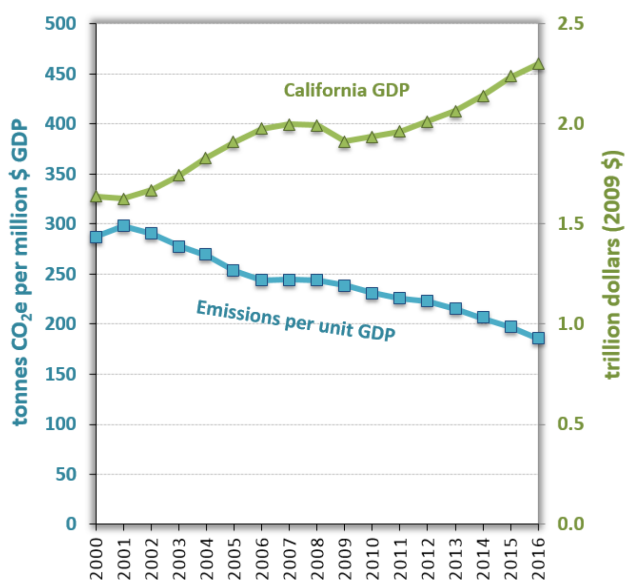


Figure 1c. Carbon Intensity of California's Economy



Figures 1(a)-(c). California's GHG emissions, population, GDP, GHG per capita, and carbon intensity of the economy. Figure 1(a) shows percent change in GHGs relative to GDP and population since 2000. Figures 1(b) and 1(c) present these indicators in the original units. In the charts with 2 vertical axes, the color of a trend line matches the color of its corresponding vertical label.

Overview of Emission Trends by Sector

The transportation sector remains the largest source of GHG emissions in the state. Direct emissions from the tailpipe of cars, trucks, off-road transportation sources, intrastate aviation, etc., accounted for 39%* of the inventory in 2016 (it was 37% in 2015), and saw an increase in emissions in 2016. Emissions from the electricity sector account for 16% of the inventory and show a significant drop in 2016 with a large increase in renewable energy driven by the Renewable Portfolio Standard requiring the state to provide 50% of its electricity from renewable sources by 2030. The industrial sector has seen a slight decrease in emissions in the past two years, but remains at 21% of the inventory in both 2015 and 2016. Emissions from the remaining sectors are relatively constant in recent years, although emissions from high Global Warming Potential (GWP) gases have continued to increase as they replace ODS banned under the 1987 Montreal Protocol.[7]

The figures below show an overview of the emission trends by sector and the relative breakdown of 2016 emissions by sector. Emissions are organized by the categories in the Initial AB 32 Scoping Plan[6] and use the 100-year GWP values from the Intergovernmental Panel on Climate Change (IPCC) 4th Assessment Report (AR4),[2] consistent with current international GHG inventory practices.

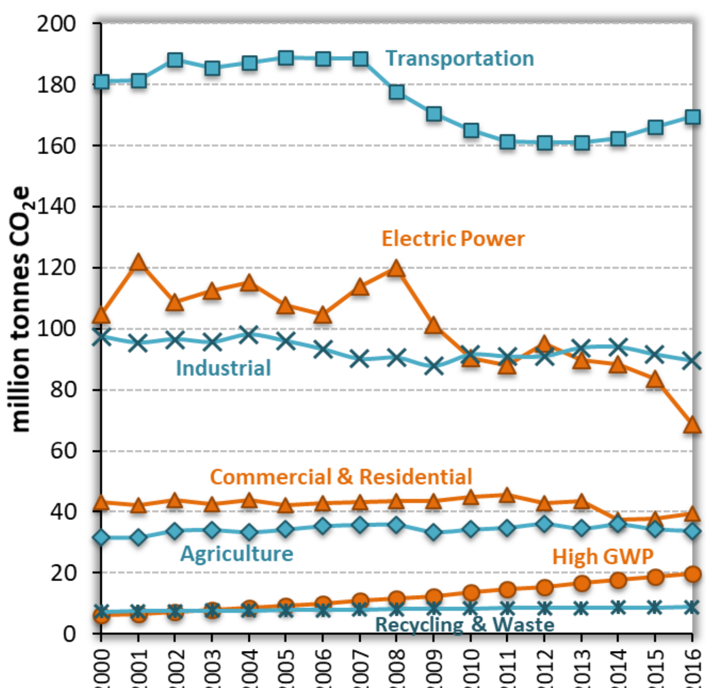


Figure 2. Trends in California GHG Emissions. This figure shows changes in emissions by sector between 2000 and 2016. Emissions are organized by the categories in the AB 32 Scoping Plan.

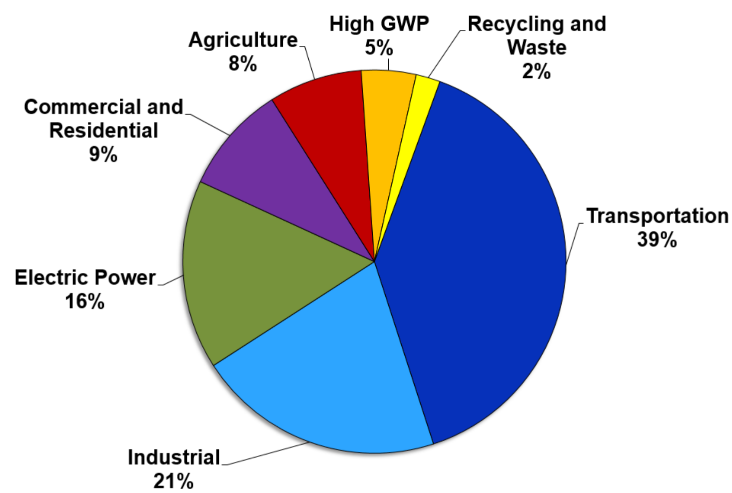


Figure 3. 2016 GHG Emissions by Sector.** This figure shows the relative size of 2016 emissions by sector. Emissions are organized by the categories in the AB 32 Scoping Plan.

* The 39% figure represents tailpipe emissions from on-road vehicles and direct emissions from other off-road mobile sources. It does not include emissions from petroleum refineries and oil production.

***Errata: Figure 3 was updated on July 11, 2018, after the initial release to show GHG emissions by economic sector. It has been updated again on November 20, 2018, to show GHG emissions by Scoping Plan categorization. The differences between economic sector categorization and the Scoping Plan categorization are as follows: (1) High-GWP gases are shown as its own category under the Scoping Plan categorization, but under the economic sector categorization, they are included as part of the economic sectors where they are used. (2) The recycling and waste sector is shown as its own category under the Scoping Plan categorization, but is included as part of the industrial sector under the economic sector categorization. Economic sector categorization generally aligns with how sectors are defined in the North America Industry Classification System (NAICS), while Scoping Plan categorization is organized by program structure of AB 32 implementation.*

Transportation Sector

The transportation sector remains the largest source of GHG emissions in 2016, accounting for 39%* of California's GHG inventory. Contributions from the transportation sector include emissions from combustion of fuels sold in-state that are used by on-road and off-road vehicles, aviation, rail, and water-borne vehicles, as well as a few other smaller sources.**

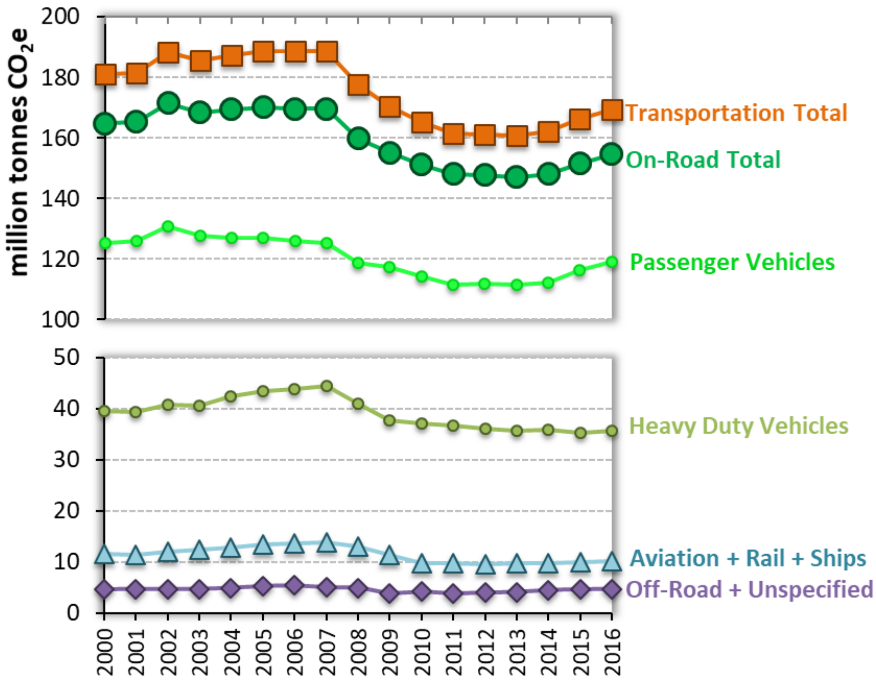


Figure 4. Overview of GHG Emissions from the Transportation Sector. "Transportation Total" is the sum of "On-Road Total," "Aviation + Rail + Ships," and "Off-Road + Unspecified." "On-Road Total" is the sum of "Passenger Vehicles" and "Heavy Duty Vehicles." The size of the symbols denotes the summing; larger symbols indicate what is summed to "Transportation Total" and small circles indicate what is summed to "On-Road Total."

The figures on following page show the trends in emissions and fuel sales for light-duty gasoline and heavy-duty diesel vehicles. Total fuel combustion emissions, inclusive of both fossil component (orange line) and bio-component (yellow shaded region) of the fuel blend, track trends in fuel sales. Consistent with the *IPCC Guidelines for National GHG Inventories*[8] and the annual GHG inventories submitted by the U.S. and other nations to the United Nations Framework Convention on Climate Change (UNFCCC), the biofuel components of fuel combustion CO_2 emissions are classified as "biogenic CO_2". They are tracked separately from the rest of the emissions in the inventory and are not included in the total emissions when comparing to California's 2020 and 2030 GHG targets. Biogenic CO_2 emissions data are available on the CARB webpage.[18]

* The 39% figure represents tailpipe emissions from on-road vehicles and direct emissions from other off-road mobile sources. It does not include emissions from petroleum refineries and oil production.

** Emissions from interstate and international aviation diesel, jet fuel use at military bases, and a portion of bunker fuel purchased in California that is combusted by ships beyond 24 nautical miles from California's shores are not included in the GHG emission inventory, but are tracked separately as informational items. Fuels purchased outside of California that are used in-state by passenger vehicles and trains crossing into California, and upstream emissions tracked by the Low Carbon Fuel Standard (LCFS) program are not included or tracked in this version of the GHG emission inventory.

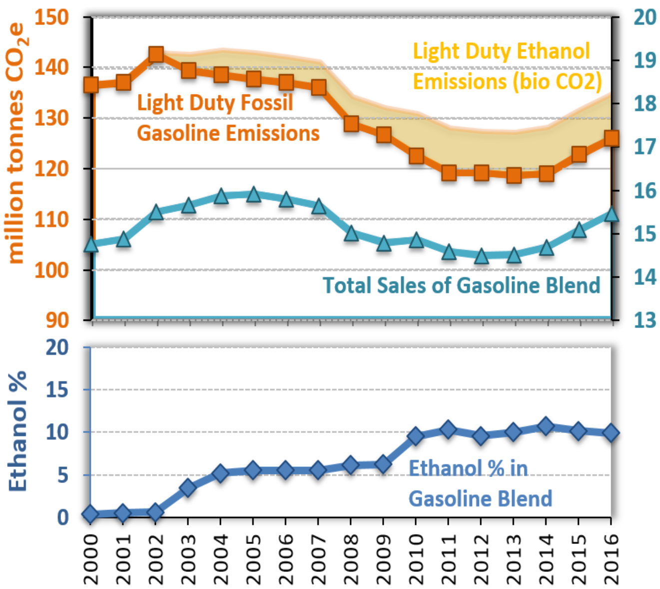


Figure 5. Trends in On-Road Light Duty Gasoline Emissions. In the top panel, the yellow shaded region represents CO_2 emissions from the ethanol-component of the fuel blend. The orange line includes emissions from the fossil gasoline component of the fuel blend, as well as the CH_4 and N_2O emissions from the ethanol-component of the fuel blend. The color of a trend line matches the color of its corresponding vertical axes label. The bottom panel shows the percent of gasoline blend that is ethanol.

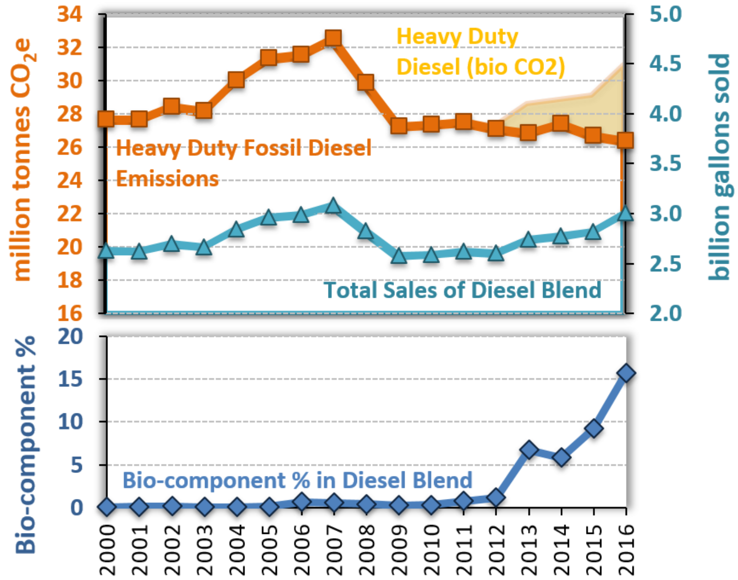


Figure 6. Trends in On-Road Heavy Duty Diesel Vehicle Emissions. In the top panel, the yellow shaded region represents CO_2 emissions from the bio-component (biodiesel and renewable diesel) of the fuel blend. The orange line includes emissions from the fossil diesel component of the fuel blend, as well as the CH_4 and N_2O emissions from the bio-component of the fuel blend. The color of a trend line matches the color of its corresponding vertical axes label. The bottom panel shows the percent of diesel blend that are biodiesel or renewable diesel.

Emissions from transportation sources were relatively constant between 2002 and 2007, declined through 2013, then increased by 7.1 $MMTCO_2e$ (or 4%) from 2014 to 2016. Emissions from gasoline used in on-road vehicles are the main driver of that increase. A combination of factors influences on-road transportation emissions. Regulations and improved fuel efficiency of the state's vehicle fleet drive down emissions over time, but population growth, lower fuel prices, improved economic conditions, and higher overall employment are factors that may increase fuel use. Biofuels such as ethanol, biodiesel, and renewable diesel displace fossil fuels and reduce the amount of fossil-based CO_2 emissions released into the atmosphere. The percent of biodiesel and renewable diesel in the total diesel blend have shown a tremendous growth in recent years, going from 1% in 2012 to 15% in 2016, due in part to the implementation of the Low Carbon Fuel Standard. The continuously increasing market penetration of biodiesel and renewable diesel was able to offset the increase in on-road heavy-duty diesel use. Transportation biofuels displaced 1.5 billion gallons of fossil gasoline and diesel in 2016,[24] roughly one tenth of all the fossil fuel California uses for vehicles.

Electric Power

Emissions from the electric power sector comprise 16% of 2016 statewide GHG emissions. The GHG emission inventory divides the electric power sector into two broad categories: emissions from in-state power generation (including the portion of cogeneration emissions attributed to electricity generation) and emissions from imported electricity.

GHG emissions from this sector declined by 18% in 2016 compared to 2015. The overall decrease in carbon intensity of California's electricity generation is driven primarily by the large increase in renewable energy resources as a result of California's Renewable Portfolio Standard and the Cap-and-Trade Program. Incrementally higher energy efficiency standards keep electricity consumption from increasing despite a growing population and economy. The GHG intensity of imported electricity has been declining steadily over time as California imports a greater share of renewable power and divests from long-term coal-fired electricity contracts.

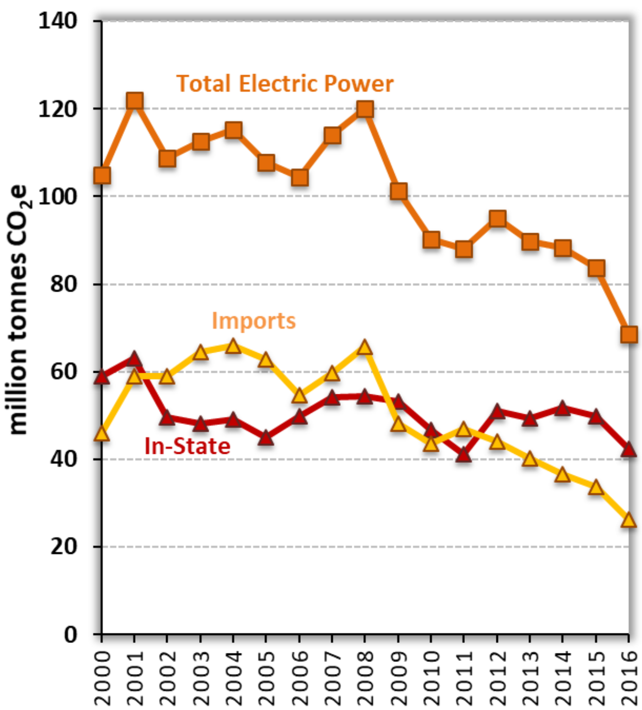


Figure 7. GHG Emissions from the Electric Power Sector. This figure shows trends in emissions of in-state electricity generation, emissions associated with electricity imported from outside of California, and the total electric power sector emissions which is the sum of in-state generation and imports.

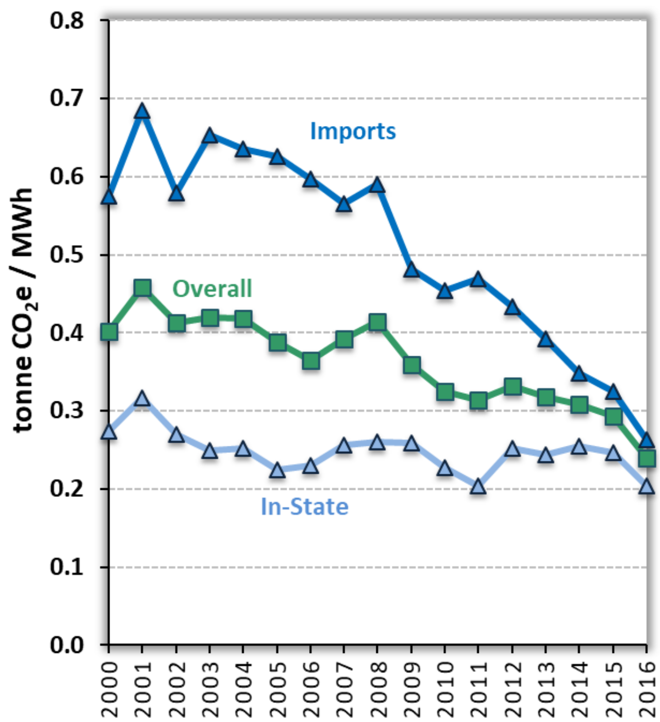


Figure 8. GHG Intensity of Electricity Generation.* This figure shows trends in GHG intensities of electricity generated by in-state power plants, electricity imported from outside of California, and the overall GHG intensities aggregating both in-state generation and electricity imports.

* All three GHG intensities account for renewables and exclude biogenic CO_2 emissions. For calculating in-state and overall intensities, in-state electricity emissions and MWh generation include on-site generation for on-site use, cogeneration emissions attributed to electricity generation, in-state generated electricity exported out of state, and rooftop solar. The denominator of overall intensity is the total MWh consumed in and exported from California, and excludes MWh lost during transmission and distribution.

The effects of the Renewable Portfolio Standard and the Cap-and-Trade Program have spurred installations of new solar generation capacity and incentivized divestment of carbon intensive electricity imports. In 2016, 46% of total electricity generation (in-state generation plus imported electricity) came from zero-GHG generation sources, which include solar, wind, hydropower, and nuclear.* Solar and wind power make up 20% of the total in-state generation in 2016. Electric power emissions dropped 15 MMTCO_2e from 2015 to 2016 due to increased supplies of renewable energy including a 33% growth in solar generation in 2016, and a drop in coal-fired electricity imports with termination of long-term coal contracts. Renewables and less carbon intensive resources replaced most of this former coal-fired demand, while the Cap-and-Trade Program has incentivized dispatch of renewables over fossil generation to serve California load. In 2016, rooftop photovoltaic solar generation is five times the generation level in 2011[10], and total solar generation (commercial-scale plus rooftop solar) increased ten-fold during the same period.[9,10] In-state wind energy generation ramped up through 2013, but its trend has remained relatively constant since 2013.[9]

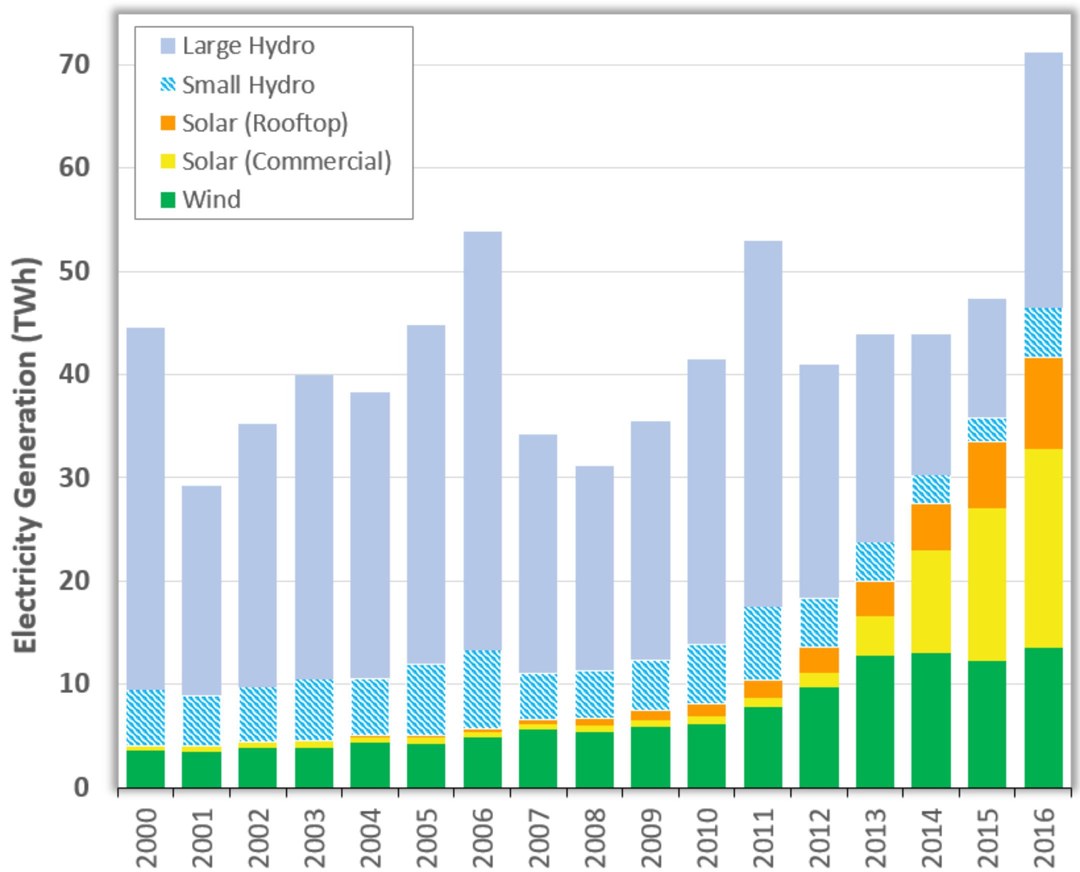


Figure 9. In-State Hydro, Solar, and Wind Electricity Generation. This figure shows the amounts of electricity generated by California's in-state wind power projects, large commercial-scale solar power projects, rooftop solar panels, and hydropower generation stations. The unit is in terawatt-hour (1 TWh = 10^9 kWh).

* "Zero GHG" includes solar, wind, hydro, and nuclear. This is distinguished from the definition of renewables under RPS, which includes generation sources that may be considered renewable energy but still release GHG emissions, such as biomass, biogas, geothermal, and municipal solid waste (MSW). Nuclear is not considered renewable but is a zero-GHG source.

Trends in the types of in-state generation and imported sources that have supplied electricity to California are presented in the figures below. In-state natural gas generation complements the year-to-year fluctuations in zero-GHG sources. Comparing the fractions of total imports in 2011 and 2016, solar generation went from 0.02% to 2%, and wind generation went from 2.7% to 5.2%.

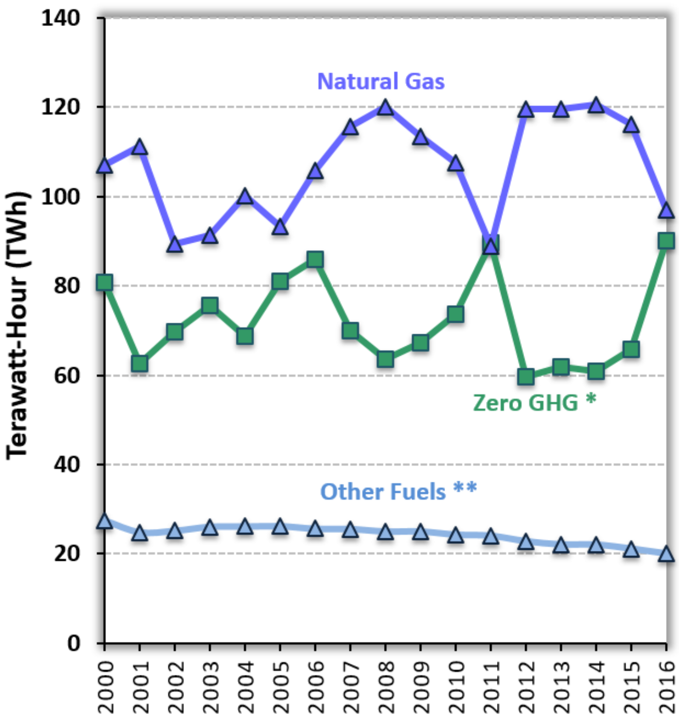


Figure 10a. In-State Electricity Generation by Fuel Type. This figure shows the amounts of electricity generated by in-state natural gas power plants, zero-GHG sources (which includes solar, wind, hydro, and nuclear), and other generation sources. The footnote ** below provides a list of other generation sources included in the "Other Fuels" line.

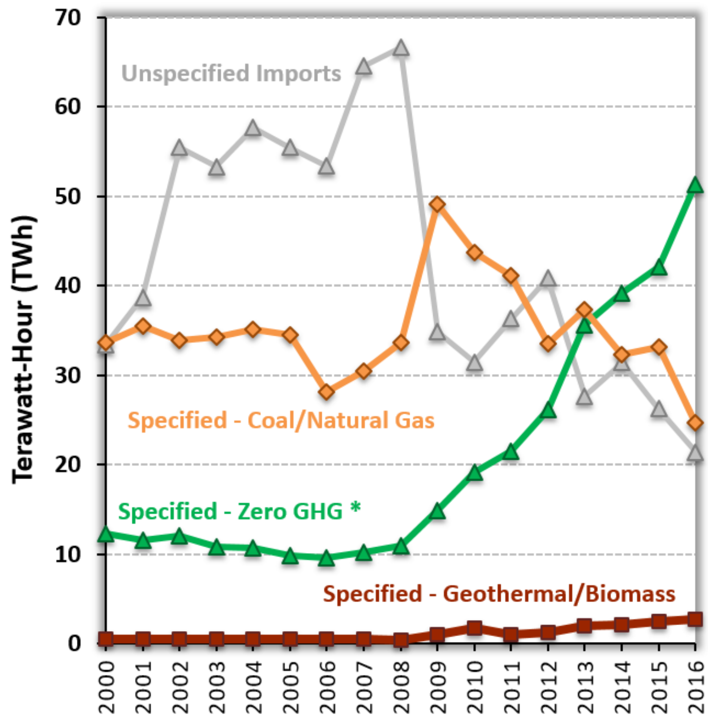


Figure 10b. Imported Electricity by Generation Type. This figure shows the amounts of imported electricity that are specified as fossil fuel (coal and natural gas), zero-GHG (solar, wind, hydro, and nuclear), and other renewables that are not zero-GHG (geothermal and biomass), as well as unspecified electricity imports.

* "Zero GHG" includes solar, wind, hydro, and nuclear. This is distinguished from the definition of renewables under RPS, which includes generation sources that may be considered renewable energy but still release GHG emissions, such as biomass, biogas, geothermal, and municipal solid waste (MSW). Nuclear is not considered renewable but is a zero-GHG source.

** "Other Fuels" include energy generations from associated gas, biomass, coal, crude oil, digester gas, distillate, geothermal, jet fuel, kerosene, landfill gas, lignite coal, municipal solid waste (MSW), petroleum coke, propane, purchased Steam, refinery gas, residual fuel oil, sub-bituminous coal, synthetic coal, tires, waste coal, waste heat, and waste oil. Although biomass and geothermal are considered renewable energy, they are not zero GHG. CO_2 and CH_4 emissions from geothermal, and CH_4 and N_2O emissions from biomass power plant, are included in the statewide total for comparing to the 2020 GHG target.

Industrial

Emissions from the industrial sector contributed 21% of California's total GHG emissions in 2016. Emissions in this sector are driven by fuel combustion from sources that include refineries, oil & gas extraction, cement plants, and other stationary sources, as well as the portion of cogeneration emissions attributed to thermal energy output. Emissions from this sector show a slight decrease in emissions in the past two years.

Refineries and hydrogen production represent the largest individual industrial source, contributing 33% of the sector's total emissions. The increase between 2015 and 2016 was likely due to the Exxon Mobil Torrance refinery's temporary partial shutdown between February 2015 and May 2016. The Torrance Refinery operations have returned to pre-2015 levels since that time.

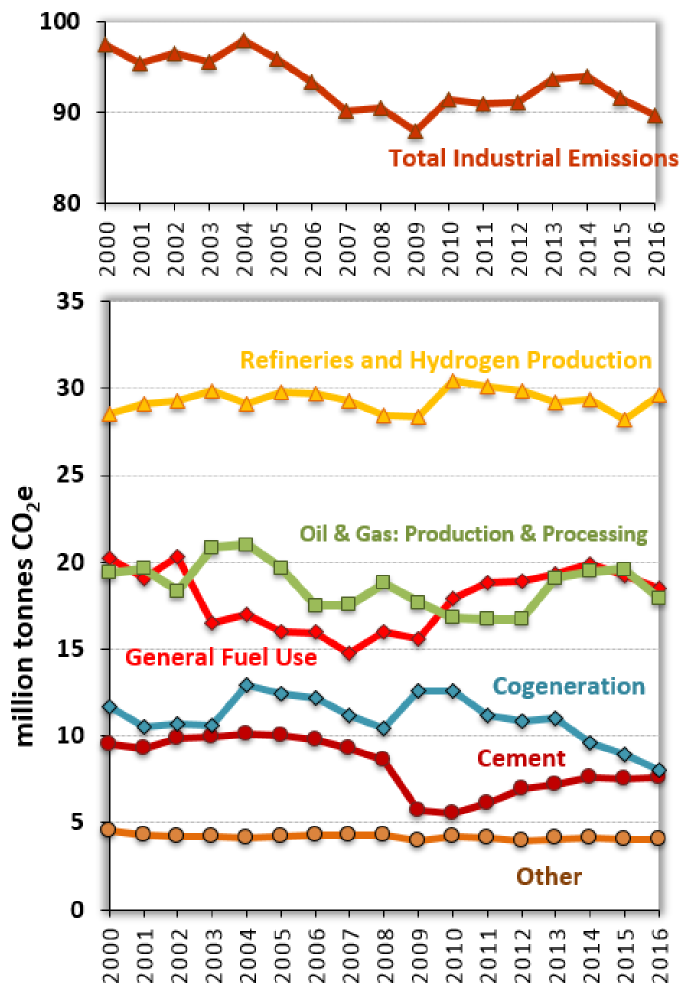


Figure 11. Industrial Sector Emissions. The top panel of this figure shows the overall emissions trend of the total industrial sector. The bottom panel shows emissions trends by sub-sector – summing the bottom panel will equal the top panel. In accordance with the IPCC Guidelines, the cogeneration category under the industrial sector includes only the portion of emissions attributed to the total thermal output of cogeneration; the portion of cogeneration emissions attributed to electricity generation is assigned to the electric power sector and not shown in this graph.

Emissions from oil and gas extraction represent 19% of 2016 industrial sector emissions. Oil and gas extraction emissions have fallen 9% from 2015 to 2016 likely due to a drop in production and the industry using less steam during extraction operation. Routine emissions from the natural gas transmission and distribution sector have remained relatively constant over time. The Aliso Canyon natural gas leak event released 1.96 $MMTCO_2e$ of unanticipated emissions in 2015 and 0.53 $MMTCO_2e$ in 2016. These leak emissions will be fully mitigated in accordance with a legal settlement and therefore are tracked separately from routine inventory emissions.

Since 2007, general fuel use by industries has followed a gradually increasing trend, signaling a growing industrial sector as the state's economy continues to expand. With the onset of the economic downturn around 2009, cogeneration (cogen) facilities used more of their capacity to generate useful thermal energy (such as steam for industrial processes); however, useful thermal energy production has been on a downward trajectory since that time. Several cogeneration facilities, most of them associated with oil and gas operations, have either shut down or become non-operational in recent years and further contributed to the downward trend in cogeneration emissions.

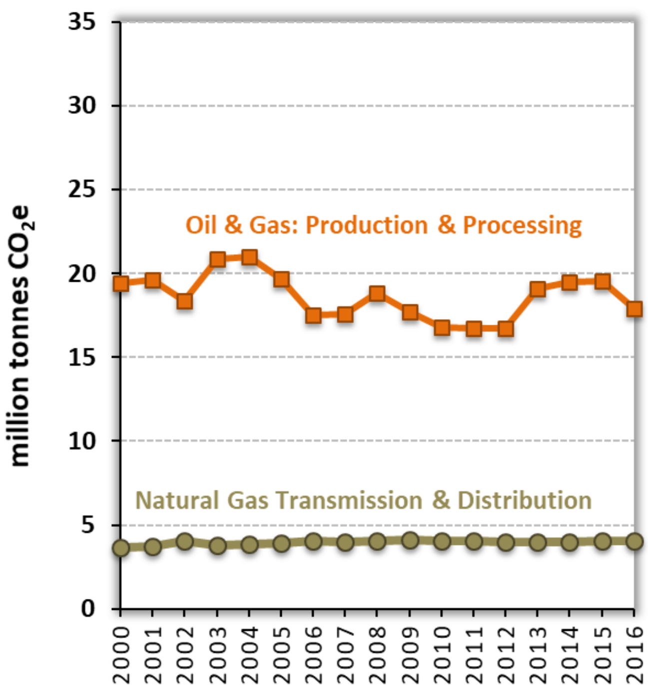


Figure 12a. Oil and Gas Sector Emissions. This figure shows the emissions trends of the oil and gas production and processing sector and the natural gas transmission and distribution sector.

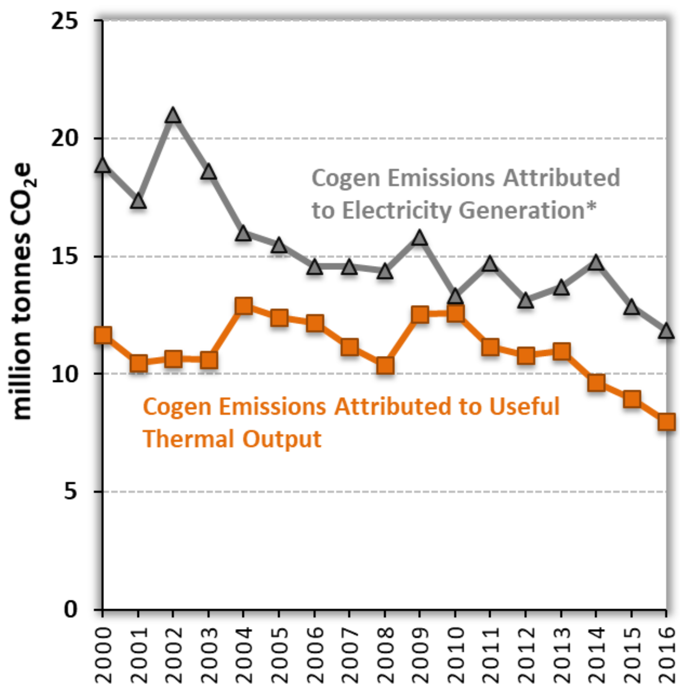


Figure 12b. Industrial Cogeneration Emissions. This figure shows the emissions from cogeneration facilities over time. *Cogeneration emissions attributed to electricity generation are categorized under the electric power sector consistent with the IPCC Guidelines. The electricity emissions are shown in this figure for the purpose of putting cogeneration emissions into context.

Commercial and Residential Fuel Combustion

Greenhouse gas emissions from the commercial and residential sectors are dominated by the combustion of natural gas and other fuels for household use and for commercial businesses, such as space heating, cooking, and hot water or steam generation. Emissions from electricity used for cooling (air-conditioning) and appliance operation are already accounted for in the Electric Power sector. Changes in annual fuel combustion emissions are primarily driven by variability in weather conditions and the need for heating in buildings, as well as increased energy efficiency standards for buildings and appliances. In 2016, emissions increased slightly compared to 2015 due to a rise in residential natural gas use. The heating degree day index,[11] an estimate of the heating energy need in a given year, declined from 2011 through 2014, but increased in the past two years. Natural gas use and residential emissions have followed this trend closely.

While the number of residential housing units grew steadily from 12.2 million units in 2000 to 14.0 million units in 2016,[12] emissions and fuel consumption per housing unit have generally followed a declining trend during this period.[13] Emissions from fuel use by the commercial sector have grown by 10% since 2000; however, during the same period, commercial floor space grew by 23%. As a result, the commercial sector also exhibits a slight decline in fuel use per unit space.

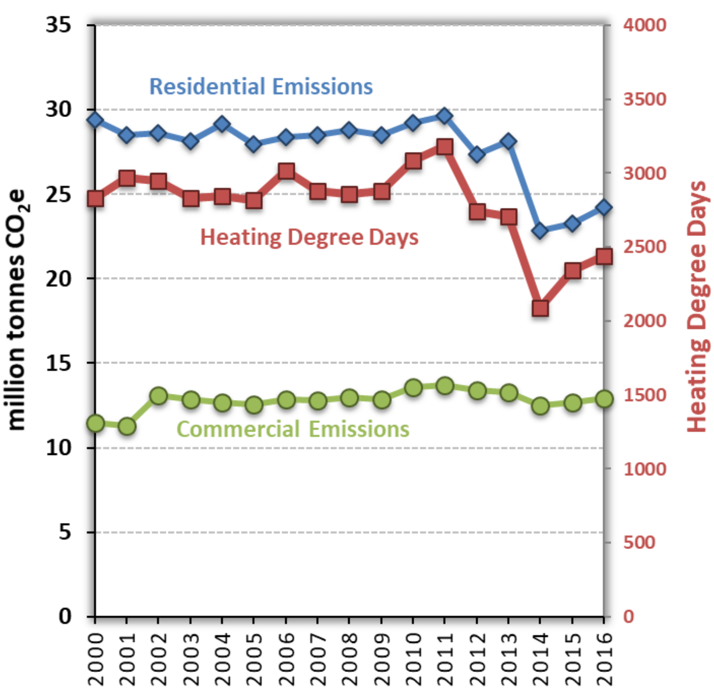


Figure 13. Emissions from Residential and Commercial Sectors. Emissions from the residential and commercial sectors are compared with heating degree days, an estimate of the heating energy need in a given year. Residential and commercial emissions correspond to the left vertical axis. Heating degree days correspond to the right vertical axis.

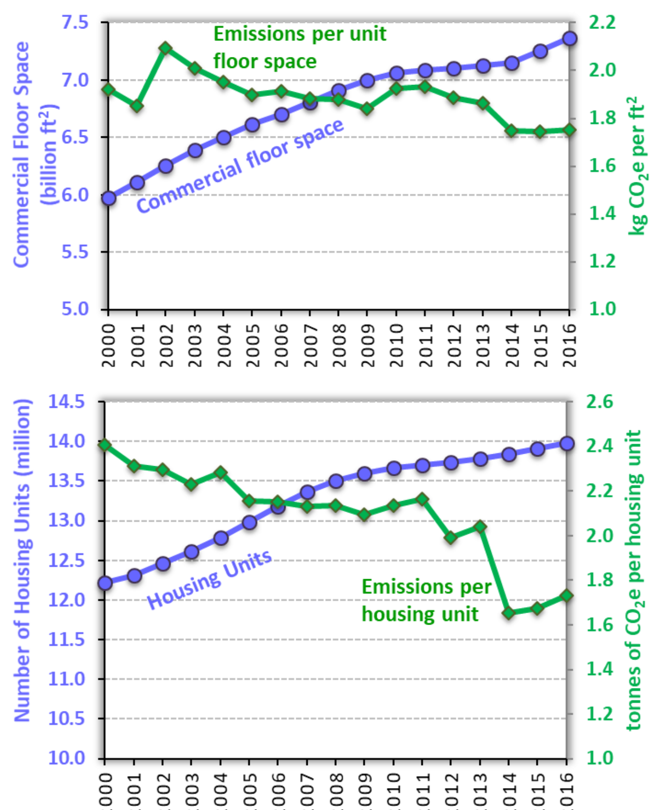


Figure 14. Emissions per Unit Floor Space and Residential Housing Unit. The top panel shows total square feet of commercial floor space and the emissions per square feet of commercial floor space. The bottom panel shows number of residential housing unit and emissions per housing unit. The color of a trend line matches the color of its corresponding vertical axes label.

Agriculture

California's agricultural sector contributed approximately 8% of statewide GHG emissions in 2016, mainly from methane (CH_4) and nitrous oxide (N_2O) sources. Sources include enteric fermentation and manure management from livestock, crop production (fertilizer use, soil preparation and disturbance, and crop residue burning), and fuel combustion associated with agricultural activities (water pumping, cooling or heating buildings, and processing commodities). Livestock accounted for approximately two thirds of the agricultural emissions, primarily CH_4 from enteric fermentation and manure management. Dairies are a major source of greenhouse gas emissions in California, accounting for roughly 60% of agricultural emissions. GHG emissions from dairy manure management and enteric fermentation followed an increasing trend between 2000 and 2007 as the industry expanded, remained relatively constant between 2007 and 2014, but have decreased slightly since then. Emissions in 2016 are 24% higher than 2000 levels.

Emissions from the growing and harvesting of crops have been declining since 2000, but leveled off from 2015 to 2016.[15] This corresponds to a reduction in crop acreage and associated synthetic fertilizer use likely due to prolonged drought events[14] and large-scale changes in irrigation management practices, specifically transitioning from flood irrigation towards sprinkler and drip irrigation. About three quarters of crop emissions are associated with fertilizer and manure use.

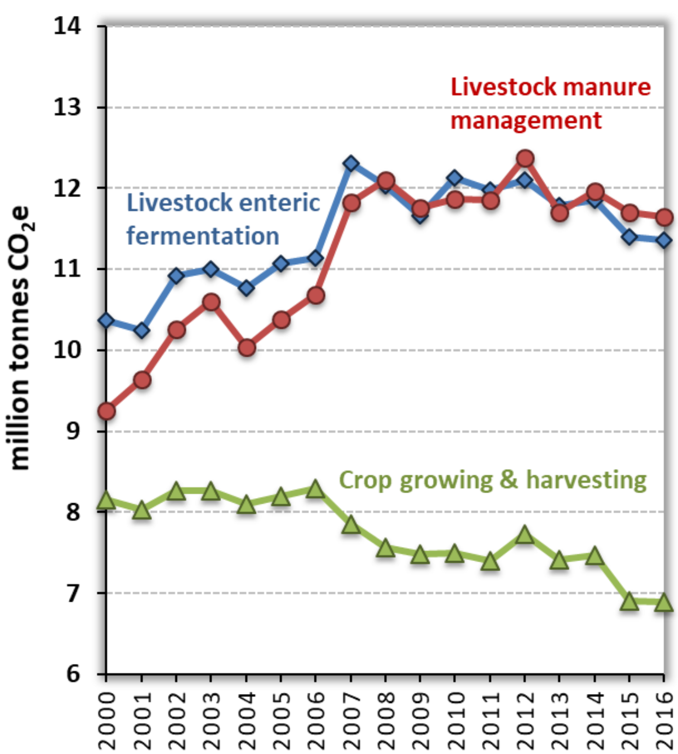
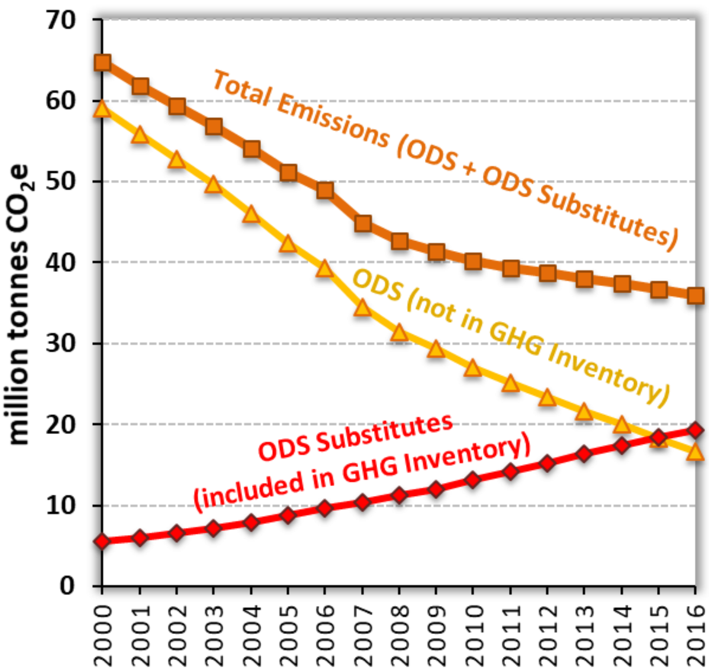


Figure 15. Agricultural Emissions. This figure presents the trends in emissions from livestock manure management and enteric fermentation, as well as emisisons from crop growing and harvesting, which include fertilizer application, soil preparation and distrubances, and crop residue burning.

High Global Warming Potential Gases

In 2016, High Global Warming Potential (high-GWP) gases comprise 4.6% of California's emissions. The GHG inventory tracks High-GWP gas emissions from releases of ozone depleting substance (ODS) substitutes only (ODSs are also high-GWP gases, but are outside the scope of the IPCC accounting framework and AB 32), losses from the electricity transmission and distribution system, and gases that are emitted in the semiconductor manufacturing process. Out of these, 97% of high-GWP gases are attributed to ODS substitutes, which are primarily hydrofluorocarbons (HFCs). ODS substitutes are used in refrigeration and air conditioning equipment, solvent cleaning, foam production, fire retardants, and aerosols. In 2016, refrigeration and air conditioning equipment across all sectors contributed 92% of ODS substitutes emissions. Emissions of ODS substitutes are expected to continue to grow as they replace ODSs banned under the Montreal Protocol.[7] Emissions of ODS have decreased significantly since they began to be phased out in the 1990s, and they dropped below ODS substitutes emissions for the first time in 2015 and continued to drop in 2016. The combined emissions of ODS and ODS substitutes have been steadily decreasing over time.



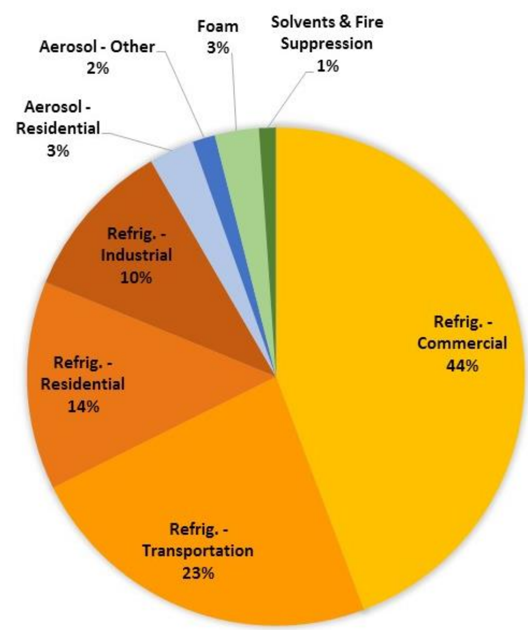


Figure 16a. Trends in ODS and ODS Substitutes Emissions. This figure presents the trends in emissions from ODS Substitutes, ODS, and their sum ("Total Emissions"). ODS Substitutes emissions are specified in IPCC Guidelines and AB 32, and are included in the inventory. ODS are also GHG but are tracked separately outside of the inventory.

Figure 16b. ODS Substitutes Emissions by Category. This figure presents the breakdown of ODS substitutes emissions by product type and sector category in 2016. Refrigerants ("Refrig.") used in various sectors make up the majority of ODS substitutes emissions.

Recycling and Waste

Emissions from the recycling and waste sector include CH_4 and N_2O emissions from landfills and from commercial-scale composting. Emissions from recycling and waste, which comprise 2% of California's GHG inventory, have grown by 20% since 2000. Landfill emissions account for 96% of the emissions in this sector,* while compost production facilities make up a small fraction of emissions. The annual amount of solid waste deposited in California's landfills grew from 39 million tons in 2000 to its peak of 46 million tons in 2005, followed by a declining trend until 2012, then increased again in the past 4 years.[16] Landfill emissions are driven by the total waste-in-place, an accumulation of degradable carbon in the solid waste stream, rather than year-to-year fluctuation in annual deposition of solid waste[17]. The amount of methane emitted to the atmosphere as a fraction of the total amount of methane generated from the decomposition of accumulated waste has gradually declined over time due to improvements in landfill gas controls.

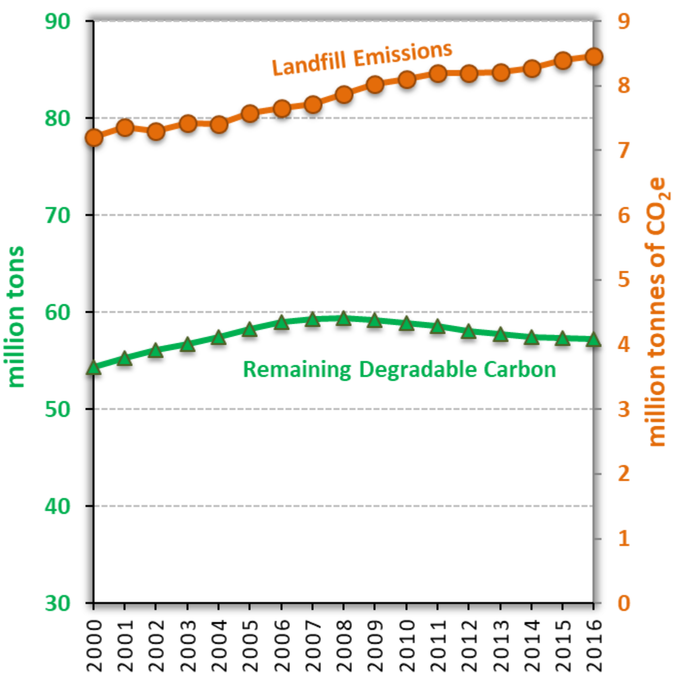


Figure 17. Landfill Methane Generation and Emissions. This figure presents trends in landfill emissions and the amount of degradable carbon remained in the landfill. The latter drives the amount of emissions emitted from the landfill. The color of a trend line matches the color of its corresponding vertical axes label.

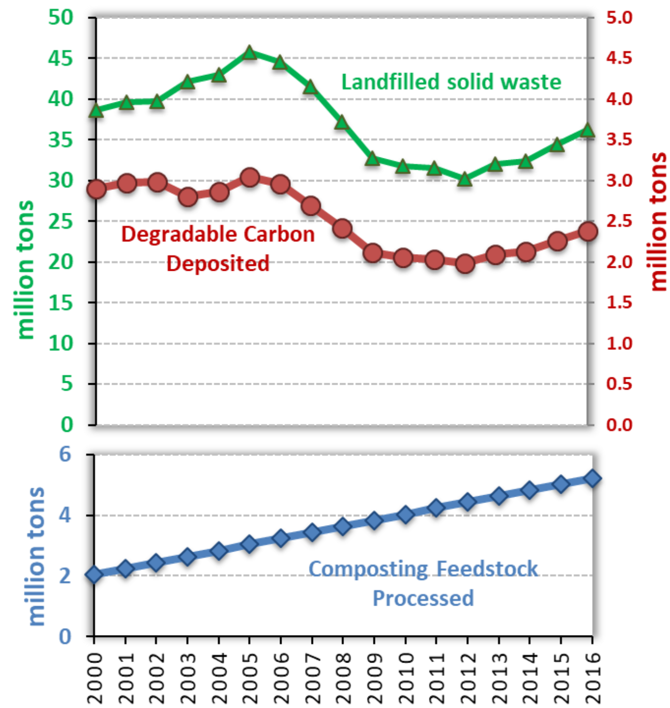


Figure 18. Landfill Waste. The top panel presents the amounts of solid waste deposited into the landfill, and the amount of degradable carbon contained in the solid waste. The color of a trend line matches the color of its corresponding vertical axes label. The bottom panel shows estimated amounts of compost feedstock processed by the state's composting facilities.

* CARB's GHG inventory methodology has been using an assumption of 75 percent methane capture efficiency, consistent with common practice nationally. CARB is currently in the process of evaluating the effects of the Landfill Methane Control Measure. Previous estimates for the measure indicated that it may potentially increase the collection efficiency at regulated landfills to 80-85 percent. However, current landfill collection efficiency estimates vary widely and are highly dependent on a variety of site-specific factors, including landfill size, age, waste composition, local climate, soil type, landfill cover, and gas collection system. Additional California-specific data is necessary to assess the overall collection efficiency at landfills. In recognition of this, CARB and CalRecycle are planning additional research to evaluate gas collection efficiencies at California's landfills. Future inventories will incorporate the results of new research in landfill collection efficiency estimates.

Additional Information

International GHG Inventory Practice of Recalculating Emissions for Previous Years

Consistent with the IPCC GHG inventory guidelines, recalculations are made to incorporate new methods or reflect updated data for all years from 2000 to 2015, to maintain a consistent inventory time series. Therefore, emission estimates for a given calendar year may be different between editions as methods are updated or if the data source agencies revise their data series. For example, in the 2015 inventory (published in 2017), total 2015 emissions were estimated to be 440.4 $MMTCO_2e$. Recalculation for the 2015 inventory revised the 2015 emissions to 441.4 $MMTCO_2e$, reflecting updated methods and information gained since 2017. Analyses of emission trends, including the emissions drop of 12.1 $MMTCO_2e$ between 2015 and 2016, are based on the recalculated numbers in the 2016 inventory (published in 2018). A description of the method updates can be found here: https://www.arb.ca.gov/cc/inventory/pubs/reports/2000_2016/ghg_inventory_00-16_method_update_document.pdf

Global Warming Potential Values

In accordance with the IPCC GHG inventory protocol, California's GHG inventory uses the 100-year GWPs from the IPCC 4th Assessment Report, consistent with the national GHG inventories submitted by the U.S. and other nations to the UNFCCC. However, other CARB programs may use different GWP values. For example, the SLCP strategy uses a 20-year GWP because the SLCP has greater climate impact in the near-term compared to the longer-lived GHGs, such as CO2.

Sources of Data Used in the GHG Emission Inventory

Statewide GHG emissions are calculated using many data sources. The primary data source is from reports submitted to the California Air Resources Board (CARB) through the Regulation for the Mandatory Reporting of GHG Emissions (MRR). MRR requires facilities and entities with more than 10,000 metric tons CO_2e of combustion and process emissions, all facilities belonging to certain industries, and all electric power entities to submit an annual GHG emissions data report directly to CARB. Reports from facilities and entities that emit more than 25,000 metric tons of CO_2e are verified by a CARB-accredited third-party verification body. Emissions data from MRR are aggregated and reallocated to match existing GHG inventory classifications developed to align with IPCC guidelines. More information on MRR emissions reports can be found at: http://www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/ghg-reports.htm

Since MRR data represent a subset of total GHG emissions in the State, CARB also relies on data from other California State and federal agencies to develop an economy-wide GHG inventory for the State of California. These additional sources include, but are not limited to, data from the California Energy Commission, Board of Equalization, Department of Conservation/ Division of Oil, Gas, and Geothermal Resources, Department of Food and Agriculture, and CalRecycle, U.S. Energy Information Administration, and U.S. Environmental Protection Agency. The latest data for this inventory is from 2016. This is because the process for verifying and validating required reporting of emissions from all facilities under the Cap-and-

Trade Program takes more than a year, and additional data undergoes rigorous vetting by other government agencies. All data sources used to develop the GHG Inventory are listed in the GHG Emission Inventory supporting documentation at: http://www.arb.ca.gov/cc/inventory/data/data.htm

The main GHG inventory page is located at: http://www.arb.ca.gov/cc/inventory/inventory.htm

Uncertainties in the Inventory

CARB is committed to continually working to increase the accuracy of the inventory. The uncertainty of emissions estimates in the inventory varies by sector. A majority of the inventory data come from the MRR program. The data reported under MRR is subject to third-party verification, ensuring a high level of accuracy. Other non-MRR sources, mainly non-combustion, biochemical processes, have varying uncertainty depending on the input data and the emission processes.

Natural and Working Lands Emissions Inventory

CARB has also compiled a natural and working lands emissions inventory. Additionally, consistent with the requirements of SB 859 (2016), the natural and working lands inventory will be updated later this year. More information on this inventory can be found here: https://www.arb.ca.gov/cc/inventory/sectors/forest/forest.htm.

Figure References

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