Appendix B-1

Original SRIA Submitted to DOF

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CALIFORNIA AIR RESOURCES BOARD

Innovative Clean Transit Regulation

Standardized Regulatory Impact Assessment (SRIA)

DATE OF RELEASE: April 19, 2018

California Air Resources Board
1001 I Street
Sacramento, California 95814

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A. INTRODUCTION

1. Regulatory History

Adopted in 2000, the Fleet Rule for Transit Agencies (Transit Fleet Rule) was designed to serve as a diesel airborne toxic control measure that requires public transit agencies to use the best available control technologies. Public transit agencies operating urban bus[1] fleets were required to select either the diesel bus path or the alternative-fuel bus path. The diesel bus path required retrofitting existing buses with diesel particulate filters, while agencies utilizing alternative-fuel path had to ensure that 85 percent of urban bus purchases were alternative fueled buses. All agencies within the jurisdiction of South Coast Air Quality Management District (SCAQMD) followed the alternative-fuel path because these agencies were required to purchase alternative fuel buses per SCAQMD Rule 1192.

The Transit Fleet Rule also included a requirement for larger transit agencies with more than 200 urban buses to purchase zero-emission buses (ZEB) starting in 2011 for transit agencies that utilized the diesel path and one year later for transit agencies that utilized the alternative fuel path. Ten transit agencies were subject to the ZEB purchase requirements and together accounted for about 60 percent of the statewide urban bus fleet.

To date, except for the ZEB purchase requirement, all other regulatory provisions have been met and are being implemented. The ZEB purchase requirement of the Transit Fleet Rule includes the following elements:

- Applies to transit agencies with more than 200 urban buses in active service based on 2007 reporting data.
- 15 percent of new bus purchases must be ZEB.
- The purchase requirement starts in 2011 for fleets that continue to operate diesel buses and 2012 for fleets that switch to alternative fuels.
- The ZEB purchase requirement sunsets in 2026.

A 2006 amendment to the Transit Fleet Rule[2] added an advanced demonstration of the ZEB requirement for larger fleets with more than 200 urban buses in active service prior to the ZEB purchase requirement being reinstated. The advanced demonstration required these larger transit agencies to operate a small number of ZEBs in actual transit service, to install maintenance and fueling/charging infrastructure, to train staff, to collect and report data, and to submit a final report. Several agencies worked together on the early demonstration of ZEBs to gain experience with the technology. Further, the 2006 amendments required CARB staff to evaluate the status of technology with the help of demonstration projects and report back to

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[1] Under the Transit Fleet Rule, urban bus means "a passenger-carrying vehicle powered by a heavy heavy-duty diesel engine, or of a type normally powered by a heavy heavy-duty diesel engine, with a load capacity of fifteen (15) or more passengers and intended primarily for intra-city operation, i.e., within the confines of a city or greater metropolitan area".

[2] California Air Resources Board, Rulemaking to consider proposed amendments to the exhaust emission standards for 2007-2009 model-year heavy duty urban bus engines and the Fleet Rule for transit agencies, OAL approved the final rulemaking and filed it with the Secretary of State on September 7, 2006. The regulation became effective on October 7, 2006 (web link: https://www.arb.ca.gov/regact/sctransit/sctransit.htm, last accessed December 2017).

Board by July 2009. Based on that evaluation, the Board would decide to proceed or adjust the ZEB requirement.

In 2009, CARB staff presented ZEB technology evaluations to the Board and concluded that the technology was not commercially ready at that time. The Board, through Resolution 09-49,[3] found, among other things, that technologies had not sufficiently advanced to appropriately assess commercial readiness, that costs of zero-emission buses remained significantly higher than the target prices on which the existing fleet rule had been premised, and that a new focus on greenhouse gas emissions reductions from transit was appropriate. The Board directed staff to prepare proposed amendments to the regulation to delay the ZEB purchase requirement, conduct further research on commercial-readiness metrics, implement the purchase requirement once commercial readiness had been achieved, and report back to the Board by 2012 on progress towards zero emission bus commercialization.

In 2010, CARB staff issued an advisory to memorialize the postponement of the purchase requirement for zero-emission buses.[4] CARB stated it did not intend to enforce the ZEB purchase requirement until after CARB had developed and the Board had approved new purchase requirements.

CARB staff conducted another technology evaluation in 2015[5] and concluded the ZEB technologies were in their early commercialization stage. CARB staff updated the Board in early 2016[6] at a public hearing about the status of ZEB technology, price, and deployment. In that update, staff discussed plans to reinstate ZEB purchases with the Board, including the public process on amending the rule with a broader goal of making a transition to an all ZEB fleet. The proposed ICT regulation is a result of that process.

2. Proposed ICT Regulation

The proposed Innovative Clean Transit (ICT) regulation (proposed ICT regulation) is part of a holistic approach to transform the transportation sector. The ICT amends the existing Fleet Transit Rule and focuses on a long-term goal of transforming the public transit sector to zero emission modes by 2040. The overall strategy includes a combination of incentives and regulatory measures to provide a strong market signal for zero emission technology deployment, utilization of engines certified with oxides of nitrogen (NOx) emissions that are lower than existing engine standards (low NOx engines), the use of renewable fuels, and encouraging innovative transit solutions. The proposed ICT regulation includes flexibility to allow transit fleets to implement zero emission technologies in a way that is consistent with

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[3] California Air Resources Board, Board resolution 09-49 in 2009 (web link: https://www.arb.ca.gov/msprog/bus/zbus/meetings/072309/res0949.pdf, last accessed December 2017).

[4] California Air Resources Board, Mail-Out #MSC 10-04, January 29,2010, available at: https://www.arb.ca.gov/msprog/bus/zbus/mailouts/msc1004.pdf, last accessed March 18, 2018.

[5] California Air Resources Board, Draft technology assessment: medium- and heavy-duty battery electric trucks and buses, released October 2015 (web link: https://www.arb.ca.gov/msprog/tech/techreport/bev_tech_report.pdf , last accessed December 2017).

[6] California Air Resources Board, public meeting to hear an update on the status of the Advanced Clean Transit Rule on February 18, 2016 (web link: https://www.arb.ca.gov/board/ma/2016/ma021816.pdf, last accessed December 2017).

their operation, provides opportunities for transit fleets to utilize incentives, and encourages innovative mobility options.

The proposed ICT regulation aims to accelerate the purchase of ZEBs and also includes requirements for low NOx engines to further reduce NOx emissions starting in 2020 until a full transition to a zero emission transit system is complete. The proposed ICT regulation is identified as a SIP strategy and is designed to help achieve a range of California's air quality and climate protection goals. ZEB requirements in the proposed ICT regulation help meet the goals of the 2016 Zero Emission Vehicle (ZEV) Action Plan and are complementary with AB 32 (Nuñez, Chapter 488, Statutes of 2006), the California Global Warming Solutions Act of 2016, SB 32 (Pavley, Chapter 249, Statutes of 2016), the Clean Energy and Pollution Reduction Act of 2015, SB 350 (De Leon, Chapter 547, Statutes of 2015), and the Sustainable Communities and Climate Protection Act of 2008, SB 375 (Steinberg, Chapter 728, Statutes of 2008).

The proposed ICT regulation applies to all public transit agencies that own, lease, or operate buses with a gross vehicle weight rating (GVWR) greater than 14,000 lbs. The proposed ICT regulation includes the following basic elements, which are detailed in subsequent sections:

(1) A ZEB purchase requirement when bus purchases are made.
(2) A low NOx engine purchase requirement if commercially available when bus purchases with combustion engines are made.
(3) Renewable fuels purchase requirements if commercially available when diesel or natural gas contracts are renewed.
(4) An option to recognize the benefits of innovative mobility programs implemented by transit agencies that use other types of ZEVs like micro transit, vans, or cars that could be used in lieu of purchasing ZEBs.

Under the proposed ICT regulation, starting on January 1, 2020 large transit fleets (with 100 or more buses) will be required to have 25 percent of all new bus purchases be ZEBs and purchase renewable fuels when diesel or natural gas fuel contracts are renewed. All transit agencies that purchase new buses will need to include low NOx engines if the transit agencies are based in areas of California that need NOx reductions and low NOx engines are commercially available for the buses. All transit agencies will also receive credit for implementing new innovative zero emission mobility programs.

Under the proposed ICT regulation, on January 1, 2023, the ZEB purchase requirement increases to 50 percent of all new bus purchases for large transit agencies and expands to medium transit agencies (with 30 to 99 buses). On January 1, 2026, the ZEB purchase requirement increases to 75 percent of new bus purchases for all transit fleets, including small transit agencies. The ZEB purchase requirement increases to 100 percent of new bus purchases on January 1, 2029 for all California transit agencies.

CARB staff continue to take public comments on the proposed ICT regulation and are considering further changes to the proposed amendments based on stakeholder input. Additional changes to the current proposed ICT regulation related to a modified phase-in of the ZEB purchase requirement or improved opportunities for agencies to access funding while fully transforming the transit system to zero emission will continue to be considered. The economic impact of the final rule (including any modifications to the current proposed ICT regulation that occur during the regulatory process) will be fully analyzed in the Economic and Fiscal Impact Statement (STD. 399) submitted to the Department of Finance and Office of Administrative Law with the final regulatory package.

a. ZEB Purchase Requirements

CARB staff is proposing to initially require ZEB purchases for larger transit agencies with deferred compliance for medium and small transit agencies. The purchase requirement applies at time of normal bus purchase and does not require any accelerated bus purchases. The proposed ZEB purchase requirement is shown in Table A1.

Table A1: ZEB Purchase Requirement

Starting January 1	Percent of Bus Purchases	Fleet Size as of 2019
2020	25%	100 or more buses
2023	50%	30 or more buses
2026	75%	All fleets
2029	100%	All fleets

All ZEB purchases made before the date required under the proposed ICT regulation or that exceed the purchase requirement generate a ZEB credit that could be banked and used to show compliance for a future purchase requirement date. This approach counts early ZEB purchases towards future obligations and is intended to be consistent with incentive programs that require early action to be eligible for funding. The ZEB credits also provide transit agencies with more flexibility in how they procure ZEBs and utilize infrastructure.

The proposed ICT regulation also provides bonus ZEB credits for early actors who already operate ZEBs or have taken risks in deploying early technologies, as shown in Table A2. Early acting transit agencies have been pioneers in addressing fuel cell maintenance, electricity rates, charging standards, education, training, developing new technologies, and other issues. These pioneers and their experiences in addressing barriers have provided benefits to the broader market for zero emission heavy-duty vehicles and for other transit fleets. The proposed ICT regulation provides bonus ZEB purchase credits to early actors, which provides additional time and flexibility in expanding ZEB fleets and taking advantage of future technology improvements.

Table A2. Bonus ZEB Purchase Credits

Technology	Placed in Service	Bonus ZEB Credit
FCEB	January 1, 2018 to January 1, 2023	+1
BEB	Before December 31, 2017*	+1
FCEB	Before December 31, 2017*	+2

* Must still be in service as of January 1, 2018

b. Innovative Zero Emission Mobility

The proposed ICT regulation also includes an optional credit mechanism, which would encourage the introduction of innovative zero emission transit services. Credits from other innovative zero emission mobility options would count towards the ZEB purchase requirement if equivalent emissions reductions would be achieved. For purposes of the proposed ICT regulation, innovative zero emission mobility options are defined as non-bus (nor fixed guide way) transportation services provided by the transit agency through lighter ZEVs that are not in the scope of the bus purchase requirements, like service with small vans and shuttles (micro transit), on-demand van or car, or autonomous shuttle services. Other modes, such as buses that are within the scope of the proposed ICT regulation and light rail, heavy rail, and trolley bus services, are considered to be conventional transit modes and are not part of innovative zero emission mobility. Zero emission mobility options directly operated by the transit agency or under contract and used to provide on demand services or for shared transportation, like vanpools, would be eligible for credit. The credit for an innovative zero emission mobility program would be provided in the form of a ZEB purchase credit where 350,000 zero emission passenger miles per year would be deemed to be equivalent to purchasing one ZEB.

c. Low NOx Engine Purchase Requirement

The proposed ICT regulation requires all transit agencies to include the best available low NOx engines when purchases are made if low NOx engines are commercially available for the bus type being purchased. This would not apply to fleets that operate in areas defined as NOx exempt areas. The requirement would begin with purchases made on or after January 1, 2020 or two years after a low NOx engine becomes commercially available for the bus fuel type being purchased. Purchases that are made before they are required would earn a low NOx engine credit that would count towards the low NOx purchase requirement for future bus purchases. The credits could be used to meet a future obligation.

Currently, the Cummins Westport 2016 and later model year 8.9 liter ISL G natural gas engine is certified to the optional 0.02 g/bhp-hr NOx standard which is 90 percent below the current NOx standard. This engine is commercially available at an incremental cost of $10,000. Staff does not believe the proposed ICT regulation would be enough of a driver to encourage other low NOx engines to be certified for transit buses. CARB is also planning on a low NOx engine regulation in 2019 that would apply to all heavy-duty engines potentially beginning with the 2023 or 2024 model year. At this time, it does not appear that many diesel engines will be certified to the optional low NOx standard prior to this anticipated new engine standard.

d. Renewable Fuel Requirements

The proposed ICT regulation also has a provision that requires large transit agencies to purchase renewable fuels when diesel or natural gas contracts are renewed. Medium and small transit agencies would be exempt from this requirement. To date, both renewable natural gas and renewable diesel are commercially available as a result of California's Low Carbon Fuel Standard (LCFS) program and the federal Renewable Fuel Standard program (RFS). Credits from the LCFS and RFS programs are assumed to offset the higher cost of producing renewable fuels in this analysis. While any GHG emissions benefits of using renewable fuels can be directly attributed to the LCFS program and are not counted as additional emissions reductions in the proposed ICT regulation, the proliferation of renewable fuels across transit modes sends a strong market signal that supports California's existing fuel policies.

3. Statement of the Need of the Proposed Regulation

The proposed ICT regulation is identified in the State Implementation Plan (SIP)[7] and 2017 Scoping Plan[8] as a necessary component for California to achieve established near- and long-term air quality and climate mitigation targets. In California, the transportation sector accounts for 39 percent of total GHG emissions[9] and is a major contributor to NOx and particulate matter (PM) emissions. ZEBs achieve the maximum GHG and NOx emissions reductions compared to conventional technologies, are 2 to 5 times much more efficient than conventional technologies and significantly reduce petroleum use. The proposed ICT regulation is one step needed to accelerate the transition to zero emissions in the heavy- duty vehicle sector.

ZEBs and their electric drivetrains have been identified as the beachheads, or technology footholds, of medium- and heavy-duty ZEV technologies.[10] The knowledge and experience gained from installing supporting infrastructure, developing training programs, and gaining operating experience with ZEB technologies is enabling market expansion into other heavy-duty vehicle applications like school buses, delivery trucks, and vocational vehicles, which have similar weight considerations, durability requirements, drivetrains, and components. In addition, the deployment of ZEBs meets goals identified in the 2016 ZEV Action Plan that supports the governor's Executive Order B-16-12[11] and Executive Order B-48-18[12], which calls for 1.5 million ZEVs (including heavy-duty vehicles) in California by 2025 and establishes several milestones on the pathway toward this target. ZEBs achieve the maximum GHG and NOx reductions.

Innovative zero emission mobility options have the potential to enhance rider access to existing transit systems with lighter ZEVs, which provide services not currently offered such as micro transit, on-demand response, or autonomous shuttle services. These options not only provide further emission reductions from the transit systems, but also encourage the introduction of innovative transit services.

The proposed utilization of low NOx engines can also result in near-term NOx reductions while zero emission technologies are being phased in. The proposed requirement to use renewable

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[7] California Air Resources Board, Revised Proposed 2016 State Strategy for the State Implementation Plan, released on March 7, 2017 (web link: https://www.arb.ca.gov/planning/sip/2016sip/rev2016statesip.pdf, last accessed January 2018).

[8] California Air Resources Board, California's 2017 Climate Change Scoping Plan, released in November 2017 (web link: https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf, last accessed January 2018)

[9] California Air Resources Board, California Greenhouse Gas Emission Inventory (web link: https://www.arb.ca.gov/cc/inventory/data/data.htm, last accessed November 2017)

[10] California Air Resources Board, Proposed Fiscal Year 2017-18 Funding Plan for Clean Transportation Incentives, released in November 2017 (web link: https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_1718_funding_plan_final.pdf, last accessed January 2017)

[11] Office of Governor, Executive Order B-16-12 (web link: https://www.gov.ca.gov/news.php?id=17472, last accessed January 2018)

[12] Office of Governor, Executive Order B-48-18 (web link: https://www.gov.ca.gov/2018/01/26/governor-brown-takes-action-to-increase-zero-emission-vehicles-fund-new-climate-investments/, last accessed March 2018)

diesel or RNG sends a clear market signal to support the LCFS program and California's GHG reduction goals but does not change GHG reductions expected from the LCFS program.

4. Major Regulation Determination

The proposed ICT regulation has been determined to be a major regulation because the annual direct cost of compliance exceeds $50 million during the period of analysis, 2020 through 2043.

5. Baseline Information

The economic impact of the proposed ICT regulation is evaluated against a baseline of full compliance with the original regulation developed by CARB in consultation with Department of Finance (Finance). This baseline reflects a situation where the same number of ZEBs are purchased as originally envisioned with the existing regulation, and is referred to as the baseline in this document. In addition, a second baseline was developed, which is referred to as "current conditions," which reflects the Board's direction to delay the purchase requirement and CARB's advisory.

The baseline assumes the regulation has been fully implemented since 2011. The regulation imposes a 15 percent ZEB purchase requirement for large transit agencies starting 2011 for a diesel fleet and 2012 for an alternative fuel fleet as was envisioned with the ZEB purchase requirement in the original Transit Fleet Rule. This ZEB purchase requirement applies to transit agencies with more than 200 urban buses, and does not apply to small transit agencies. This baseline represents a situation that results in the same number of ZEBs in the fleet as if the 2009 Board Resolution to withhold the ZEB purchase requirement had not been issued. Therefore, this baseline scenario would have the same emissions benefits in 2020 as if the Transit Fleet Regulation had been fully implemented as originally envisioned.

In the baseline, CARB estimates that full compliance with the 15 percent ZEB purchase requirement in the Transit Fleet Rule would result in a ZEB fleet of 600 buses by 2020. From 2020 to 2026, the 15 percent ZEB purchase requirement continues to be met, and after 2026, the existing Transit Fleet rule sunsets, and ZEB purchases would no longer be required. No ZEB purchases are assumed after 2026 as there would be no regulation in force to require continued purchase.

Under "current conditions," the Transit Fleet Rule ZEB purchase requirement is stayed by the 2009 Board Resolution and no ZEB purchases are made. This scenario assumes the Board Resolution that stayed implementation of the ZEB purchase requirements remains in effect. There have been some recent ZEB purchases by large fleets, but in an effort to be conservative, this analysis assumes there are no ZEBs in the fleet in 2020, thus all costs to purchase ZEBs are attributed to the proposed ICT regulation.

6. Public Outreach and Input

For the proposed ICT regulation, CARB has conducted a multi-level public process. Staff created a technical workgroup that comprises interested stakeholders including transit agencies, environmental groups, utilities, technology providers, and fuel providers. In addition, CARB created a transit subcommittee with two subgroups to discuss transit specific issues: one subgroup focused on cost, the second on the regulatory concept. In addition to group meetings, CARB staff also conducted individual meetings with over ten transit agencies. Staff also had frequent discussions with ZEB technology providers and non-governmental environmental organizations.

Since 2015, CARB has also held two workshops, five workgroup meetings, four subcommittee meetings, various subgroup meetings, one LCFS overview meeting, three transportation electrification meetings, and one technology symposium to provide information to the public and solicit feedback. CARB posted information regarding these events and any associated materials on the ICT website[13] and distributed notice of these meetings through a public list serve that includes over 5,300 recipients. At the meetings, which were available by webcast and teleconference, CARB solicited stakeholder feedback on the proposed ICT regulation and the overall regulatory process.[14]

In addition to continued efforts to solicit feedback from stakeholders about ICT regulation, CARB has devoted two meetings to the discussion of regulatory alternatives, including an October 4, 2016 workgroup meeting[15] to discuss implementation strategies and methods to meet State goals and an October 26, 2916 transit subcommittee meeting[16] to discuss alternatives, specifically performance-based approaches.

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[13] California Air Resources Board, Meeting notice of public workshop to discuss the proposed innovative clean transit rule (web link: https://www.arb.ca.gov/msprog/mailouts/msc1719/msc1719.pdf, last accessed January 2018).

[14] California Air Resources Board, Innovative Clean Transit meetings and workshops (https://arb.ca.gov/msprog/ict/meeting.htm, last accessed January 2018).

[15] California Air Resources Board, Meeting summary of ACT workgroup meeting on October 4, 2016 (web link: https://arb.ca.gov/msprog/ict/meeting/mt161004/161004meetingsummary.pdf, last accessed January 2018).

[16] California Air Resources Board, Meeting summary of Transit Agency Subcommittee meeting on October 26, 2016 (web link: https://www.arb.ca.gov/msprog/bus/tas_summary_10_26.pdf, last accessed January 2018).

B. BENEFITS

1. Benefits to California Businesses

a. Transit Agencies

The proposed ICT regulation impacts transit agencies in California, who will see several direct benefits as a result of the rule. The proposed ICT regulation could result in lower fuel costs for transit agencies depending on ZEB purchases and fuel choice. Fuel cost saving will depend on the existing fuel type, bus fuel economy, and electricity costs, which are discussed in section C.1.e. In addition, transit agencies will benefit from reduced maintenance costs, as expected maintenance costs for BEBs are lower than those of conventional buses. The lower cost is due primarily to the fact that BEBs have simpler mechanical systems and fewer moving parts compared to conventional buses (see section C.1.b. for maintenance cost discussion).

Transit agencies that opt into the LCFS program will also benefit from the proposed ICT regulation as they can generate credits through operating ZEBs. Transit agencies that use CNG can also generate a small number of credits for dispensing CNG. For renewable natural gas and other alternative fuels the fuel producer has the first right to generate credits, see section C.1.b. for LCFS credit discussion.

b. Other California Businesses

In addition to transit agencies, the proposed ICT regulation may result in benefits to ZEB manufacturing industry, zero emissions bus component suppliers, electrical vehicle supply equipment (EVSE) suppliers and installers, and hydrogen fuel station suppliers. There are several ZEB manufacturers with plants located in California, including BYD Motors Inc., Complete Coach Works, Ebus, ElDorado National-California, Gillig, Greenpower[17], and Proterra. Due to higher demand for ZEBs from the proposed ICT regulation, production of ZEBs in California would likely increase potentially leading to increases in manufacturing and related jobs throughout the state. The increase in the production and usage of ZEBs could also benefit various businesses related to the ZEB component supply chain, including those involved in battery, fuel cell, and electric drivetrain businesses. Some of these are in California.

The proposed ICT regulation may also benefit ESVE suppliers who may see an increase in charging equipment installation as a result of increased BEB purchases. Increased installation of charging infrastructure will benefit the ESVE suppliers, equipment installers, and electricians. All of the installations will be in California, and some of the EVSE equipment may be manufactured in California. Increased purchase of ZEBs under the proposed ICT regulation could also benefit various businesses related to installing hydrogen fueling stations and supplying hydrogen for fuel cell buses. All of these will likely be in California.

[17] The Greenpower Porterville manufacturing plant is expected to begin production in 2018.

2. Benefits to Small Businesses

Electricians, construction companies, including infrastructure installers, some bus manufacturers, fuel cell and electric drivetrain parts and components businesses may fall into the small business category. The benefits to ZEB manufacturers and other related business discussed above also apply to small businesses.

3. Benefits to Individuals

The proposed ICT regulation will benefit California residents mainly from reductions in GHG emissions and from improvements in California air quality. The emissions estimates of the proposed ICT regulation, the baseline, and the "current conditions" are based on CARB staff analysis relying on the emissions inventory of EMFAC2017.[18,19] The proposed ICT regulation is expected to result in $PM_{2.5}$, NOx, and GHG emissions reductions relative to the baseline after 2023 and in all years relative to the "current conditions". GHG and $PM_{2.5}$ emissions reductions benefits are the direct results of replacing conventional buses (that have internal combustion engines) with ZEBs. NOx emissions reductions of the proposed ICT regulation are anticipated due to increased ZEB and low NOx engines purchases.

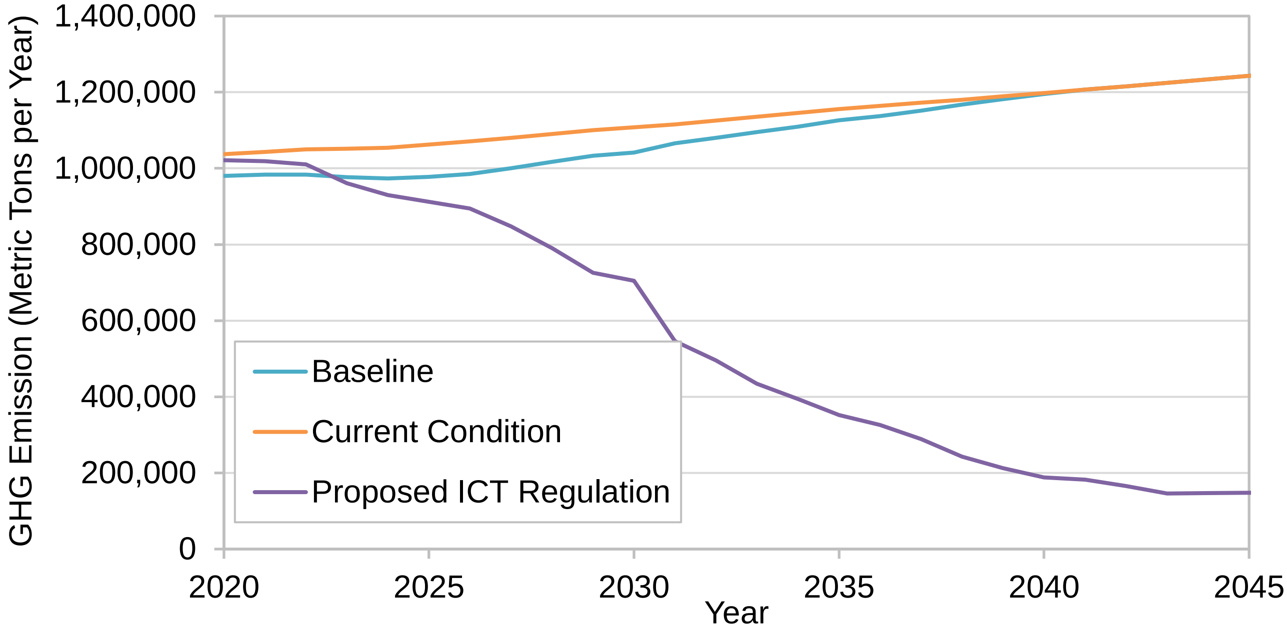
a. GHG Emissions Benefits

Figure B1 summarizes the estimated well-to-wheel (WTW) GHG emissions reductions under the two baselines and proposed ICT regulation. Staff expects the proposed ICT regulation to reduce GHG emissions by an estimated 12.1 Million Metric Tons (MMT) carbon dioxide equivalent (CO_2e) relative to the baseline and 13.2 MMT CO_2e relative to the "current conditions," from 2020 to 2043.

[18] California Air Resources Board, EMFAC2017 Web Database (v1.0.2) (web link: https://www.arb.ca.gov/emfac/2017/, last accessed in March 2018)

[19] California Air Resources Board, EMFAC2017: An update to California On-road Mobile Source Emission Inventory (web link: https://www.arb.ca.gov/msei/downloads/emfac2017_workshop_11_09_2017_final.pdf, last accessed in March 2018)

Figure B1: Estimated GHG Emissions under the Baseline, Current Conditions, and the Proposed ICT Regulation



The benefit of these GHG reductions can be estimated using the Social Cost of Carbon (SC-CO_2), which provides a dollar valuation of the damages caused by one ton of carbon pollution and represents the monetary benefit today of reducing carbon emissions in the future.

In this analysis, CARB utilizes the current the Interagency Working Group (IWG) supported SC-CO_2 values to consider the social costs of actions to reduce GHG emissions. This is consistent with the approach presented in the Revised 2017 Climate Change Scoping Plan [20] and is in line with Executive Orders including 12866 and the OMB Circular A-4 of September 17, 2003, and reflects the best available science in the estimation of the socio-economic impacts of carbon.[21]

The IWG describes the social costs of carbon as follows:

> *The social cost of carbon (SC-CO_2) for a given year is an estimate, in dollars, of the present discounted value of the future damage caused by a 1-metric ton increase in carbon dioxide (CO_2) emissions into the atmosphere in that year, or equivalently, the benefits of reducing CO_2 emissions by the same amount in that year. The SC-CO_2 is intended to provide a comprehensive measure of the net damages – that is, the monetized value of the net impacts- from global climate change that result from an additional ton of CO_2.*

[20] CARB, 2017. The Revised 2017 Climate Change Scoping Plan. https://www.arb.ca.gov/cc/scopingplan/revised2017spu.pdf. Accessed Oct. 30th 2017.
[21] OMB circular A-4 is available at: https://www.transportation.gov/sites/dot.gov/files/docs/OMB%20Circular%20No.%20A-4.pdf.

These damages include, but are not limited to, changes in net agricultural productivity, energy use, human health, property damage from increased flood risk, as well as nonmarket damages, such as the services that natural ecosystems provide to society. Many of these damages from CO_2 emissions today will affect economic outcomes throughout the next several centuries.[22]

The SC-CO_2 is year specific, and is highly sensitive to the discount rate used to discount the value of the damages in the future due to CO_2. The SC-CO_2 increases over time as systems become more stressed from the aggregate impacts of climate change and future emissions cause incrementally larger damages. A higher discount rate decreases the value today of future environmental damages. This analysis uses the IWG standardized range of discount rates from 2.5 to 5 percent to represent varying valuation of future damages. Table B1 presents the range of IWG SC-CO_2 values used in California's regulatory assessments.[23]

Table B1: SC-CO_2, 2015-2030 (in 2007$ per Metric Ton)

Year	5 Percent Discount Rate	3 Percent Discount Rate	2.5 Percent Discount Rate
2015	$11	$36	$56
2020	$12	$42	$62
2025	$14	$46	$68
2030	$16	$50	$73
2035	$18	$55	$78
2040	$21	$60	$84
2045	$23	$64	$89
2050	$26	$69	$95

Source: See Footnote 23.

As there is no Social Cost of CO_2e, there is not a straightforward metric to estimate the benefits of the proposed ICT regulation. If all GHG reductions under the proposed ICT regulation are assumed to be carbon reductions, the SC-CO2 from 2020 to 2043 is the sum of the annual WTW GHG emissions reductions multiplied by the SC-CO2 in each year. The estimated benefits from the proposed ICT regulation, from 2020 to 2043, would range from approximately $270 million to $1.1 billion (in 2016$) relative to the baseline. The estimated benefits of the proposed ICT regulation from 2020 to 2043 are estimated to range from $288 million to $1.2 billion (in 2016$) relative to the "current conditions."[24]

It is important to note that the SC-CO_2, while intended to be a comprehensive estimate of the damage caused by carbon globally, does not represent the cumulative cost of climate change and air pollution to society. There are additional costs to society outside of the SC-CO_2, including costs associated with changes in co-pollutants, the social cost of other GHGs

[22] National Academies, 2017. *Valuing Climate Damages: Updating Estimation of Carbon Dioxide*. http://www.nap.edu/24651. Accessed Nov 14th 2017.
[23] The SC-CO_2 values are of July 2015 and are available at: https://obamawhitehouse.archives.gov/sites/default/files/omb/inforeg/scc-tsd-final-july-2015.pdf
[24] Staff adjusted the social cost of CO2 in 2007 dollars to 2016 dollars by using the Consumer Price Index (CPI). The CPI report is available at http://www.bls.gov/cpi/tables.htm.

including methane and nitrous oxide, and costs that cannot be included due to modeling and data limitations. The Intergovernmental Panel on Climate Change (IPCC) has stated that the IWG SC-CO_2 estimates are likely underestimated due to the omission of significant impacts that cannot be accurately monetized, including important physical, ecological, and economic impacts.

b. Criteria Pollutant Emissions Benefits

The NO_X and $PM_{2.5}$ emissions impact of the proposed ICT regulation, relative to the baseline and the "current conditions," are presented in Figures B2 and B3 and are shown in tons per day (tpd). Relative to the baseline, from 2020 to 2043 the proposed ICT regulation is estimated to result in a 4,159 ton reduction in NOx and a 25 ton reduction in $PM_{2.5}$. Relative to the "current conditions," the proposed ICT regulation is estimated to result in 4,477 ton reduction in NOx and a 27 ton reduction in $PM_{2.5}$ from 2020 through 2043.

Figure B2: Estimated NOx Emissions under the Baseline, Current Conditions, and the Proposed ICT Regulation

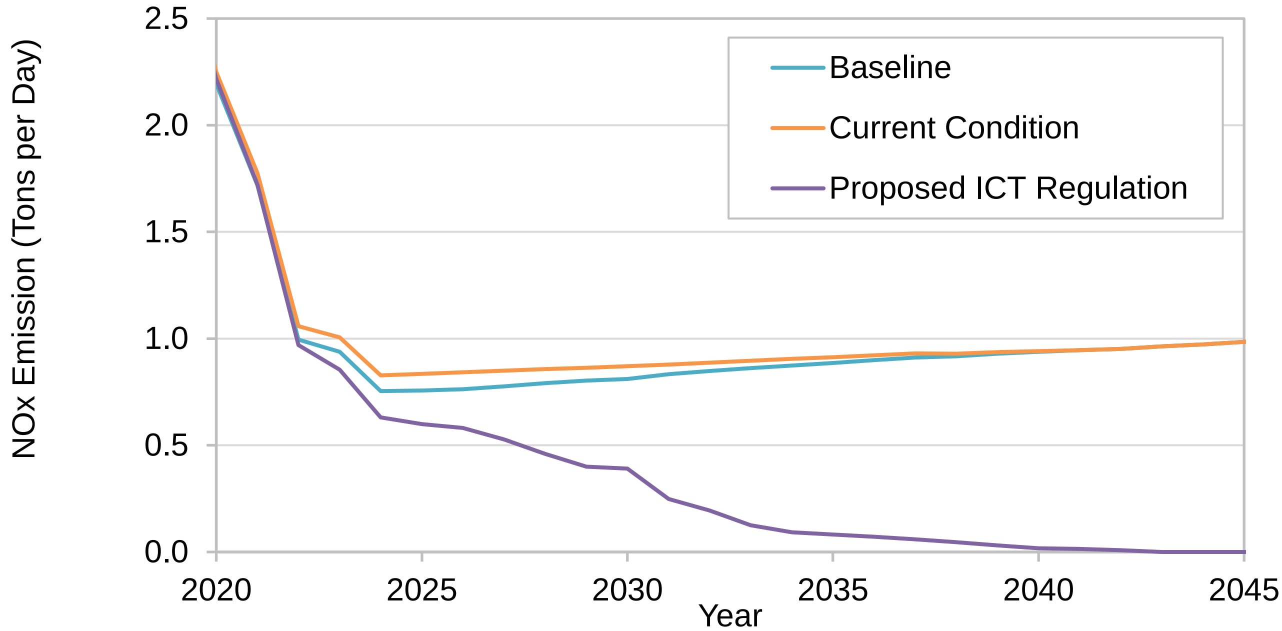
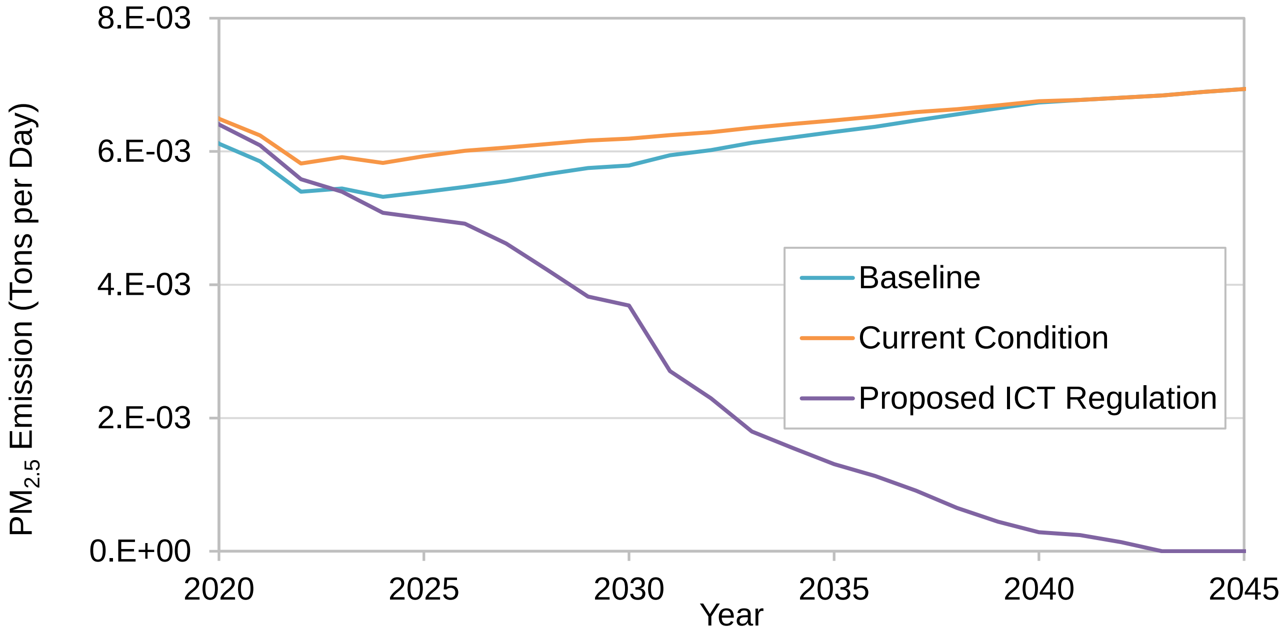


Figure B3: Estimated $PM_{2.5}$ Emissions under the Baseline, Current Conditions, and the Proposed ICT Regulation



Over time, the proposed ICT regulation results in lower GHG, NOx, and $PM_{2.5}$ emissions relative to the baseline and the "current conditions." Compared with the baseline, the proposed ICT regulation achieves slightly fewer emissions reductions from 2020 to 2023, but achieves substantially more emissions reductions after 2023 for WTW GHG and NOx, and $PM_{2.5}$. Relative to the "current conditions," the proposed ICT regulation is anticipated to result in greater emissions reductions every year, from 2020 through 2043.

c. Health Benefits

The proposed ICT regulation reduces NOx and $PM_{2.5}$ emissions, resulting in health benefits for individuals in California. The value of these health benefits are due to fewer instances of premature mortality, fewer hospital and emergency room visits, and fewer lost days of work. As part of setting the National Ambient Air Quality Standard for PM, the U.S. EPA quantifies the health risk from exposure to PM[25] and CARB relies on the same health studies for this evaluation. The evaluation method used in this analysis is the same as the one used for CARB proposed Low Carbon Fuel Standard 2018 Amendments, and Heavy-Duty Vehicle Inspection Program and Periodic Smoke Inspection Program. A detailed summary of the health modeling methodology is included in Appendix A of the Proposed Regulatory

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[25] U.S. EPA, Quantitative Health Risk Assessment for Particulate Matter (Final Report, released June 2010) (web link: https://www3.epa.gov/ttn/naaqs/standards/pm/data/PM_RA_FINAL_June_2010.pdf, last accessed February 2018)

Amendments to the Heavy-Duty Vehicle Inspection Program and Periodic Smoke Inspection Program SRIA.[26]

The largest estimated health benefits correspond to regions in California with the most transit buses such as South Coast Air Basin and San Francisco Bay Air Basin, with minor health benefits distributed among other regions. Tables B2 and B3 show the estimated avoided mortality and morbidity incident because of the proposed ICT regulation for 2020 through 2043 by California air basin, relative to the baseline and the "current conditions," respectively. Only the regions with values of 1 or higher are shown, and regions with zero or insignificant impacts are not shown. Values in parenthesis represent the 95 percent confidence intervals of the central estimate. As detailed in the previous section, the proposed ICT regulation is estimated to reduce overall emissions of $PM_{2.5}$ and NOx in most years, and lead to net reduction in adverse health outcomes statewide, relative to the baseline and the "current conditions."

The proposed ICT regulation may decrease the occupational exposure to air pollution of California bus operators, passengers, and employees who work around bus traffic. CARB staff cannot quantify the potential effect on occupational exposure due to lack of data on the typical occupational exposure for these types of workers.

Table B2: Incremental Regional and Statewide Avoided Mortality and Morbidity Incidents from 2020 to 2043 under the Proposed ICT Regulation (Relative to the Baseline)*

Region	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits
Sacramento Valley	2 (2-2)	0 (0-1)	1 (0-1)
San Diego County	2 (2-3)	0 (0-1)	1 (1-1)
San Francisco Bay	6 (4-7)	1 (0-2)	2 (2-3)
San Joaquin Valley	2 (1-2)	0 (0-1)	1 (0-1)
South Coast	22 (17-26)	3 (0-7)	9 (6-13)
Statewide	**35 (27-42)**	**5 (1-12)**	**15 (9-20)**

* Values in parenthesis represent the 95% confidence interval. Totals may not add due to rounding.

[26] California Air Resources Board, Proposed Regulatory Amendments to the Heavy-Duty Vehicle Inspection Program and Periodic Smoke Inspection Program, Standardized Regulatory Impact Assessment (SRIA), released August 10, 2017 (web link: http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/documents/CARB%20HDVIP%20PSIP%20SRIA.pdf, last assessed February 2018)

Table B3: Incremental Regional and Statewide Avoided Mortality and Morbidity Incidents from 2020 to 2043 under the Proposed ICT Regulation (Relative to the Current Conditions)*

Region	Avoided Premature Deaths	Avoided Hospitalizations	Avoided ER Visits
Sacramento Valley	2 (2-2)	0 (0-1)	1 (0-1)
San Diego County	3 (2-3)	0 (0-1)	1 (1-1)
San Francisco Bay	6 (5-7)	1 (0-2)	3 (2-4)
San Joaquin Valley	2 (1-2)	0 (0-1)	1 (0-1)
South Coast*	24 (19-29)	3 (0-8)	10 (7-14)
Statewide	**37 (29-46)**	**6 (1-13)**	**16 (10-22)**

* Values in parenthesis represent the 95% confidence interval. Totals may not add due to rounding.

In accordance with U.S. EPA practice, health outcomes are monetized by multiplying each incident by a standard value derived from economic studies.[27] The value per incident is shown in Table B4. The value for avoided premature mortality is based on willingness to pay,[28] which is a statistical construct based on the aggregated dollar amount that a large group of people would be willing to pay for a reduction in their individual risks of dying in a year. While the cost-savings associated with premature mortality is important to account for in the analysis, the valuation of avoided premature mortality does not correspond to changes in expenditures, and is not included in the macroeconomic modeling (Section E). As avoided hospitalizations and ER visits correspond to reductions in household expenditures on health care, these values are included in the macroeconomic modeling.

Unlike mortality valuation, the cost-savings for avoided hospitalizations and ER visits are based on a combination of typical costs associated with hospitalization and the willingness of surveyed individuals to pay to avoid adverse outcomes that occur when hospitalized. These include hospital charges, post-hospitalization medical care, out-of-pocket expenses, and lost earnings or both individuals and family members, lost recreation value, and lost household production (e.g., valuation of time-losses from inability to maintain the household or provide childcare).[29] These monetized benefits from avoided hospitalizations and ER visits are included in macroeconomic modeling (Section E).

[27] U.S. EPA, Appendix B: Mortality Risk Valuation Estimates, Guidelines for Preparing Economic Analyses (240-R-10-001, released December 2010) (web link: http://yosemite.epa.gov/ee/epa/eerm.nsf/vwAN/EE-0568-22.pdf/$file/EE-0568-22.pdf, last accessed February 2018)

[28] U.S. EPA, An SAB Report on EPA's White Paper Valuing the Benefits of Fatal Cancer Risk Reduction (EPA-SAB-EEAC-00-013, released July 27, 2000) (web link: https://yosemite.epa.gov/sab%5CSABPRODUCT.NSF/41334524148BCCD6852571A700516498/$File/eeacf013.pdf, last accessed February 2018)

[29] Chestnut, L. G., Thayer, M. A., Lazo, J. K. and Van Den Eeden, S. K. (2006), The Economic Value Of Preventing Respiratory And Cardiovascular Hospitalizations, *Contemporary Economic Policy*, 24: 127– 143. doi: 10.1093/cep/byj007

Table B4: Valuation per Incident for Avoided Health Outcomes

Outcome	Units	2016$
Premature mortality	avoided death	$8,793,190
Hospitalizations for cardiovascular illness	avoided hospitalization	$52,826
Hospitalizations for respiratory illness	avoided hospitalization	$46,078
Emergency room visits for respiratory illness	avoided ER visit	$756
Emergency room visits for asthma	avoided ER visit	$756

The total statewide valuation because of avoided health outcomes for the proposed ICT regulation is summarized in Table B5. The spatial distribution of these cost-savings follows the distribution of emission reductions and avoided health outcomes, therefore most cost savings will occur in the South Coast and San Francisco Bay air basins.

Table B5: Estimated Incremental Valuation from Avoided Health Outcomes under the Proposed ICT Regulation from 2020 through 2043

Outcome	Relative to the Baseline		Relative to the Current Conditions	
	Avoided Incidents	Statewide Health Valuation (2016M$)	Avoided Incidents	Statewide Health Valuation (2016M$)
Avoided premature deaths	35	$303,365,048	37	$328,131,757
Avoided hospitalization	5	$256,159	6	$278,579
Avoided ER Visits	15	$11,101	16	$12,090
Total		**$303,632,308**		**$328,422,426**

d. Other Benefits to Individuals

In addition to benefits from emissions reductions, ZEBs can also provide a smoother and quieter ride when compared to conventional buses and offer a more pleasant, smoother and quieter ride to passengers than diesel and CNG and may reduce noise levels in communities.

C. DIRECT COSTS

1. Direct Cost Inputs

The estimated direct costs of the proposed ICT regulation, the baseline, and the "current conditions" in this analysis include upfront capital costs for bus purchases and cleaner engines, charging or fueling infrastructure, as well as maintenance bay upgrades. The direct cost also includes annual operational costs for bus and infrastructure maintenance and fuel consumption. Compared to conventional buses, ZEBs generally have higher upfront capital cost but lower operational cost that result in annual savings when compared to conventional buses. The assumptions underlying the direct costs are detailed in the following sections.

a. Upfront Capital Cost

Transit agencies make the initial investment in buses and charging or fueling infrastructure and pay upfront capital cost. The total capital cost of buses and infrastructure is based on the number of buses purchased and the unit cost per bus or infrastructure element. These two factors are discussed in details in the following sections.

Bus Population

In this analysis, the current estimates of bus population are based on the Natural Transit Database (NTD).[30] Most transit agencies report to NTD about their vehicle fleet by mode[31] and vehicle type.[32] Urban agencies report vehicles by fuel type, but rural agencies do not. Rural reporters usually own 100 or fewer buses, as shown in the NTD. The reported fuel types for buses in urban agencies include:

- Compressed natural gas (CNG),
- Liquefied natural gas (LNG),
- Liquefied petroleum gas (LPG),
- Diesel fuel,
- Hybrid diesel,
- Gasoline,
- Hybrid gasoline,
- Battery electric, and
- Hydrogen cell.

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[30] National Transit Database (NTD), NTD Data Reports (Annual Database Revenue Vehicle Inventory) (web link: https://www.transit.dot.gov/ntd/ntd-data, last accessed January 2018)

[31] According to NTD Glossary, "Mode" is defined as "a system for carrying transit passengers described by specific right-of-way (ROW), technology and operational features." NTD recognizes eight non-rail modes, including bus (MB) and commuter bus (CB) (web link: https://www.transit.dot.gov/ntd/national-transit-database-ntd-glossary, last accessed January 2018).

[32] According to NTD Glossary, "Vehicle Type" is defined as "The form of passenger conveyance used for revenue operations" (web link: https://www.transit.dot.gov/ntd/national-transit-database-ntd-glossary, last accessed January 2018).

For ease of calculation in this analysis, the fuel types with similar powertrains are regrouped into four categories:

- CNG (including CNG, LNG, and LPG),
- Diesel fuel (including diesel fuel and gasoline fuel),
- Hybrid diesel (including hybrid diesel and hybrid gasoline), and
- ZEBs (including battery electric and hydrogen cell).

Without fuel type data for rural agencies, the bus distributions among fuel types in this analysis are assumed to be the same for both rural and urban agencies. Table C1 shows the total bus population by agency size and fuel type based on NTD 2016.

Table C1: Statewide Bus Population by Agency Size and Fuel Type (NTD 2016)

Reporting Type	Agency Group	Diesel	Diesel Hybrid	CNG	ZEBs[a]	Total
Urban	Large (>=100)	4300	357	5640	62	10359
	Medium (>=30 & <100)	1392	149	749	5	2295
	Small (<30)	317	3	452	2	774
Subtotal		*6009*	*509*	*6841*	*69*	*13428*
Rural	Large (>=100)	0	0	0	0	0
	Medium (>=30 & <100)	219[b]	23[b]	118[b]	1[b]	361
	Small (<30)	165[b]	2[b]	235[b]	1[b]	403
Subtotal		384[b]	25[b]	353[b]	2[b]	*764*
Total		**6393[b]**	**534[b]**	**7194[b]**	**71[b]**	**14192**

[a] This ZEB population is based on NTD 2016; CARB's ZEB maps provides more up-to-date information (web link: https://arb.ca.gov/msprog/ict/zbusmap.pdf, last accessed January, 2018)

To analyze fuel cost, the bus population is further grouped and allocated to different utility areas. For this analysis, all the diesel and diesel hybrid buses are assumed to be operated in Pacific Gas and Electric Company (PG&E) area. For CNG buses, those operating in San Diego Metropolitan Transit System (SD MTS) and North County Transit District (NCTD) are assigned to San Diego Gas and Electric (SDG&E) territory, all CNG buses operating within the City of Los Angeles Department of Transportation (LADOT) and 67 percent of CNG buses within the Los Angeles County Metropolitan Transportation Authority (LA Metro) are assigned to the Los Angeles Department of Water and Power (LADWP) area (the LA Metro fleet is the largest in the State and spans two utility service areas). The remaining CNG buses are assumed to operate in the Southern California Edison (SCE) area.

Bus population projections and turnover are based on a 14-year average bus lifetime, which is consistent with the existing practices of most transit fleets. While it is possible that future bus population may vary with human population, the status of economy, regional transportation planning, and other factors, the cost analysis does not reflect growth in the bus population to simplify the analysis and the relative change in costs are proportionally the same.

The Federal Transit Administration's (FTA's) service-life policy for transit buses and vans establishes the minimum number of years (or miles) that transit vehicles purchased with federal funds must be in service before they can be retired without financial penalty. The minimum service-life requirements differ by vehicle size and range from 4 to 12 years.[33] Typically transit agencies keep buses for additional 2 years beyond the minimum requirements. Most industry experts commonly refer to a standard, 40-foot bus as a "12-year" bus reflecting its minimum useful life, and many transit authorities have adopted 12 years as their retirement policy for this vehicle type. While the statewide bus fleet is comprised of a variety of bus types and sizes, with diverse minimum service-lives, in this analysis, all buses are treated as standard buses with a 12-year minimum requirement, plus two additional years, which results in a 14-year lifetime. This is the consensus approach proposed by transit agencies.

Since each transit agency has different purchase patterns and cycles, it is difficult to estimate the number of buses to be replaced and purchased each year by a specific agency. However, on a statewide basis, CARB staff assume a uniform bus age distribution where on average 7.1 percent (=1/14) of bus population will be replaced by new ones in each year.

The ZEB phase-in schedule, or the percentage of ZEBs in each new purchase, determines the number of ZEBs that enter bus fleets annually. Table C2 shows ZEB phase-in schedules for the baseline, the "current conditions," and proposed ICT regulation. The corresponding projections of ZEBs within the fleet are presented in Figure C1. Under the baseline, ZEBs would enter the fleet with the 15 percent ZEB purchase requirement for large transit agency beginning in 2011 or 2012 until 2026 when the existing rule sunset and no ZEBs would be purchased. The number of ZEBs peak at around 920 in 2026. Afterwards, ZEBs gradually phase-out because of the sunset of the existing rule. Under the proposed ICT regulation, 25 percent of ZEBs start to be purchased by large transit agencies beginning in 2020 and the ZEB fleet exceeds the baseline by 2023. Under the proposed ICT regulation, the number of ZEBs in the fleet will be around 2,000 (14 percent) in 2025, 6,200 (44 percent) in 2030, 10,900 (77 percent) in 2035, and eventually 100 percent of the bus fleet after 2042.

[33] Federal Transit Administration, Useful Life of Transit Buses and Vans (Report No. FTA VA-26-7229-07.1), released in April 2007 (web link: https://www.transitwiki.org/TransitWiki/images/6/64/Useful_Life_of_Buses.pdf, last accessed January 2017)

Table C2: ZEB Phase-In Schedules for the Baseline, the Current Condition, and the Proposed ICT Regulation

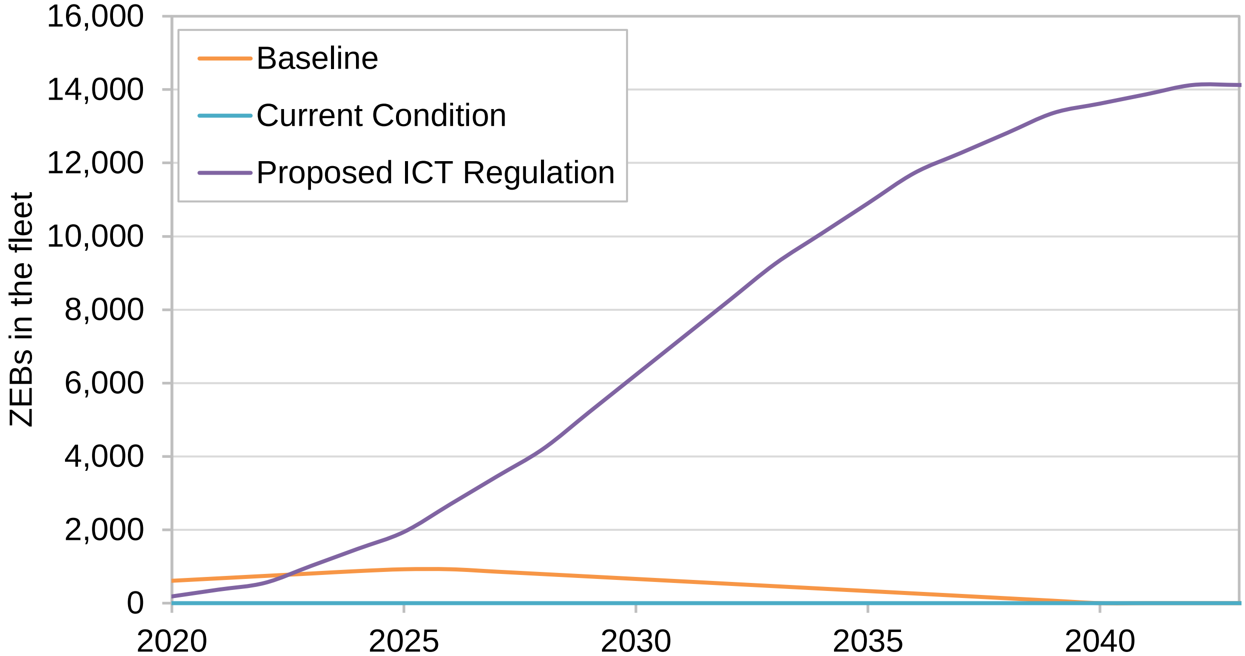
Year[c]	Baseline		Current Conditions	Proposed ICT		
	Large Diesel[a]	Large CNG[a]	All agencies	Large[b]	Medium[b]	Small[b]
2011	15%	0%	0%	0%	0%	0%
2012	15%	15%	0%	0%	0%	0%
2013	15%	15%	0%	0%	0%	0%
2014	15%	15%	0%	0%	0%	0%
2015	15%	15%	0%	0%	0%	0%
2016	15%	15%	0%	0%	0%	0%
2017	15%	15%	0%	0%	0%	0%
2018	15%	15%	0%	0%	0%	0%
2019	15%	15%	0%	0%	0%	0%
2020	15%	15%	0%	25%	0%	0%
2021	15%	15%	0%	25%	0%	0%
2022	15%	15%	0%	25%	0%	0%
2023	15%	15%	0%	50%	50%	0%
2024	15%	15%	0%	50%	50%	0%
2025	15%	15%	0%	50%	50%	0%
2026	15%	15%	0%	75%	75%	75%
2027	0%	0%	0%	75%	75%	75%
2028	0%	0%	0%	75%	75%	75%
2029	0%	0%	0%	100%	100%	100%

[a] The transit agencies with more than 200 urban buses are required to purchase 15% of ZEBs in the new purchase. The requirement for agencies following diesel-path starts from 2011 and for agencies following alternative fuel-path starts from 2012 and it sunsets after 2026.

[b] The definitions of large, medium, and small agencies in the proposed ICT regulation are different from the existing Transit Fleet Rule. The fleet sizes are defined based the number of buses within modes and vehicles types mentioned in this section

[c] The ZEB phase-in schedules are shown from 2011 to 2029. Before 2011, there is 0% of ZEBs in new purchases under all scenarios; after 2029, ZEB purchase percentages are the same as the ones in 2029.

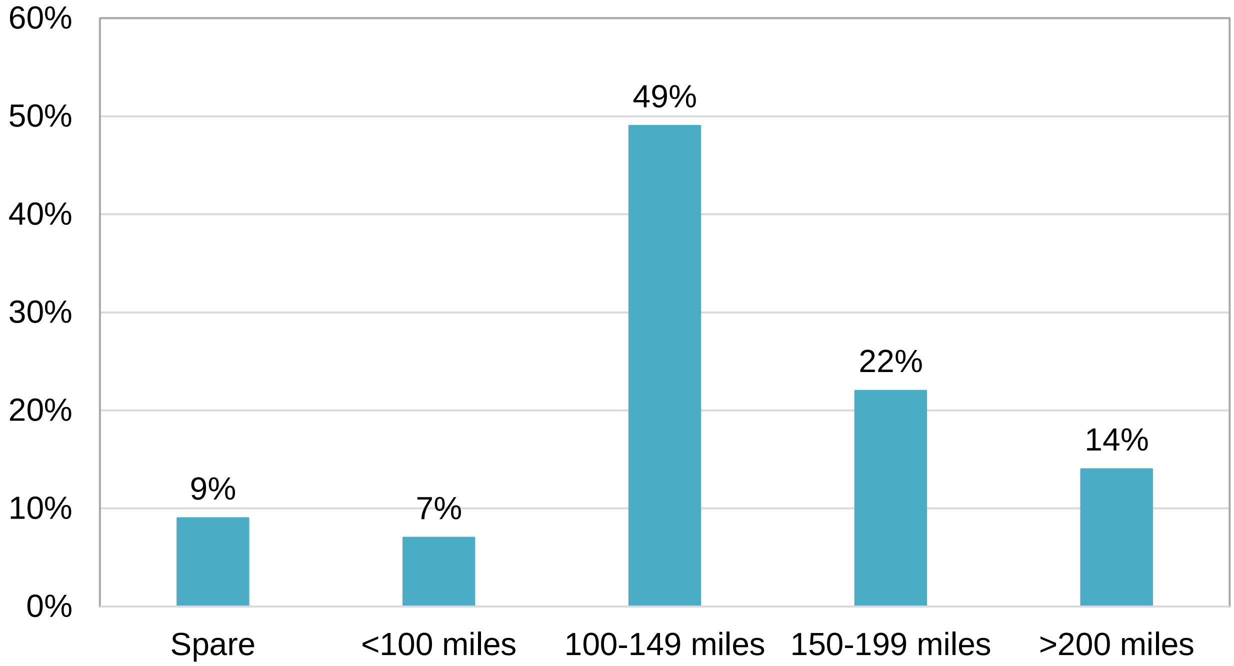
Figure C1: ZEB Population Projections for the Baseline, Current Conditions, and the Proposed ICT Regulation



Transit agencies can choose different pathways and zero-emission technologies to comply with the ZEB purchase requirements. Though it is difficult to predict transit agencies' choice of zero emission technologies, a majority of ZEBs currently in the fleet are BEBs. More fleets are expected to use charge in the depot overnight especially as battery technology improves and daily bus range becomes longer rather than rely on strategies that require charging on-route. This analysis assumes that the ZEB fleet is 90 percent depot charging BEBs, 9 percent on-route charging BEBs, and 1 percent FCEBs. Additionally, for depot charging BEBs, transit agencies are expected to purchase lower range buses in the early years to meet their shorter range needs, and to purchase buses with longer range in later years to meet their longer range needs as more ZEBs are deployed in the fleet. More buses are becoming available with higher daily range as technology continues to improve, battery costs come down, and battery energy density improves. The assumptions are consistent with survey data from transit fleets in Figure C2 that shows about 50 percent of buses operate less than 150 miles per day, and about 85 percent of buses operate less than 200 miles per day.[34]

[34] California Air Resources Board, Transit Agency Survey Preliminary Results, ACT Workgroup Meeting on August 29, 2016 (web link: https://www.arb.ca.gov/msprog/bus/transit_survey_summary.pdf, last accessed February 2018)

Figure C2: Daily Bus Mileage Distribution



For the statewide analysis, staff assumes that initially buses with up to 150 mile range per charge will be purchased for shorter range needs and over time, as more BEBs are deployed in the fleet, higher range buses will be purchased to meet service needs without increasing the fleet size. This analysis reflects purchases of BEBs with 330 kWh or up to 150 nominal miles per charge from 2020-2024. Mid-range buses with 440 kWh batteries or approximately 200 nominal miles per charge are purchased from 2025-2029, and longer range buses with an average of approximately 550 kWh batteries or 250 nominal miles per charge from 2030 and afterwards. The assumed ZEB ranges are within the daily range of buses currently in service as shown in Figure C2 and does not require an increase in number of buses to provide the same level of service

Under the baseline and the “current conditions,” the non-ZEB purchases are replaced by conventional buses of the same fuel type. Under the proposed ICT regulation, the non-ZEB purchases are replaced by buses of the same fuel type with low NOx engines when they are available. CNG buses with low NOx engines are already commercially available, and the analysis assumes that this combination will be phased-in to the fleet starting in 2020. A low NOx diesel bus is not available and the analysis does not assume they become available as a result of the proposed ICT regulation. Propane and gasoline low NOx engines have recently become available, but have not been incorporated into buses that are available for purchase with federal funds.

Bus Capital Cost

Bus capital costs constitute a large share of the total costs of the proposed ICT regulation. In this analysis, CARB uses estimates of bus capital costs for different powertrains in 2016[35] dollars based on direct communications with Original Equipment Manufacturers (OEMs) and recent bus purchase contracts for 40-foot standard buses. Future bus prices reflect declining costs of batteries for BEBs and national trends showing that all bus prices increase faster than inflation.

Proterra and BYD, two OEMs, provided BEB price information to CARB and confirmed that the current prices for BEBs used in the CARB analysis are pre-tax prices and include Americans with Disabilities Act (ADA) and standard equipment but do not include additional bus options like fare boxes or cameras. The 2016 bus prices are $770,000 for the BYD bus with a 12-year battery warranty and $749,000 for the Proterra bus with extended range and on-route charging.

Bus contracts often include different options and specify different equipment for what is referred to as the "base" bus. CARB staff reviewed the bus specifications from a consortium 2013 bus purchase bid from the Central Contra Costa Transit Authority (CCCTA)[36,37] and a bus purchase bid for different propulsion technologies from the Washington State Department of Enterprise in 2015[38,39] and use the 2016 pre-tax bus prices in this cost analysis, as shown in Table C3. Bus prices in the future are projected based on the 2016 bus prices. The projected prices are shown in Figure C3 and Table C4.

Table C3: Proposed 2016 Pre-Tax Bus Price for a Basic Bus (2016$)

Diesel	CNG	Diesel Hybrid	BEB (depot charge)	BEB (on-route charge)	FCEB
$435,000	$485,000	$640,000	$770,000	$750,000	$1,200,000

35 California Air Resources Board, Bus Price Analysis, released on June 26, 2017 (web link: https://arb.ca.gov/msprog/ict/meeting.htm, last accessed January 2018)

36 Central Contra Costa Transit Authority, Request for Proposals 2012-MA-02 for Purchase and Delivery of Heavy-duty Buses (web link: http://unioncity.granicus.com/MetaViewer.php?view_id=3&clip_id=841&meta_id=43950, last accessed January 2018)

37 Gillig, Cost Proposal to CCCTA, released on May 23, 2013 (web link: http://unioncity.granicus.com/MetaViewer.php?view_id=3&clip_id=841&meta_id=43951, last accessed January 2018)

38 Washington State Department of Enterprise Services, Heavy-duty public transit vehicles (Solicitation 09214) (web link: https://fortress.wa.gov/ga/apps/contracting/09214b.doc, last accessed January 2018)

39 Washington State Department of Enterprise Services, Heavy-duty Mass Transit Vehicles (Contract# 09214) (web link: https://fortress.wa.gov/ga/apps/ContractSearch/ContractSummary.aspx?c=09214, last accessed January 2018)

The bus prices for ZEBs have come down significantly[40] in the past several years due to technology commercialization. Future BEB prices are based on projections of battery price reductions, but do not included estimates of cost reductions for electric drivetrain components nor economies of scale.

On average, bus price in nominal dollars for 40-ft diesel and CNG buses increased 2 percent per year faster than inflation from 2005 to 2015[41] and this trend is continued for bus prices applying a 2 percent inflation rate to diesel buses[42,43] and adding the 50,000 incremental cost for CNG and 200,000 incremental cost for hybrid buses.

In this analysis, the price projection for BEBs is similar to projections for CNG and diesel hybrid buses, except that projected cost reductions from bus batteries are also included. CARB estimates that battery costs for buses will decrease over time with costs of $725/kWh in 2015, $405/kWh in 2020, and $218/kWh for batteries used in depot-charging buses.[44] To calculate BEB prices, the battery unit costs are then converted to 2016 constant dollars by using 2 percent inflation rate. Finally, the BEB price is a combination of cost reduction in batteries and cost increases associated with all buses regardless of fuel type. This method is very conservative in that it does not reflect any bus price reductions from economies of scale with increasing bus production.

There is limited information for capital cost estimates or projections about FCEBs.[45] The capital cost in 2016 is based on prices quoted price from a pilot program. The FCEB price is assumed to be $900,000 in 2020, which is a preliminary projection, based on a purchase volume of 40 buses in 2016. In 2014, New Flyer is the largest transit bus manufacturer in the United States and stated that $900,000 per FCEB would be feasible with an order of 40 or more buses to be delivered over a 3-year period. [46,47]

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[40] National Renewable Energy Laboratory (NREL), Foothill Transit Battery Electric Bus Demonstration Results: Second Report, released in June 2017 (web link: https://www.afdc.energy.gov/uploads/publication/foothill_transit_beb_demo_results_2nd_rpt.pdf, last accessed January 2018)

[41] American Public Transportation Association, Public Transportation Vehicle Database (weblink: http://www.apta.com/resources/statistics/pages/otheraptastatistics.aspx)

[42] Consumer Price Index (CPI), Detailed Report Tables for September 2015, Table 24(web link: http://www.bls.gov/cpi/tables.htm), last accessed February 2017

[43] Producer Price Index (PPI), Series ID: WPU1413 (web link: https://data.bls.gov/cgi-bin/srgate, last accessed February 2017)

[44] California Air Resources Board, Battery cost for heavy-duty electric vehicles, released in August 2017 (weblink: https://www.arb.ca.gov/msprog/bus/battery_cost.pdf, last accessed January 2018)

[45] National Renewable Energy Laboratory (NREL), Zero Emission Bay Area (ZEBA) Fuel Cell Bus Demonstration Results: Fifth Report, released in June 2016 (web link: https://www.afdc.energy.gov/uploads/publication/zeba_fcb_rpt5.pdf, last accessed January 2018)

[46] New Flyer Letter to Erik White, May 29, 2014

[47] California Air Resources Board, Draft Technology Assessment: Medium- and Heavy-Duty Fuel Cell Electric Vehicles (released November 2015) (web link: https://www.arb.ca.gov/msprog/tech/techreport/fc_tech_report.pdf, last accessed February 2018)

For this analysis, a depot charging Proterra BEB is used to estimate capital costs which may overstate the capital costs. The battery is expected to be replaced at midlife, and the bus requires a separate charger and results in a total cost that is higher than if using costs associated with buses that include an on-board charger and come with a 12-year battery warranty that does not require replacement at midlife. Figure C3 shows bus price projections for depot charging BEBs with a battery size of 330 kWh (around 150 miles per charge). As described in Section C.1.a, BEBs with longer ranges are assumed to be phased-into the fleet after 2025, and their prices would be higher because of larger battery. Table C4 shows the bus capital costs for different powertrains in this analysis and how they change over time.

Figure C3: Projected of Bus Capital Cost for Different Powertrains (2016$)

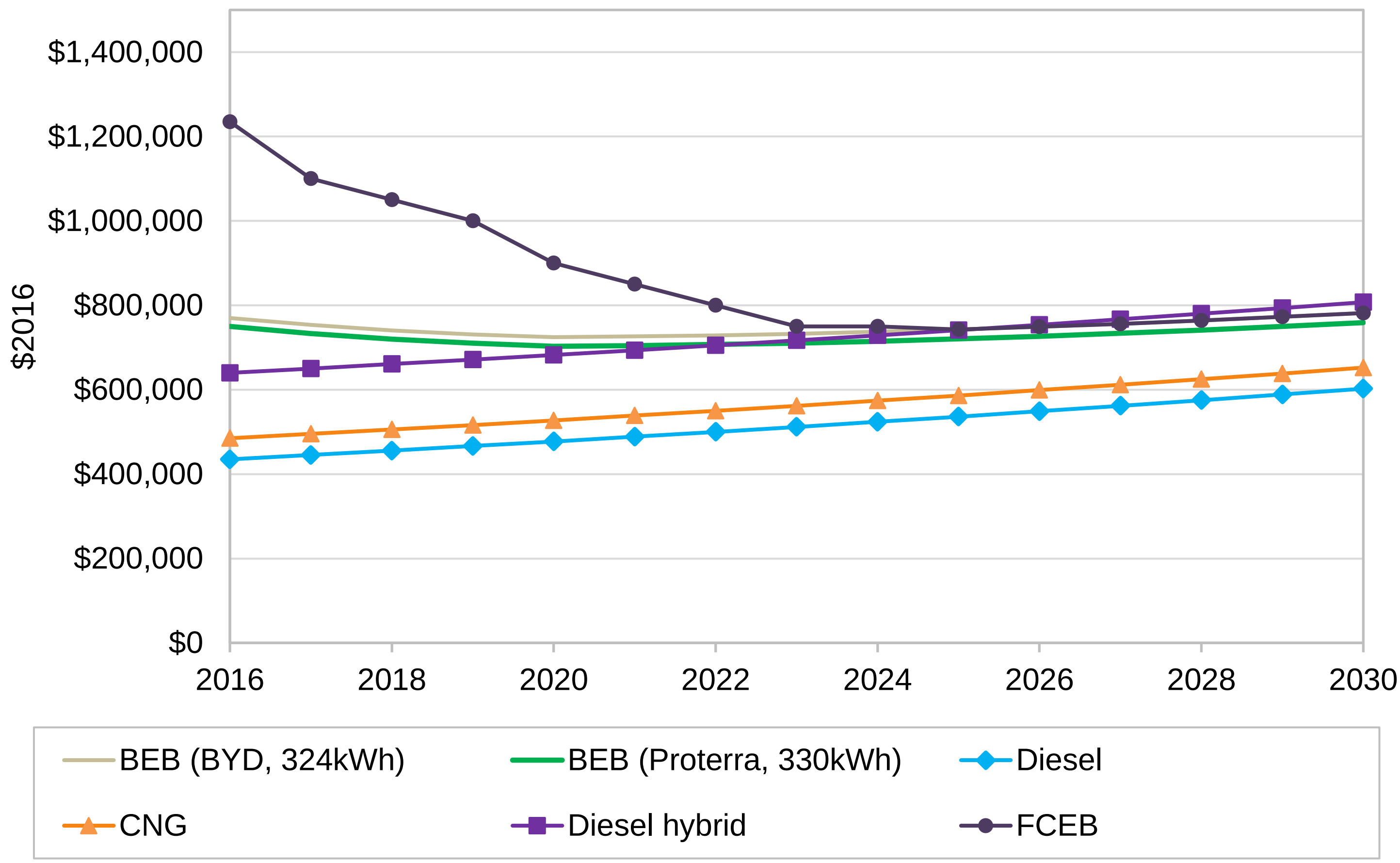


Table C4: Projected of Bus Capital Cost for Different Powertrains (2016$)

Year	Diesel	CNG	Low NOx CNG	Diesel Hybrid	BEB (on-route charge)	BEB (330kWh) (depot charge)	BEB (440kWh) (depot charge)	BEB (550kWh) (depot charge)	FCEB
2016	435,000	485,000	500,000	640,000	750,000	750,000	821,000	892,000	1,235,000
2017	445,000	495,000	510,000	650,000	733,000	733,000	795,000	857,000	1,100,000
2018	456,000	506,000	521,000	661,000	720,000	720,000	774,000	828,000	1,050,000
2019	466,000	516,000	531,000	671,000	710,000	710,000	757,000	804,000	1,000,000
2020	477,000	527,000	542,000	682,000	703,000	703,000	744,000	785,000	900,000
2021	489,000	539,000	554,000	694,000	704,000	704,000	742,000	780,000	850,000
2022	500,000	550,000	565,000	705,000	707,000	707,000	742,000	777,000	800,000
2023	512,000	562,000	577,000	717,000	711,000	711,000	743,000	775,000	750,000
2024	524,000	574,000	589,000	729,000	715,000	715,000	745,000	774,000	750,000
2025	536,000	586,000	601,000	741,000	720,000	720,000	748,000	775,000	750,000
2026	549,000	599,000	614,000	754,000	727,000	727,000	752,000	777,000	750,000
2027	562,000	612,000	627,000	767,000	734,000	734,000	757,000	780,000	756,000
2028	575,000	625,000	640,000	780,000	741,000	741,000	763,000	784,000	764,000
2029	589,000	639,000	654,000	794,000	750,000	750,000	770,000	789,000	773,000
2030	602,000	652,000	667,000	807,000	759,000	759,000	777,000	795,000	782,000

Infrastructure Cost

In this analysis, infrastructure costs due to ZEBs include costs for hydrogen stations, BEB chargers, electrical service upgrades, charger installation, and maintenance bay upgrades. The major assumptions about infrastructure cost and data sources are available on the ICT website[48] and are summarized in Table C5. It is assumed that there is no additional infrastructure cost for buses with internal combustion engines because the infrastructure is already in place.

Table C5: Infrastructure Capital Costs, Installation Cost, and Maintenance Cost (2016$)

Technology Type	Charger Capital Cost	Service Upgrade and Installation	Other Costs	Buses Supported per Unit
Depot Charger Maintenance	$50,000	$55,000	$500/charger/yr	1
On-Route Charger	$349,000	$250,000	$0.026/kWh	6
Hydrogen Station	$5,050,000			40
Maintenance Bay Upgrade for BEBs[a]				
From CNG	$25,000		$2,000	15
From Diesel	$25,000		$3,000	15
From Diesel Hybrid	$25,000		$0	15
Maintenance Bay Upgrade for FCEBs				
From CNG	$1,000			15
From Diesel	$750,000			15
From Diesel Hybrid	$750,000			15

[a] CARB assumes that two bays share one shop charger, and it costs $50,000 per charger

The number of chargers, hydrogen stations, and upgraded maintenance bays are based on the projected number of ZEBs and throughput of each infrastructure type. It is also assumed that once the infrastructure is in place, it can be used for other vehicles even after the vehicles the infrastructure originally served are retired.

b. Operational and Maintenance Cost

Bus Midlife Cost

The costs in this analysis includes costs for one midlife overhaul for engine rebuild or battery or fuel cell system replacement. This occurs at midlife, at bus age seven. The costs for the midlife overhaul does not include maintenance costs for repairing or replacing seats, windows and other items that are common to all buses regardless of drivetrain.

[48] Data sources for these assumptions are summarized in the excel file for Cost Data & Sources (web link: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626costdatasources.xlsx, last accessed January 2018)

Table C6 summarizes the cost of bus midlife overhaul for different powertrains. With the increase of BEB range and battery size, the cost of the battery replacement at midlife is assumed to scale proportionally to battery size, but remains relatively constant over time as battery sizes increase and battery prices decline. The estimated cost for replacing a battery at midlife for a BEB with a battery size of 330 kWh, 440 kWh or 550 kWh is $75,000, $100,000 and $125,000, respectively.

CNG and diesel engine overhauls are both estimated at $35,000 per bus based on information provided by transit agencies reflecting their actual costs. Some agencies replace engines at midlife at more than $100,000 per engine because they have determined that replacing engines with new ones at mid-life is more cost effective for the remaining use of the bus than rebuilding engines. These higher baseline mid-life engine replacement costs are not included in the analysis.

Table C6: Cost of Bus Midlife Overhaul by Technology (at year 7)

Technology	Cost (2016$)
CNG	$35,000
Diesel	$35,000
Diesel hybrid	$35,000
Low NOx CNG	$38,000
BEB (Proterra, 330 kWh)[a]	$75,000
Fuel Cell	$200,000

[a] Midlife battery replacement varies with battery size

Bus Maintenance Cost

This analysis includes drivetrain related maintenance costs for CNG buses and diesel buses from the Transit Agency cost subgroup recommendations. These costs are based on CNG data from Los Angeles Metro which shows a 14 year average of $0.85/mile and transit fleet experience showing slightly lower costs per mile for diesel bus maintenance. The drivetrain related maintenance estimates exclude midlife overhauls or battery replacements that are calculated separately.

Battery electric buses are expected to have an average maintenance cost that is about $0.19/mile lower than a conventional diesel bus. This estimate is based on empirical data from a literature review[49] of all available data and reflects a cost savings of $0.11/mile associated with regenerative braking and about $0.08/mile from eliminating regular maintenance items like oil changes, fluid changes, and other consumables. Regenerative braking reduces brake repair frequency and associated repair costs by about 55 percent. Hybrid diesel buses maintenance cost is expected to be about $0.11 per mile lower than conventional diesel buses due to brake cost savings. As described in the literature review mentioned above, the regular maintenance cost for FCEB is based on $0.95/mile from AC transit and $1.35/mile from Sunline data with a $100 per hour labor rate. The maintenance costs used in this analysis are summarized in Table C7.

[49] California Air Resources Board, Literature Review on Transit Bus Maintenance Cost, released in August 2016 (web link: https://www.arb.ca.gov/msprog/bus/maintenance_cost.pdf, last accessed January 2018)

Table C7: Average Repair Maintenance Costs (Excluding Midlife Costs)

Technology	$/mile (2016$)
CNG	$0.85
Diesel	$0.79
Hybrid Diesel	$0.68
BEB	$0.60
FCEB	$1.00

Infrastructure Maintenance Cost

Depot and on-route chargers for ZEBs need to be maintained regularly. The maintenance costs of depot chargers are estimated by considering costs for replacing charger heads, connectors, and other components, as well as labor costs for regular inspections.[50] The information about on-route chargers is based on data from Foothill Transit who has experience with Proterra on-route chargers.[51] Charger maintenance costs are summarized in Table C8.

CARB Staff assume that the maintenance cost for other fueling infrastructures are reflected in the fuel price.

Table C8: Estimated Charger Maintenance Costs

Technology Type	Maintenance Cost	Buses/Unit
Depot Charger	$500/charger each year	Each bus has its own charger
On-Route Charger	~$13,000/charger each year and ($0.03/kWh)	6 buses share one charger

Fuel Cost

Fuel costs for each bus are calculated based on total fuel use each year and the total cost of the fuel. Fuel economy for conventional buses is based on fuel economy data from seven transit agencies.[52] The weighted fuel efficiencies for diesel and CNG buses are 3.87 miles/gal and 2.91 miles/diesel gallon equivalent (dge), respectively. The fuel efficiency of a diesel hybrid bus is assumed to be 25 percent higher than that of a diesel bus[53] and is around 4.8 miles/dge. This is comparable to the fuel efficiency of a diesel hybrid bus reported by the Golden Gate Bridge, Highway and Transportation District. The energy use for a BEB is based

50 Personal communications with Tesla and Clipper Creek in October 2016

51 Foothill Transit, email communication with Andrew Papson, Electric Bus Program Manager, in March 2017

52 California Air Resources Board, Cost Data & Sources, Table 3 (Fuel Efficiency-Fleet Specific Examples), released on June 26, 2017 (web link: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626costdatasources.xlsx, last accessed January 2018)

53 National Renewable Energy Laboratory (2016), King County Metro Transit Hybrid Articulated Buses: Final Evaluation Results, released in December 2016 (web link: https://www.nrel.gov/docs/fy07osti/40585.pdf, last accessed February 2018)

on data from Foothill Transit[54] with an overall average energy use of 2.15 kWh/mile, or 0.47 mile/kWh. Fuel efficiency for a FCEB is estimated to be 6.3 miles per kilogram (kg) based on the energy efficiency ratio of 1.9[55] used in the LCFS regulation. Table C9 summarizes the average fuel efficiency used for this analysis.

Table C9: Average Fuel Efficiency of Buses by Technology

Technology	Fuel Efficiency	Unit
CNG	2.91	mile/dge
Diesel	3.87	mile/dge
Hybrid Diesel	4.84	mile/dge
BEB	0.48	mile/kWh
FCEB	6.30	mile/kg

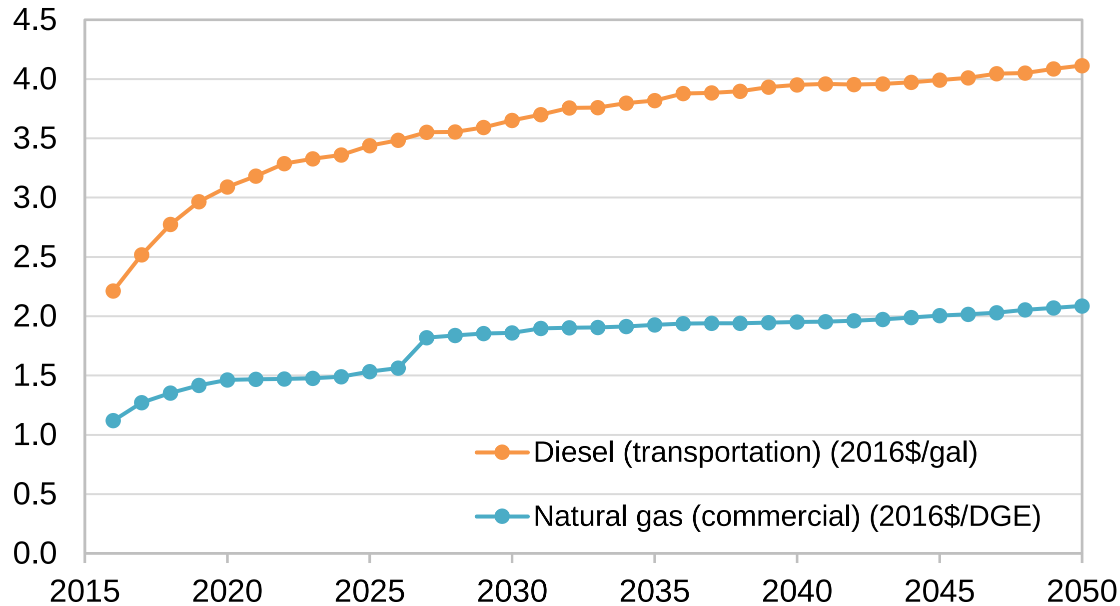
CNG and diesel fuel prices are based on Energy Information Administration (EIA)'s Annual Energy Outlook 2017[56] and start at $1.12/dge and $2.21/dge, respectively in 2016. The EIA commercial natural gas prices are consistent with the total pump price[52] paid by California transit agencies per responses to transit agency survey conducted by CARB in 2016 and are used in this analysis. Future CNG and diesel prices the EIA 2017 prices shown in Figure C4.

[54] National Renewable Energy Laboratory (2016), Foothill Transit Agency Electric Bus Demonstration Results, released in January 2016 (web link: https://www.nrel.gov/docs/fy16osti/65274.pdf, last accessed January 2018)

[55] California Air Resources Board (2014), Staff Report: Initial Statement Of Reasons for Proposed Rulemaking, Proposed Re-Adoption of the Low Carbon Fuel Standard, Table III-3 (web link: https://www.arb.ca.gov/regact/2015/lcfs2015/lcfs15isor.pdf, last accessed January 2018)

[56] Energy Information Administration, Annual Energy Outlook 2017 (Table 3), Energy Prices by Sector and Source, Reference case for the Pacific Region (web link: http://www.eia.gov/forecasts/aeo/tables_ref.cfm, last accessed June 2017).

Figure C4: Diesel and Natural Gas Fuel Price from EIA 2017



Electricity cost per kWh varies by electric utility service areas and charging strategy,[57] as shown in Table C10. For this analysis, it is assumed that most transit agencies will utilize managed charging at the depot, which is the primary charging method expected in the future. Under managed depot charging, total energy demand is managed by charging management software or timers to charge buses in sequence and to reduce total electricity demand and costs. An individual transit agency may experience higher electricity costs when charging a small number of buses at a depot, and will have lower electricity costs when charging more buses at the same depot. For determining statewide average costs from 2020 to 2043, this analysis uses a simplified assumption for electricity costs based on managed charging for a fleet with 100 BEBs in one depot. For on-route charging the electricity costs are based on an having an average of six buses for each charger.

The fuel efficiency assumptions utilized in this analysis are shown in the footnotes of Table C10. The growth rate of electricity price from EIA 2017 is applied to the values shown in Table C10 for future projections.

[57] California Air Resources Board, Charging Cost Calculator, released on June 26, 2017 (web link: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626chargecostcalcv3.xlsm, last accessed January 2018)

Table C10: Electricity Costs by Utility and Charging Pattern (2016$/kWh)

Utility	Depot (Unmanaged)[a]	Depot (Managed)[b]	On-Route[c]
PG&E	$0.20	$0.15	$0.25
SCE	$0.11	$0.09	$0.20
LADWP	$0.11	$0.09	$0.16
SDG&E	$0.24	$0.18	$0.31
SMUD	$0.12	$0.11	$0.15

[a] Represents a scenario where all vehicles charged simultaneously. All vehicles charged within 5.1 hours at 60 kW each. Assumptions used: 100-bus fleet; 130 miles/day; 2.1 kWh/mile; 90% charging efficiency; "Late Night" (10p-7a) charging.

[b] Represents a scenario where charging in the depot reduces maximum demand by 50% through decreased charge power, sequential bus charging, or other means. Vehicles charged in 10.2 hours at 60 kW. Assumptions used: 100-bus fleet; 130 miles/day; 2.1 kWh/mile; 90% charging efficiency; "Evening" (7p-6a) charging.

[c] Represents on-route charging up to 10/15 min (500 kW charger); 6 buses/charger; 130 miles/day; 2.1 kWh/mile; 90% charging efficiency; "Day Time" (6a-10p) charging.

Hydrogen prices are highly dependent on station throughputs and are expected to decrease when more FCEBs are in use. This analysis uses $8.00/kg as the 2016 hydrogen price[58] and assumes the future hydrogen price will decrease to $4.00/kg in 2020.[59]

LCFS Credit

The LCFS program is a regulation designed to reduce GHG emissions associated with the lifecycle of transportation fuels used in California. A transit agency that opts into the LCFS program is currently the first in line to receive the LCFS credits if it consumes fossil natural gas, electricity, or produces an alternative fuel (e.g., hydrogen) onsite. For renewable diesel and renewable natural gas, the LCFS credit goes to the producer or importer of the renewable fuel. A transit agency can also receive credits for renewable natural gas and other alternative fuels if the fuel producer or other party with the first right to generate credits passes on the right to the transit agency through a fuel purchase contract. The credits can be sold to regulated parties in the LCFS credit market to reduce operating costs for transit fleets.

The amount of LCFS credits that are generated varies by fuel type, pathway and compliance target. The compliance target declines to achieve a 10 percent reduction from the 2010 baseline through 2020 and beyond. The amount of credits that can be generated for a given fuel pathway is determined by how much its carbon intensity (CI) is below the compliance target for the year. As the compliance target declines through 2020, the amount of credits that can be generated for a fuel at a given CI will also decline. It is expected that, as alternative fuel production continues to expand and innovations occur, these CIs will improve over time resulting in higher credit generation potential.

[58] National Renewable Energy Laboratory, American Fuel Cell Bus Project Evaluation: Second Report, released in September, 2015 (web link: http://www.nrel.gov/docs/fy15osti/64344.pdf, last accessed January 2018)

[59] U.S. Department of Energy Hydrogen and Fuel Cells Program, 2016 Annual Merit Review and Peer Evaluation Meeting, page 11: DOE cost targets and status, released June 6, 2016 (web link: https://www.hydrogen.energy.gov/pdfs/review16/02_satyapal_plenary_2016_amr.pdf, last accessed January 2018)

A credit value calculator[60] is available to determine how many credits can be earned each year from 2016 to 2020. The calculator uses input variables (including calendar year, Energy Economy Ratio (EER) for the vehicle type, CI of the fuel used, and credit price) to determine the potential revenue generated by a given fuel pathway in a compliance year. Table C11 provides examples of the CI of different fuel pathways to show how the credit value would change as the regulation becomes more stringent and the CI target declines. In this example, the credit price remains constant at $100/MTCO_2e$ and the CIs of the fuel pathways do not change over time. The actual credit price will fluctuate with market conditions and improvements in CIs may occur over time. The numbers used in the examples are for illustration purpose.

Table C11. LCFS Credit Revenue for Selected Fuels in 2016 and in 2020[a] at Credit Price $100/MT

	Representative Carbon Intensity[b] (CI) (gCO2e/MJ)	EER for transit buses	LCFS Credit Revenue in 2016	LCFS Credit Revenue in 2020
Fossil diesel	102	1		
Renewable diesel	30	1	$0.94/DGE	$0.83/DGE
Fossil CNG	78	0.9	$0.16/DGE	$0.06/DGE
Renewable CNG	40	0.9	$0.67/DGE	$0.57/DGE
Electricity (Grid)	105	4.2	$0.11/kWh	$0.10/kWh
Electricity (Solar)	0	4.2	$0.15/kWh	$0.14/kWh
33% Renewable Hydrogen[c]	88	1.9	$1.22/kg	$1.03/kg
100% Renewable Hydrogen[d]	0	1.9	$2.28/kg	$2.09/kg

a: The revenues shown for 2020 assume no improvement in carbon intensities.
b: Certified CI values can be found at http://www.arb.ca.gov/regact/2015/lcfs2015/lcfsfinalregorder.pdf (Table 6 on p. 66) and at http://www.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm
c: Hydrogen made by reforming a mixture of natural gas with 33% biomethane.
d: A certified pathway for hydrogen produced by electrolysis using solar PV power.

The LCFS regulation is currently in the process of being amended.[61] The staff proposal would increase the battery electric bus EER by almost 20 percent from 4.2 to 5.0, expand LCFS rewards for zero-emission vehicle fueling infrastructure consistent with Governor Brown's Executive Order B-48-18, and strengthen the program by targeting a 20 percent reduction in average fuel CI by 2030. Once approved, these amendments would provide more credits for BEBs and allow transit agencies to be the first in line to claim the credits for dispensing hydrogen. For the ICT SRIA analysis, staff used the proposed CI benchmark and the proposed CIs for fuels from the LCFS SRIA document dated November 16, 2017.[62]

[60] Available at www.arb.ca.gov/fuels/lcfs/dashboard/creditpricecalculator.xlsx
[61] The scheduled Board hearing date for the LCFS amendments is in April 2018.
[62] California Air Resources Board, Low Carbon Fuel Standard 2018 Amendments, Standard Regulatory Impact Assessment (SRIA), date of submission: November 16, 2017 (web link:

c. Total Costs

The total direct cost to transit agencies due to the proposed ICT regulation is the summation of the upfront capital costs and annual operational and maintenance costs. The capital costs for conventional buses includes the bus purchase price, but does not include infrastructure that is already in place. For low NOx engines, the costs of the proposed ICT regulation are the incremental cost of the engine relative to the cost of a conventional bus. For ZEBs, the total costs include costs for the bus purchase, charger and fueling station purchase and installation, and maintenance bay upgrades. The annual operational and maintenance costs for all technologies include costs for bus midlife overhaul (including battery replacement for BEBs) and regular maintenance, infrastructure maintenance, fuel consumption, and the value of LCFS credits. Figure C5 and Table C12 provide a breakdown of the estimated annual direct costs to transit agencies.

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http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/documents/LCFS_SRIA_CARB_11-16-17.pdf, last accessed January 2018)

Table C12: Estimated Total Direct Costs of the Proposed ICT Regulation to Transit Agencies Relative to the Baseline and the Current Conditions (million 2016$)

(a) Estimated Direct Cost Relative to the Baseline

Year	Upfront Capital Cost		Operational and Maintenance Cost					Total Cost*
	Bus Purchase	Infrastructure	Bus Midlife	Bus Maintenance	Infrastructure Maintenance	Fuel Consumption	LCFS Credits	
2020	$30	$31	-$3	$4	$0	$6	$3	$70
2021	$29	$11	-$3	$3	$0	$4	$2	$46
2022	$28	$12	-$3	$2	$0	$2	$1	$42
2023	$71	$47	-$3	-$1	$0	-$3	-$2	$108
2024	$68	$41	-$3	-$5	$0	-$9	-$6	$87
2025	$75	$44	-$3	-$8	$1	-$16	-$9	$84
2026	$118	$80	$6	-$14	$1	-$27	-$15	$149
2027	$123	$80	$6	-$22	$2	-$44	-$21	$124
2028	$118	$80	$6	-$29	$2	-$59	-$26	$92
2029	$147	$106	$17	-$38	$3	-$79	-$34	$123
2030	$158	$107	$17	-$47	$3	-$100	-$41	$97
2031	$156	$106	$26	-$56	$4	-$123	-$49	$64
2032	$154	$107	$44	-$65	$5	-$146	-$56	$43
2033	$153	$111	$48	-$74	$5	-$167	-$64	$12
2034	$151	$88	$48	-$82	$6	-$187	-$70	-$47
2035	$149	$87	$64	-$90	$7	-$207	-$77	-$66
2036	$148	$87	$87	-$97	$7	-$230	-$83	-$81
2037	$146	$59	$87	-$103	$7	-$243	-$87	-$134
2038	$145	$57	$87	-$108	$8	-$258	-$92	-$160
2039	$143	$58	$87	-$113	$8	-$274	-$96	-$186
2040	$142	$27	$87	-$116	$9	-$283	-$98	-$232
2041	$140	$31	$87	-$118	$9	-$289	-$100	-$239
2042	$139	$27	$87	-$120	$9	-$296	-$102	-$255
2043	$138	$0	$87	-$120	$9	-$298	-$102	-$286
Total*	$2,868	$1,483	$964	-$1,416	$106	-$3,327	-$1,222	-$546

* Totals may not add due to rounding

(b) Estimated Direct Cost Relative to the Current Conditions

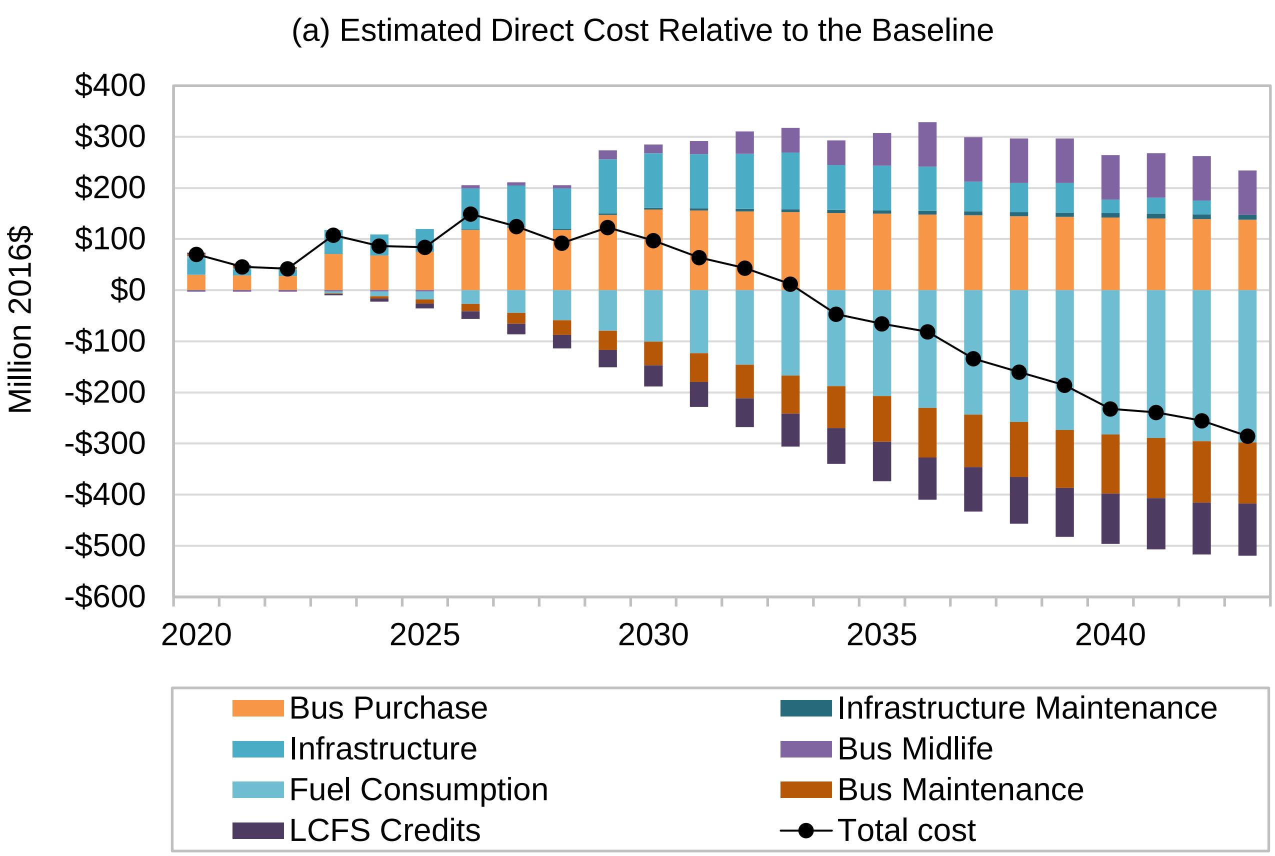
Year	Upfront Capital Cost		Operational and Maintenance Cost					Total Cost*
	Bus Purchase	Infrastructure	Bus Midlife	Bus Maintenance	Infrastructure Maintenance	Fuel Consumption	LCFS Credits	
2020	$42	$37	$0	-$2	$0	-$3	-$2	$74
2021	$40	$19	$0	-$3	$0	-$5	-$3	$48
2022	$39	$19	$0	-$5	$0	-$8	-$5	$41
2023	$81	$54	$0	-$9	$1	-$14	-$8	$105
2024	$78	$49	$0	-$13	$1	-$21	-$12	$82
2025	$86	$49	$0	-$16	$1	-$28	-$16	$76
2026	$129	$80	$9	-$23	$2	-$40	-$21	$135
2027	$123	$80	$9	-$29	$2	-$59	-$27	$100
2028	$117	$80	$9	-$36	$3	-$72	-$32	$69
2029	$147	$106	$20	-$44	$3	-$92	-$39	$102
2030	$158	$107	$20	-$53	$4	-$112	-$45	$78
2031	$156	$106	$30	-$61	$5	-$134	-$53	$49
2032	$154	$107	$48	-$70	$5	-$156	-$60	$30
2033	$152	$111	$48	-$79	$6	-$176	-$67	-$3
2034	$151	$88	$48	-$86	$7	-$195	-$73	-$60
2035	$149	$87	$64	-$93	$7	-$213	-$79	-$77
2036	$148	$87	$87	-$100	$8	-$235	-$85	-$90
2037	$146	$59	$87	-$104	$8	-$247	-$89	-$140
2038	$145	$57	$87	-$109	$8	-$260	-$92	-$165
2039	$143	$58	$87	-$114	$9	-$275	-$96	-$188
2040	$142	$27	$87	-$116	$9	-$282	-$98	-$232
2041	$140	$31	$87	-$118	$9	-$289	-$100	-$239
2042	$139	$27	$87	-$120	$9	-$295	-$102	-$255
2043	$138	$0	$87	-$120	$9	-$298	-$102	-$286
Total*	$2,941	$1,523	$1,003	-$1,521	$116	-$3,506	-$1,302	-$747

* Totals may not add due to rounding

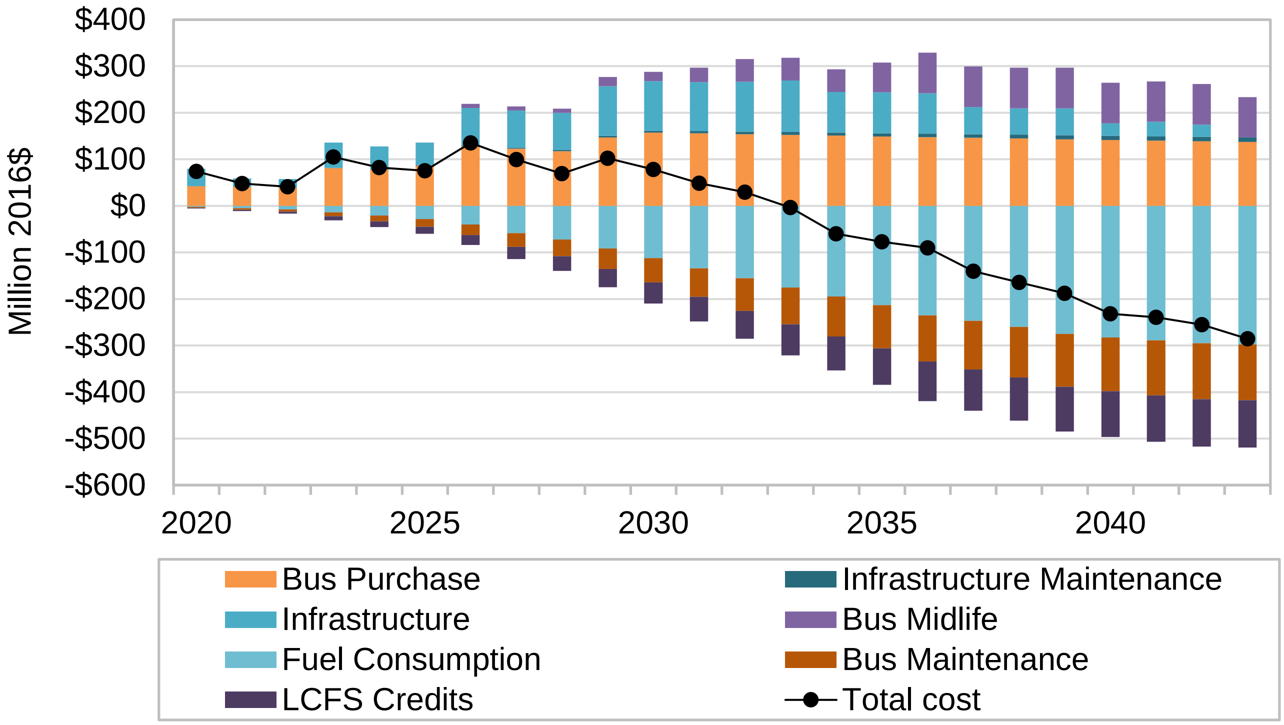
The proposed ICT regulation is estimated to result in a net savings relative to the baseline and the “current conditions.” The comparison is made from 2020 to 2043 because the costs of the proposed ICT regulation begin in 2020 and all conventional buses are phased out in 2042. From 2020 through 2043, the proposed ICT regulation is estimated to result in total savings of $546 million and $747 million relative to the baseline and the “current conditions,” respectively. Relative to the baseline and the “current conditions,” the highest annual cost of the proposed ICT regulation occurs in 2026 with estimated direct cost of $135 million and $149 million, respectively.

At the beginning of the proposed ICT regulation adoption (2020-2025), the annual costs are positive and increase over time relative to both the baseline and the “current conditions,” mainly because of the gradual phase-in of ZEBs and associated service upgrades and infrastructure installation. After 2033, the annual savings begin to outweigh the higher incremental cost of ZEBs due to savings in ZEB maintenance, fuel, credits from LCFS program, and as continued ZEB replacements don’t need new infrastructure nor electrical service upgrades.

Figure C5: Estimated Total Direct Costs of the Proposed ICT Regulation to Transit Agencies Relative to the Baseline and the Current Conditions (million 2016$)



(b) Estimated Direct Cost Relative to the Current Condition



2. Direct Costs on Typical Businesses

The proposed ICT regulation primarily affects transit agencies. A transit agency is an entity that provides public transportation. Transit agencies are diverse. There are currently over 200 public transit agencies in California operating more than 14,000 transit buses. Some agencies are small, operate in rural areas, and provide service with a few number of vans and small buses. Other agencies are big, serving dense urban areas with various modes of transportations and have complex service schedules.

In this section, staff estimated the annual costs for a typical transit agency with 200 standard CNG buses in the Southern California Edison service area to comply with the proposed ICT regulation, detailed in Table C13. As discussed in Section C.1.a, transit agencies usually operate a standard bus by 14 years. With a uniform bus age distribution, 7.1 percent (=1/14) of bus population, about 14 buses, will be replaced by new ones in each year. Following the requirements of the proposed ICT regulation, a few percent of the newly purchased buses should be ZEBs. A typical transit agency with 200 standard buses belongs to the group of large transit agency, and the ZEB purchase requirements start from 2020 (Section A. 2.).

With ZEB purchases, the initial costs for a typical transit agency are mainly for the capital costs for ZEBs, electrical service and infrastructure upgrades. The capital costs for ZEBs are higher than the diesel and CNG buses, but fuel and maintenance cost saving can offset all or most of the initial costs.

The long term incremental costs for buses are expected to decline due to battery cost reductions. CARB staff did not estimate bus cost reductions from economies of scale and believe the incremental costs will be smaller than projected. The ongoing costs are the operating and maintenance (O&M) costs. The O&M costs of ZEBs are lower than that of conventional buses (diesel and CNG buses) and may offset some or all of the initial capital costs.

For the first 10 years of the proposed ICT regulation, a typical transit agency would have higher annual costs relative to both the baseline and the "current conditions" except for 2020 when compared to the baseline where more ZEBs would be purchased in that year. The higher costs are primarily because of the higher incremental costs associated with ZEBs and associated electrical service upgrades and infrastructure installation. After around 2033, the annual savings from lower bus maintenance, fuel savings, and credits of LCFS program, begin to outweigh the higher incremental cost of ZEBs. In addition, around 2034 new infrastructure is not needed when ZEBs are replaced.

Table C13 Estimated Direct Cost for a Typical Transit Agency with 200 Standard Buses under the Proposed ICT Regulation Relative to the Baseline and the Current Conditions (million 2016$)

Year	Relative to the Baseline	Relative to the Current Conditions
2020	$1.1	$1.2
2021	$1.0	$1.0
2022	$0.9	$0.8
2023	$2.0	$1.8
2024	$1.2	$1.0
2025	$1.1	$0.9
2026	$2.1	$1.6
2027	$1.9	$1.1
2028	$1.4	$0.6
2029	$2.1	$1.5
2030	$1.1	$0.5
2031	$0.6	$0.1
2032	$0.3	-$0.1
2033	-$0.1	-$0.6
2034	-$1.0	-$1.5
2035	-$0.7	-$1.0
2036	-$1.4	-$1.7
2037	-$2.0	-$2.2
2038	-$2.4	-$2.5
2039	-$2.7	-$2.8
2040	-$3.4	-$3.4
2041	-$3.5	-$3.5
2042	-$3.6	-$3.6
2043	-$4.1	-$4.1
Total*	-$8.1	-$14.8

* Totals may not add due to rounding

3. Direct Costs on Small Businesses

There is no expected direct cost on small businesses.

4. Direct Costs on Individuals

There are no direct regulatory costs incurred by individuals as a result of the proposed ICT regulation. Transit agencies that incur increased costs may pass on costs to individuals, through changes in service or bus fares. However, grant funding can reduce or eliminate most of the initial capital costs of the proposed ICT regulation. To the extent that transit agencies are successful in offsetting the upfront incremental costs, there would be no increase in fares for individual with potential fare reductions in later years due to operational cost savings. To the extent that some of the incremental costs for an agency are not offset with grants, there could be an increase in fares for some years followed by fare reductions in later years as operational savings increase as the ZEB fleet expands. Transit agencies could also defer some incremental costs with battery lease arrangements that would be paid with operational savings. Potential indirect costs to individuals are discussed in the Macroeconomic Modeling in Section E.

5. Potential Funding

The analysis attributes all of the incremental costs associated with the proposed ICT regulation when compared to either the baseline or the “current conditions” to the proposed ICT regulation, and no grant funding is included in this analysis. Thus, the costs included in this analysis represent an upper bound where all incremental costs of the proposed ICT regulation are borne by the transit agency. However, the proposed ICT regulation is structured to provide an opportunity for transit fleets to take early action, ahead of regulatory deadlines and would allow agencies to be eligible for grant funding that could substantially reduce or eliminate the costs of ZEB purchases and infrastructure that could offset most of the costs to transit agencies. A description of various grant programs is described below. The following section describes several funding sources and an estimate of ways the incremental costs to transit agencies of the proposed ICT regulation could be offset without relying on financing options.

Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP)

The Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) is administered by CARB. The amount allocated for the HVIP is $188 million for FY 17-18.[63] At least $35 million is available for ZEBs. The base voucher amount is shown in Table C14 with higher amounts available for disadvantaged communities (DAC) or low income census tracts. The voucher amounts are intended to fully cover the incremental cost for a low NOx engines, the majority of the incremental cost of a BEB, and about half of the incremental cost of a FCEB. Additional amounts are potentially available to assist with needed infrastructure including up to $30,000 for chargers and up to $100,000 per bus for the purchase of five or more fuel cell electric buses. To the extent that transit agencies take early action and utilize this program their costs would be lower than estimated in this analysis.

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[63] California Air Resources Board (CARB), Proposed Fiscal Year 2017-18 Funding Plan for Clean Transportation Incentives, released November 2017 (web link: https://www.arb.ca.gov/msprog/aqip/fundplan/proposed_1718_funding_plan_final.pdf, last accessed January 2018)

Table C14: Proposed HVIP Voucher Amounts for FY 17-18

Category	Base Amount[a]
Low NOx Engine (8.9 Liter)	$10,000
Zero Emission Bus (20 ft – 24 ft)	$80,000
Zero Emission Bus (25 ft – 29 ft)	$90,000
Zero Emission Bus (30 ft – 39 ft)	$120,000
Battery Electric Bus (40 ft – 59 ft)	$150,000
Battery Electric Bus (60 ft)	$175,000
Fuel Cell Electric Bus (⩾ 40 ft).	$300,000

[a] Up to $15,000 more for use in a DAC.

SB 350 – Clean Energy and Pollution Reduction Act of 2015

The California Public Utilities Commission (CPUC) is collaborating with CARB and the California Energy Commission (CEC) to implement requirements set forth by California Senate Bill (SB) 350 to support widespread transportation electrification. Three major investor owned utilities (IOU) have proposed over $750 million worth of investments in infrastructure to support transportation electrification that could offset most of the costs of making electrical service upgrades and installing charging infrastructure for ZEBs over a 5-year period. The CPUC issued its first proposed decision approving 15 of the IOUs' transportation electrification "priority review" pilot projects[64] that could be implemented quickly. San Diego Gas and Electric in January 2018 also submitted a subsequent proposal to allocate and additional $150 million to support heavy duty transportation electrification for consideration by the CPUC. Some of the priority review projects directly benefit transit agencies and if the proposed five year programs are approved this year, they have the potential to offset most or all of the infrastructure upgrade and charger costs for transit agencies over a 5 year period. If approved the costs to transit agencies would be lower than estimated in this cost analysis.

Volkswagen Environmental Mitigation Trust

The Volkswagen Environmental Mitigation Trust provides California approximately $423 million to fund specified eligible actions to mitigate the lifetime excess NOx emissions caused by Volkswagen's emissions test defeat device. CARB is proposing to allocate $130 million for zero emission transit buses, school buses and airport shuttle buses. To the extent that transit agencies take advantage of these funds by taking early action, their direct costs would be reduced.

Low Carbon Transit Operations Program

The Low Carbon Transit Operations Program (LCTOP) was created to provide operating and capital assistance for transit agencies to reduce GHG emissions and improve mobility, with a priority on serving disadvantaged communities. Approved projects in LCTOP will support new or expanded bus or rail services, expand intermodal transit facilities, and may include equipment acquisition, fueling, maintenance and other costs to operate those services or facilities, with each project reducing GHG emissions. Five percent of the annual auction

[64] California Public Utilities Commission (CUPC), Decision on the Transportation Electrification Priority Review Projects, released November 2017 (we link: http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M198/K874/198874393.PDF, last accessed January 2018)

proceeds in the Greenhouse Gas Reduction Fund (GGRF) are continuously appropriated for LCTOP. To the extent that transit agencies take early action and utilize this program their costs would be lower than estimated in this analysis

Transit and Intercity Rail Capital Program

The Transit and Intercity Rail Capital Program (TIRCP) provides grants from the GGRF to fund transformative capital improvements that will modernize California's intercity, commuter, and urban rail systems, and bus and ferry transit systems, to significantly reduce GHG emissions, vehicle miles traveled, and congestion. To the extent that transit agencies take early action and utilize this program their costs would be lower than estimated in this analysis.

D. FISCAL IMPACTS

1. Local Government

The proposed ICT regulation directly impacts public transit agencies. Transit services are typically operated by cities, local transportation or transit authorities. The revenues of transit agencies come from different sources, including federal grants, local grants, local taxes, and operating revenues (e.g., fares, advertising sales).

The fiscal impact to local governments and transit agencies is a net positive. In the short run, the cash flows from higher capital investments needed to deploy ZEBs and related infrastructure affect local government and transit agency annual budget and resource allocations. In the longer run, the total direct cost to transit agencies due to the proposed ICT regulation result in annual savings and would affect the resource allocation for regional planning and paying off debt. The annual total direct costs of the proposed ICT regulation to transit agencies relative to the baseline and the “current conditions” from 2020 to 2043 are summarized in Table D1.

Table D1: Estimated Total Direct Costs of the Proposed ICT Regulation to Transit Agencies Relative to the Baseline and the Current Conditions (million 2016$)

Year	Relative to the Baseline	Relative to the Current Conditions
2020	$70	$74
2021	$46	$48
2022	$42	$41
2023	$108	$105
2024	$87	$82
2025	$84	$76
2026	$149	$135
2027	$124	$100
2028	$92	$69
2029	$123	$102
2030	$97	$78
2031	$64	$49
2032	$43	$30
2033	$12	-$3
2034	-$47	-$60
2035	-$66	-$77
2036	-$81	-$90
2037	-$134	-$140
2038	-$160	-$165
2039	-$186	-$188
2040	-$232	-$232
2041	-$239	-$239
2042	-$255	-$255
2043	-$286	-$286
Total*	-$546	-$747

* Totals may not add due to rounding

Table D1 shows that at the beginning of the proposed ICT regulation adoption (2020-2030), the annual costs are higher relative to both the baseline and the current condition, mainly because of the gradual phase-in of ZEBs and associated service upgrades and infrastructure installation. After 2033, the cost savings begin to outweigh the incremental capital costs of adding ZEBs due to the lower annual O&M expenditures and revenues earned with credits from the LCFS program[65].

[65] The revenue from the LCFS program for dispensing CNG decreases over time, and become zero after 2024 due to the decrease in carbon intensity benchmark.

A ZEB has a higher upfront cost than a conventional bus that can be offset with operational savings over the life of the bus and results in a net positive for the transit agency even without grants. Local agencies will need to determine how to address the higher costs bus purchase costs and infrastructure. Grant funding is available now to significantly reduce the initial cost of deploying ZEBs and additional incentives are being proposed. Additional grant funding sources discussed in section C.5 may help address the incremental costs of the proposed ICT regulation. Local agencies may also need to consider alternative methods to purchase buses including battery lease arrangements that eliminate the higher bus costs and can be repaid with operational savings. In some cases, local governments or transit agencies may need to augment grant funding to address the remaining incremental costs. Local governments or transit agencies may need to reallocate revenue resources among different municipality services or transportation programs to comply with the proposed ICT regulation. As discussed in section C.1.c, it is expected that the reduced annual O&M expenditures from deploying an increasing number of ZEBs will offset some of the incremental costs of future bus purchases.

2. State Government

a. CARB

The ICT proposal would have small impact on staffing resources and would require one additional person year for developing a reporting system prior to initial reporting in 2020, assisting transit agencies with compliance, and annual reporting, disseminating information to transit fleets and for enforcement including audit of reported information and site visits to confirm vehicle equipment. The cost of the position is estimated to be $165,000 in 2019, and $164,000 every year afterwards.

b. Other State Agencies

The ICT proposal would affect transit agencies and is not expected to have adverse impacts on other state agencies. The implementation of the proposed ICT regulation will help ensure the accountability, and enhance the scalability of the implementation of SB 350.

c. Cost-savings from Avoided Health Impacts

With the reduction in $PM_{2.5}$ and NO_x emissions and improvement in air quality, it is expected that the state will benefit from fewer employee sick days and a reduction in public hospital and emergency room visits. The proposed ICT regulations will lead to some cost-savings. Based on the spatial distribution of emissions reductions and associated health benefits (Tables B2-B4), most avoided hospitalizations and ER visit cost-savings will occur in the South Coast and San Francisco Bay air basins. The state will also benefit from a greater ability to attain regional air quality goals.

E. MACROECONOMIC IMPACTS

1. Methodology for Determining Economic Impacts

Section E estimates the cumulative impact of the proposed ICT regulation on the California economy. The proposed ICT regulation result in changes in expenditures by California transit agencies which affects employment, output, and investment in sectors that supply goods and services in support of public transportation operations. These lead to additional induced effects, like changes in personal income that affect consumer expenditures across other spending categories. The incremental impacts of the proposed ICT regulation are modeled relative to the baseline and the "current conditions" using the cost data described in Section C. The analysis focuses on the incremental changes in major macroeconomic indicators from 2020 through 2045[66] including employment, growth, and gross state product (GSP). The years of the analysis are used to simulate the proposed amendments through 12 months post full implementation.

Regional Economic Models, Inc. (REMI) Policy Insight Plus Version 2.1.1 is used to estimate the macroeconomic impacts of the proposed ICT regulation on the California economy. REMI is a structural economic forecasting and policy analysis model that integrates input-output, computable general equilibrium, econometric and economic geography methodologies. REMI Policy Insight Plus provides year-by-year estimates of the total impacts of the proposed ICT regulation, pursuant to the requirements of SB 617[67] and the California Department of Finance.[68] CARB uses the REMI single-region, 160-sector model with the model reference case adjusted to reflect the Department of Finance conforming forecasts dated June 2017. These forecasts include California population figures, U.S. real GDP forecast, and civilian employment growth numbers.

2. REMI Inputs

The estimated economic impacts of the proposed ICT regulation are sensitive to modeling assumptions. This section provides a summary of the assumptions used to determine the suite of policy variables that best reflect the macroeconomic impacts of the proposed ICT regulation. The costs and benefits of the proposed ICT regulation estimated in Section C are translated into REMI policy variables and used as inputs for the macroeconomic analysis.[69] Estimated changes to local government spending for capital purchases and operating and maintenance as a result of the proposed ICT regulation are input into REMI as a change in local government spending. The analysis in Section C shows that, in general, net local government spending will increase in early years as initial capital investments, including ZEBs and charging infrastructure, outweigh operational savings until 2033, relative to the "current

[66] Macroeconomic impacts through 2043 are used to simulate proposed amendments through 12 months post full implementation, however, macroeconomic impacts are shown through 2045.

[67] http://dof.ca.gov/Forecasting/Economics/Major_Regulations/SB_617_Rulemaking_Documents/documents/Section%202000%20ISOR%201%20sb_617_bill_20111006_chaptered.pdf

[68] http://dof.ca.gov/Forecasting/Economics/Major_Regulations/SB_617_Rulemaking_Documents/documents/Order_of_Adoption-1.pdf

[69] Refer to Section G: Macroeconomic Appendix for a full list of REMI inputs for this analysis.

conditions," and 2034, relative to the baseline. After these years, anticipated operational savings and LCFS credit generation grows to exceed the annual expenditures of ZEB technologies resulting a net saving under the proposed ICT regulation. Figure C5 shows the estimated change in spending by transit agencies by year, modeled in REMI using the local government spending variable.

The proposed ICT regulation requires the addition of one CARB staff to develop a reporting system, disseminate information to transit fleets for enforcement, and perform site visits to confirm vehicle equipment. One State employee was input into REMI beginning in 2020 for the proposed ICT regulation under both the baseline and "current conditions" scenarios. Figure C5 breaks down the changes in each spending category. Spending changes result in indirect impacts to secondary industries that are affected by the proposed amendments.

Manufacturers of transit buses that meet the requirements of the proposed ICT regulation are expected to see an increase in demand as a result of the ZEB phase-in schedule outlined in Table C2. The analysis assumes that many of conventional bus manufacturers will simply shift their operations to ZEB manufacturing to accommodate the increased demand for ZEB technologies. The incremental spending on ZEBs by California transit agencies, as compared to their conventional counterparts, are modeled as an increase in demand to the motor vehicle manufacturing industry, illustrating the demand for increased output for higher value buses.

Infrastructure installation impacts multiple industries during installation and through ongoing maintenance. Generally, infrastructure capital is modeled as an increase in demand for electrical equipment manufacturing and basic chemical manufacturing, illustrating an increased demand for electric charging and hydrogen fueling stations. Infrastructure installation will be contracted out to engineers and other technical specialists, as well as the industry representing support activities for transportation services. These two industries will see an increase in demand for services as ZEB infrastructure is installed.

Operating and maintenance expenditures will be also be altered as ZEB buses are phased-in to the California bus fleet. Spending on conventional fuels will decline, reducing demand for the oil and gas extraction and natural gas industries. This cost saving will be offset by the increase in demand for electricity and hydrogen fuels. Maintenance expenditures are expected to decline, as ZEB technologies are assumed to require less maintenance than their conventional counterparts. This is modeled as a reduction in demand for automobile repair and maintenance services. Incremental expenditures for operating and maintenance decline significantly for the proposed ICT regulation relative to the baseline and "current conditions" scenario.

LCFS credits are generated through the operation of CNG buses, BEBs, and FCEBs, as outlined in Section C. LCFS credit revenue is modeled as a cost saving for transit agencies and an increase in production cost for the oil and gas extraction industry, simulating the compliance cost of purchasing LCFS credits.

The proposed ICT regulation is anticipated to reduce hospitalizations and emergency room visits through estimated reductions in $PM_{2.5}$ and NOx emissions. The cost savings from reduced hospital and emergency room visits are calculated in Section B-Benefits. The cumulative monetized health savings result in an indirect impact on individuals from 2020 through 2043, valued at $267,000-290,000, depending on the modeling scenario, and is input into REMI as a reduction in annual consumer spending on hospitals.

3. Results of the Assessment

The REMI output provides the impact of the proposed ICT regulation on the California economy, and is presented as the annual incremental change from the proposed ICT regulation relative to the baseline and “current conditions” scenario. The California economy is anticipated to grow through 2043, therefore, negative impacts reported here should be interpreted as a slowing of growth and positive impacts as an increase in the rate of growth resulting from the proposed ICT regulation relative to the baseline and “current conditions” scenario.

a. California Employment Impacts

Table E1 and E2 present the impact of the proposed ICT regulation on total employment in California across all industries. As modeled, the proposed ICT regulation is anticipated to result in a negligible decrease in total employment growth in the early years of the assessment as ZEBs are purchased and infrastructure installed. Employment growth begins to increase in later years as operating and maintenance savings begin to outweigh capital costs, however, the change is indiscernible from employment levels under either modeling scenario.

Table E1: Estimated Change in California Employment Growth Relative to the Baseline

	2020	2025	2030	2035	2040	2045
Employment (Million Jobs)	23.4	24.4	25.4	26.4	27.5	28.6
% Change	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%
Change in Total Jobs	-1300	-1400	-1750	-150	1150	1200

The value for percent change and total change in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 50.

Table E2: Estimated Change in California Employment Growth Relative to Current Conditions

	2020	2025	2030	2035	2040	2045
Employment (Million Jobs)	23.7	24.7	25.7	26.7	27.8	28.9
% Change	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%
Change in Total Jobs	-1450	-1400	-1700	-100	1000	1100

The value for percent change and total change in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 100.

Table E3 and E4 break out the changes in employment growth[70] for local government and secondary industries impacted by the proposed ICT regulation. Employment growth slows very minimally for local government during the early years of the assessment as transit agencies begin phasing-in ZEB technologies. In later years, as operating and maintenance spending decreases, local government sees positive, though small, employment growth relative to the baseline and “current conditions” scenarios. The REMI model makes assumptions about local government employment as it relates to local government spending. Because transit agencies are anticipated to spend less in the later years of the analysis, the model assumes that local government spending will shift monetary resources and increase local government employment as operational savings cumulate which is illustrated by the employment growth in later years of the analysis under both modeling scenarios. The change in employment growth, however, would represent no noticeable change, as local government is anticipated to employ almost 2.1 million people in 2045.[71]

Industries that manufacture, install, and support ZEB technologies see employment growth at levels higher than both the baseline and “current conditions” scenarios. These industries include ZEB manufacturing, charging infrastructure manufacturing, engineering services, electricity generation, and hydrogen generation. As transit agencies begin the deployment of ZEBs, demand for maintenance and conventional fuels decline, corresponding with the slowing in employment growth that is anticipated in these industries.

[70] In the REMI model, employment comprises estimates of the number of jobs, full-time plus part-time, by place of work. Full-time and part-time jobs are counted at equal weight. Employees, sole proprietors, and active partners are included, but unpaid family workers and volunteers are not included.

[71] REMI forecasted employment levels for local government employees.

Table E3: Estimated Change in California Employment Growth Relative to the Baseline: Regulated Parties and Secondary Industries

		2020	2025	2030	2035	2040	2045
Local Government	% Change	-0.03%	-0.04%	-0.04%	0.02%	0.07%	0.09%
	Change in Jobs	-560	-690	-790	380	1470	1800
Secondary Industries (NAICS)[72]							
Motor Vehicle Manufacturing (3361)	% Change	0.06%	0.13%	0.23%	0.18%	0.13%	0.10%
	Change in Jobs	0	10	20	20	10	10
Other Electrical Equipment and Component Manufacturing (3359)	% Change	0.06%	-0.03%	0.12%	0.32%	0.33%	0.28%
	Change in Jobs	10	0	20	40	50	40
Automotive Repair and Maintenance (8111)	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	-10	-10	-10	0	0	0
Oil and Gas Extraction (211)	% Change	0.02%	-0.06%	-0.37%	-0.78%	-1.09%	-1.21%
	Change in Jobs	10	-30	-160	-340	-510	-580
Electric Power Generation, Transmission, and Distribution (2211)	% Change	-0.01%	0.04%	0.18%	0.32%	0.40%	0.41%
	Change in Jobs	0	10	50	80	90	70
Basic Chemical Manufacturing (3251)	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	0	0	0	0	0	0
Natural Gas Distribution (2212)	% Change	0.06%	-0.06%	-0.59%	-1.17%	-1.52%	-1.60%
	Change in Jobs	10	-10	-70	-120	-140	-130
Electrical Equipment Manufacturing (3353)	% Change	0.06%	0.14%	0.29%	0.19%	0.04%	-0.01%
	Change in Jobs	10	10	30	20	10	0
Support Activities for Transportation (488)	% Change	0.03%	0.10%	0.23%	0.18%	0.07%	0.03%
	Change in Jobs	40	120	290	240	100	40
Architectural, Engineering, and Related Services (5413)	% Change	0.00%	0.00%	-0.01%	0.00%	-0.01%	-0.01%
	Change in Jobs	0	-10	-20	-10	-20	-30

The value in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 10.

[72] The North American Industry Classification System (NAICS) classifies business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. economy. The NAICS industry codes define establishments based on the activities in which they are primarily engaged. https://www.census.gov/eos/www/naics/

Table E4: Estimated Change in California Employment Growth Relative to Current Conditions: Regulated Parties and Secondary Industries

		2020	2025	2030	2035	2040	2045
Local Government	% Change	-0.03%	-0.03%	-0.04%	0.02%	0.07%	0.09%
	Change in Jobs	-610	-640	-670	460	1470	1800
Secondary Industries							
Motor Vehicle Manufacturing (3361)	% Change	0.08%	0.14%	0.22%	0.17%	0.13%	0.10%
	Change in Jobs	10	10	20	20	10	10
Other Electrical Equipment and Component Manufacturing (3359)	% Change	0.08%	0.00%	0.14%	0.32%	0.33%	0.28%
	Change in Jobs	10	0	20	40	50	40
Automotive Repair and Maintenance (8111)	% Change	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	-10	-10	-10	0	0	0
Oil and Gas Extraction (211)	% Change	-0.01%	-0.12%	-0.43%	-0.82%	-1.10%	-1.21%
	Change in Jobs	-10	-50	-180	-360	-520	-590
Electric Power Generation, Transmission, and Distribution (2211)	% Change	0.00%	0.06%	0.19%	0.33%	0.40%	0.41%
	Change in Jobs	0	20	60	80	90	70
Basic Chemical Manufacturing (3251)	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	0	0	0	0	0	0
Natural Gas Distribution (2212)	% Change	-0.02%	-0.19%	-0.69%	-1.22%	-1.51%	-1.58%
	Change in Jobs	0	-20	-80	-120	-140	-130
Electrical Equipment Manufacturing (3353)	% Change	0.09%	0.16%	0.28%	0.19%	0.04%	-0.01%
	Change in Jobs	10	20	30	20	10	0
Support Activities for Transportation (488)	% Change	0.05%	0.12%	0.23%	0.18%	0.07%	0.03%
	Change in Jobs	60	140	290	240	100	40
Architectural, Engineering, and Related Services (5413)	% Change	0.00%	0.00%	-0.01%	0.00%	-0.01%	-0.01%
	Change in Jobs	-10	-10	-20	-20	-20	-30

The value in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 10.

b. California Business Impacts

Gross output is used as a proxy for business impacts because it is principally a measure of an industry's sales or receipts and tracks the quantity of goods or services produced in a given time period. Output growth, as defined in REMI, is the sum of output in each private industry and State and local government as it contributes to the state's gross domestic product (GDP), and is affected by production cost and demand changes. As production cost increases or demand decreases, output is expected to contract, but as production costs decline or demand increases, industry will likely experience output growth. Table E5 and E6 presents the estimated changes to output growth resulting from the proposed ICT regulation.

Secondary industries that manufacture or support ZEB technologies will see an increase in demand as a result of the proposed ICT regulation. This results in the expansion of output in affected ZEB and component manufacturing, electric generation, and support activities for transportation. Industries that see less demand as a result of the proposed ICT regulation do see a slight contraction in output growth. Operational savings from the proposed ICT regulation result in less demand for conventional fuels and maintenance, which is reflected in the individual industries' output growth forecast.

Industry trends often tend to suppress the impacts expected in the modeling output. Although maintenance expenditures are estimated to decrease under the proposed ICT regulation, the modeling output shows an increase in output growth in the industry for repair and maintenance. This is likely due to the interaction between motor vehicle manufacturing and automotive repair and maintenance where the model assumes that as motor vehicle manufacturing increases output, automotive repair and maintenance will also see an increase in output since they are complementary industries. This characterizes the tendency for REMI to produce positive output growth, when output growth in automotive repair and maintenance is expected to decline under the proposed ICT regulation.

REMI makes assumptions about regional supply, in that there may be discrepancies between the pattern of output and employment growth for a single industry. This is due to the embedded Regional Purchase Coefficients[73] that estimate the amount of demand that can be satisfied by local supply. For example, most manufacturing is likely to occur out of state, illustrating the minimal job growth in manufacturing industries. The estimated changes in output growth for most industries, however, follow similar trends to those in employment growth in secondary industries.

[73] Regional purchase coefficients represent the proportion of local demand that is supplied within the same region. In this case the REMI region is California, and the regional purchase coefficients directly impact the volume of imports and exports into the state.

Table E5: Estimated Change in California Output Growth Relative to the Baseline

Industry (NAICS)		2020	2025	2030	2035	2040	2045
Motor Vehicle Manufacturing (3361)	% Change	0.06%	0.13%	0.23%	0.18%	0.14%	0.10%
	Change (2016M$)	4.5	10.3	20.5	18.2	16.0	13.9
Other Electrical Equipment and Component Manufacturing (3359)	% Change	0.06%	-0.03%	0.12%	0.33%	0.34%	0.29%
	Change (2016M$)	2.8	-1.5	7.9	25.3	30.7	30.4
Automotive Repair and Maintenance (8111)	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-1.0	-0.8	-1.0	-0.1	0.7	0.7
Oil and Gas Extraction (211)	% Change	0.02%	-0.06%	-0.37%	-0.78%	-1.10%	-1.22%
	Change (2016M$)	2.0	-7.0	-44.2	-102.7	-160.1	-194.3
Electric Power Generation, Transmission, and Distribution (2211)	% Change	-0.01%	0.04%	0.18%	0.33%	0.41%	0.41%
	Change (2016M$)	-3.1	9.5	48.1	90.0	113.2	115.8
Basic Chemical Manufacturing (3251)	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-0.4	-0.2	0.0	0.5	0.6	0.3
Natural Gas Distribution (2212)	% Change	0.06%	-0.06%	-0.59%	-1.18%	-1.53%	-1.62%
	Change (2016M$)	5.1	-5.5	-55.3	-112.4	-149.1	-159.4
Electrical Equipment Manufacturing (3353)	% Change	0.06%	-0.03%	0.12%	0.33%	0.34%	0.29%
	Change (2016M$)	1.1	2.7	6.0	4.6	1.3	-0.2
Support Activities for Transportation (488)	% Change	0.03%	0.10%	0.23%	0.18%	0.07%	0.03%
	Change (2016M$)	6.5	22.5	57.5	51.6	23.4	10.1
Architectural, Engineering, and Related Services (5413)	% Change	0.00%	0.00%	-0.01%	0.00%	-0.01%	-0.01%
	Change (2016M$)	-0.8	-2.0	-3.3	-3.1	-4.8	-8.1

The value in each year is interpreted as the referenced year less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table E6: Estimated Change in California Output Growth Relative to Current Conditions

Industry (NAICS)		2020	2025	2030	2035	2040	2045
Motor Vehicle Manufacturing (3361)	% Change	0.08%	0.14%	0.23%	0.17%	0.13%	0.10%
	Change (2016M$)	6.4	11.7	20.3	18.0	15.8	13.7
Other Electrical Equipment and Component Manufacturing (3359)	% Change	0.09%	0.00%	0.14%	0.33%	0.34%	0.28%
	Change (2016M$)	4.4	-0.1	9.3	25.5	30.9	30.6
Automotive Repair and Maintenance (8111)	% Change	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-1.1	-0.8	-1.0	-0.1	0.6	0.6
Oil and Gas Extraction (211)	% Change	-0.01%	-0.12%	-0.43%	-0.82%	-1.11%	-1.22%
	Change (2016M$)	-1.4	-14.1	-51.9	-108.8	-163.5	-196.4
Electric Power Generation, Transmission, and Distribution (2211)	% Change	0.00%	0.06%	0.19%	0.33%	0.40%	0.41%
	Change (2016M$)	0.5	16.0	53.0	92.7	113.7	116.2
Basic Chemical Manufacturing (3251)	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-0.3	-0.1	0.0	0.5	0.5	0.3
Natural Gas Distribution (2212)	% Change	-0.02%	-0.19%	-0.70%	-1.22%	-1.52%	-1.60%
	Change (2016M$)	-2.1	-17.3	-65.6	-118.0	-149.5	-159.8
Electrical Equipment Manufacturing (3353)	% Change	0.09%	0.16%	0.29%	0.19%	0.05%	-0.01%
	Change (2016M$)	1.5	3.0	6.0	4.6	1.3	-0.2
Support Activities for Transportation (488)	% Change	0.05%	0.12%	0.23%	0.18%	0.07%	0.03%
	Change (2016M$)	10.1	25.7	58.3	52.2	23.3	10.0
Architectural, Engineering, and Related Services (5413)	% Change	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%
	Change (2016M$)	-1.2	-2.3	-3.7	-3.7	-5.4	-8.6

The value in each year is interpreted as the referenced year less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

c. Impacts on Investments in California

Private domestic investment consists of purchases of residential and nonresidential structures and of equipment and software by private businesses and nonprofit institutions. It is used as a proxy for impacts on investments in California because it provides an indicator of the future productive capacity of the economy. Table E7 and E8 present the gross private domestic investment level in California under the prosed ICT regulation, as well as the impact of the proposed ICT regulation on gross private domestic investment growth.

The induced demand for ZEB technologies by the transit agencies is not likely responsible for the overall decrease in gross domestic private investment for the proposed ICT regulation. As modeled, the proposed ICT regulation shows a slight decrease in investment growth, likely driven by the cumulative changes in government demand across multiple industries as ZEB technologies are phased in. The relative changes to growth in private investment, however, are indiscernible from the baseline in either modeling scenario, never exceeding a change of more than 0.1 percent in any one year.

Table E7: Estimated Change in Gross Domestic Private Investment Growth Relative to the Baseline

	2020	2025	2030	2035	2040	2045
Private Investment (2016B$)	382.7	446.1	508.5	590.8	677.1	782.8
% Change	0.00%	-0.01%	-0.02%	-0.03%	-0.04%	-0.05%
Change (2016M$)	-15.9	-31.3	-91.4	-169.2	-280.0	-389.3

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table E8: Estimated Change in Gross Domestic Private Investment Growth Relative to Current Conditions

	2020	2025	2030	2035	2040	2045
Private Investment (2016B$)	391.4	454.4	517.9	602.1	690.5	798.5
% Change	-0.01%	-0.01%	-0.02%	-0.03%	-0.04%	-0.05%
Change (2016M$)	-27.5	-46.9	-109.8	-187.5	-294.4	-401.6

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

d. Impacts on Individuals in California

The proposed amendments will impose no direct costs on California individuals, and produce no noticeable change in personal income growth in any year of the assessment. Table E9 and E10 show that the annual change in growth of personal income through 2045 varies less than 0.1 percent relative to both modeling scenarios. This amounts to roughly $1 per person increase in personal income under the proposed ICT regulation in 2045,[74] relative to either modeling scenario. The minimal reduction in personal income growth in the early years of this assessment is likely due to the contraction of local government spending, as a result of contributing more general funds to transit agencies in support of ZEB capital purchases. This spending contraction would reduce spending across all local government expenditure categories, indirectly impacting personal income through the decrease in demand for goods and services by local government. Although personal income growth is positive in the later years of the assessment, the relative change in either modeling scenario is considered negligible in all years of the assessment.

Table E9: Estimated Change in Personal Income Growth Relative to the Baseline

	2020	2025	2030	2035	2040	2045
Personal Income (2016B$)	2329.7	2600.5	2893.9	3257.5	3690.7	4211.1
% Change	0.00%	0.00%	-0.01%	0.00%	0.00%	0.00%
Change (2016M$)	-90.6	-103.2	-154.9	-66.0	39.8	55.2

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table E10: Estimated Change in Personal Income Growth Relative to Current Conditions

	2020	2025	2030	2035	2040	2045
Personal Income (2016B$)	2337.7	2616.7	2912.1	3277.9	3714.9	4238.6
% Change	0.00%	0.00%	-0.01%	0.00%	0.00%	0.00%
Change (2016M$)	-103.9	-109.8	-153.4	-67.6	31.3	46.1

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

e. Impacts on Gross State Product (GSP)

GSP is the market value of all goods and services produced in California and is one of the primary indicators used to gauge the health of an economy. Under the proposed ICT regulation, GSP growth is anticipated to decline slightly compared to both baselines as a result of changes in expenditures by transit agencies. GSP grows slightly slower under the proposed ICT regulation than either baseline in all years of the assessment. This analysis indicates the impact of the proposed ICT regulation on GSP is indiscernible in California's estimated $4.9 trillion economy in 2045.[75]

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[74] Based on California Department of Finance State population projections, http://www.dof.ca.gov/Forecasting/Demographics/Projections/documents/P1_County_1yr_interim.xlsx. Accessed March 1st, 2018.
[75] This GSP forecast is estimated in the REMI model using the default U.S. Bureau of Economic Analysis data, including the DOF calibration dated June 2017.

Table E11: Estimated Change in Gross State Product Growth Relative to the Baseline

	2020	2025	2030	2035	2040	2045
GSP (2016B$)	2616.2	2966.6	3341.6	3779.5	4277.8	4842.5
% Change	0.00%	0.00%	-0.01%	0.00%	0.00%	0.00%
Change (2016M$)	-121.0	-144.8	-228.9	-117.0	-38.0	-77.1

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table E12: Estimated Change in Gross State Product Growth Relative to Current Conditions

	2020	2025	2030	2035	2040	2045
GSP (2016B$)	2647.6	3002.9	3382.4	3825.7	4330.1	4901.9
% Change	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%
Change (2016M$)	-141.5	-158.5	-234.6	-128.8	-57.1	-91.6

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

f. Incentives for Innovation

Due to the proposed ICT regulation, there is anticipated to be growth in the industries that manufacture ZEB technologies, including the manufacturing industry for ZEB infrastructure and parts. There is still opportunity to improve upon existing technologies as there have been steady advancements in electric and fuel cell buses historically, which staff assumes will continue throughout the life of the Transit Fleet Rule.

g. Competitive Advantage or Disadvantage

The proposed ICT regulation imposes requirements on California transit agencies that are publically owned and operated. There are no transit agencies anticipated to enter the public transportation market, giving no explicit competitive advantage or disadvantage to California transit agencies.

h. Creation or Elimination of Business

CARB expects the proposed ICT regulation to provide incentives for the expansion of zero emission bus and bus component manufacturing. Business creation can occur both in-state and out-of-state, however, many manufacturers of ZEBs and component suppliers are already operating in California. This growth is estimated to increase major economic indicators discussed previously (GSP, personal income, and employment growth), which is anticipated to expand businesses through the implementation of the proposed ICT regulation. This is supported by the increases in output growth among most secondary industries impacted in this analysis, as outlined in Table E5 and E6. This growth strengthens market reliability for the phase-in of ZEB technologies throughout all years in this analysis.

4. Summary and Agency Interpretation of the Assessment Results

California transit agencies will be faced with higher operating costs during the early years of implementation of the proposed ICT regulation, but will ultimately see reduced operational spending in later years as fuel savings and LCFS credit generation grow. As transit agencies implement these changes, demand for goods and services in supporting industries will benefit as a result of phasing in ZEB technology in public transportation systems across the State.

As modeled, CARB estimates the proposed ICT regulation is unlikely to have a significant impact on the California economy. The results show that purchases made by transit agencies have a positive impact on many industries, and that the transition from conventional technologies to zero emission technologies will bring many indirect and induced economic benefits to California.

F. ALTERNATIVES

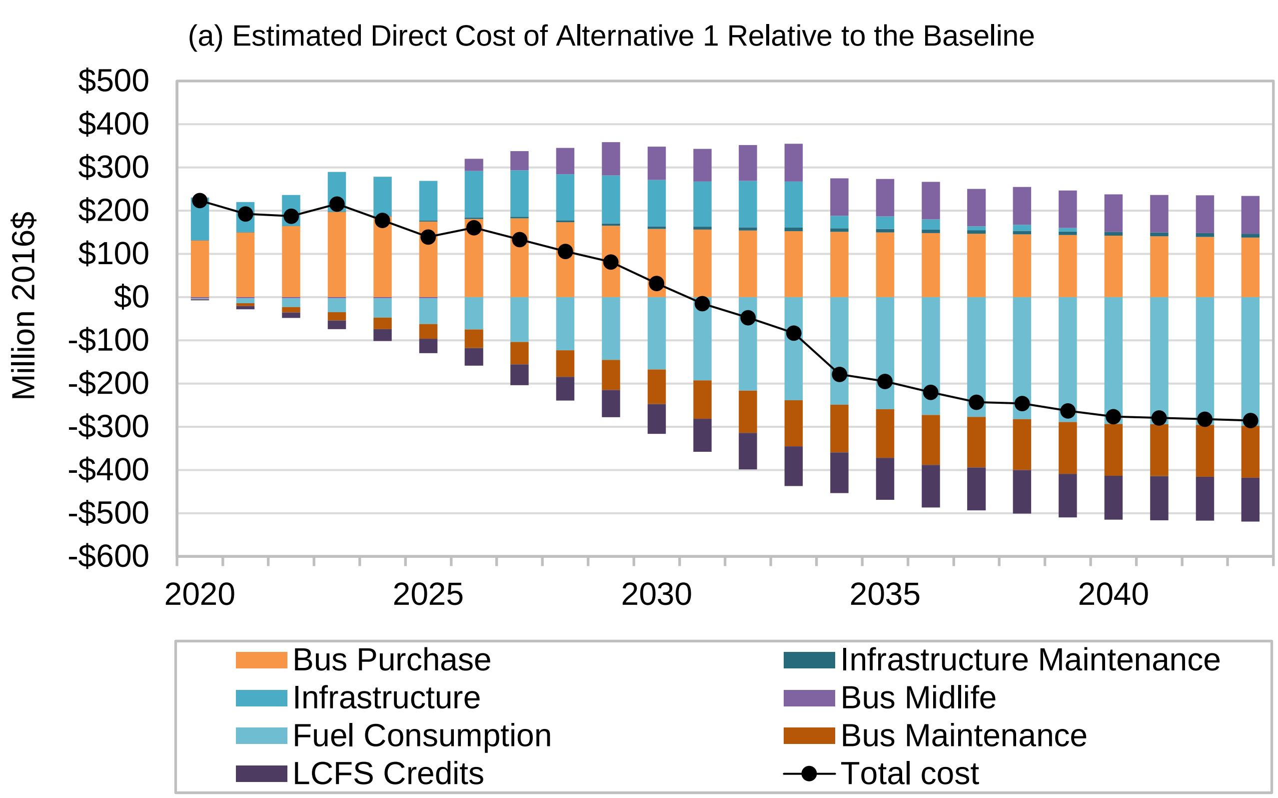
1. Alternative 1: Higher ZEB purchase requirement starting 2020

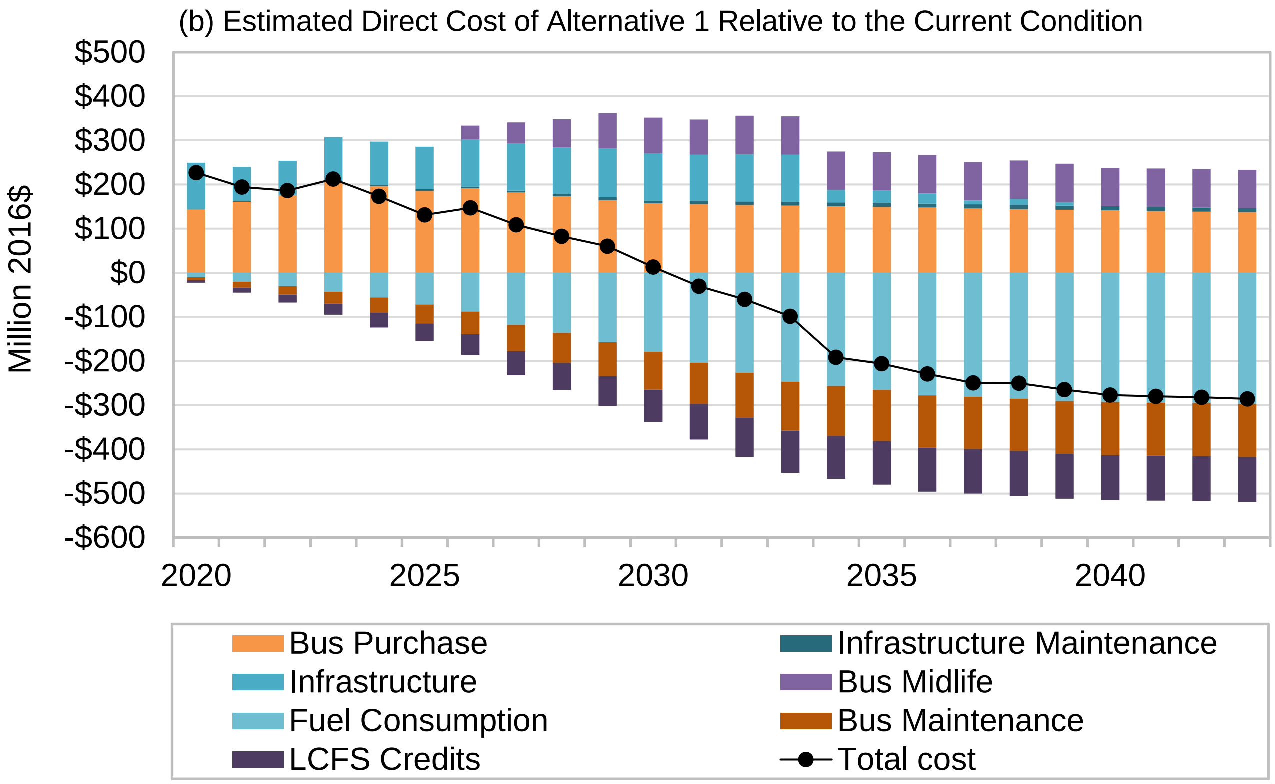
Alternative 1 includes a more aggressive ZEB purchase requirement than the proposed ICT regulation. Under this alternative, starting 2020, large transit agencies with more than 100 buses would need to purchase 100 percent ZEB when bus purchases are made. This requirement would apply to medium size transit fleets starting 2023. In 2026, the requirement would apply to all transit agencies (including smaller transits). The end result of reaching 100 percent of new bus purchases remains the same but would occur earlier than planned. Other aspects of the proposed ICT regulation would remain unchanged.

a. Costs (Total and Incremental)

The total direct cost to transit agencies under to Alternative 1 is the summation of the cost of bus purchase, midlife, maintenance, fuel consumption, infrastructure, and LCFS credit. Figure F1 provides a breakdown of the estimated annual direct costs to transit agencies. From 2020 through 2043, Alternative 1 is estimated to increase initial capital costs to about $200 million per year in 2021 to 2025, but will result in total costs that are $967million lower and $1,168 million lower relative to the baseline and the “current conditions” scenario, respectively. However, the incremental capital costs of buses and infrastructure would be much higher than the proposed ICT regulation in the first 10 years.

Figure F1: Estimated Total Direct Costs of Alternative 1 to Transit Agencies Relative to the Baseline and the Current Conditions (million 2016$)



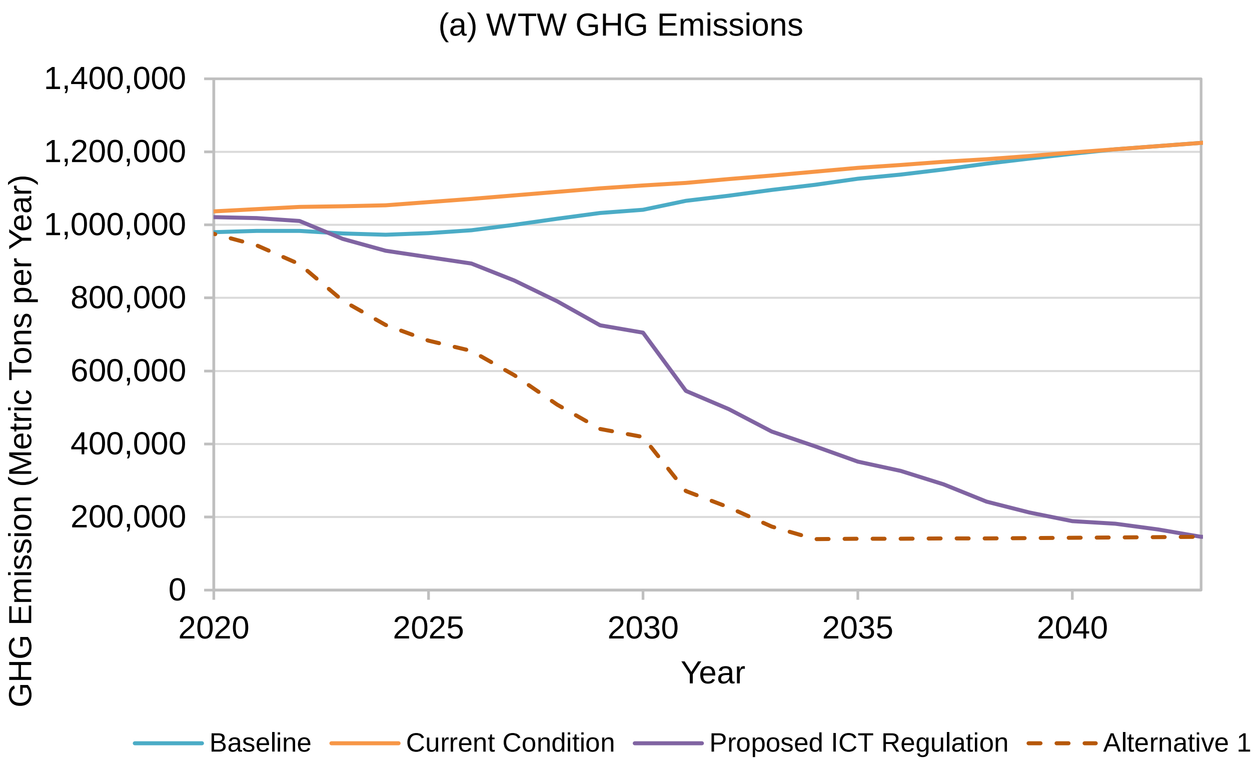


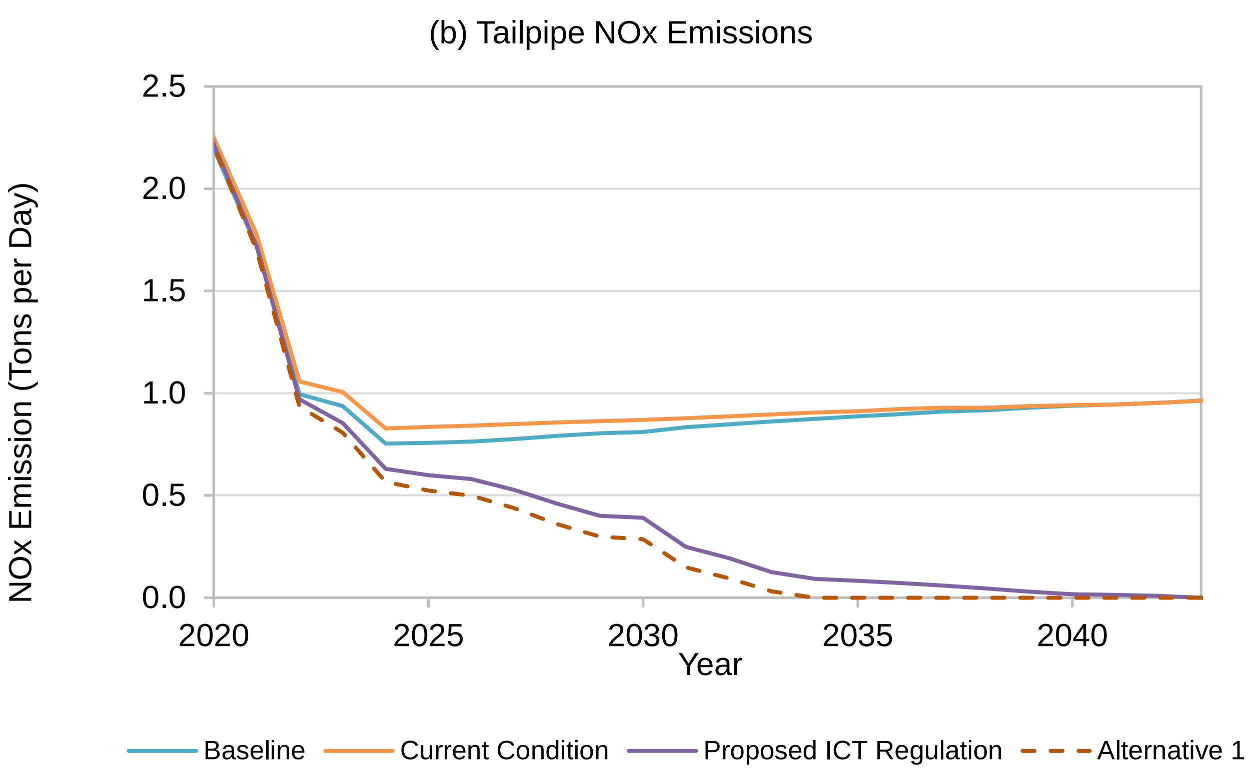
b. Benefits (Total and Incremental)

Alternative 1 provides additional WTW GHG, and tailpipe NOx and $PM_{2.5}$ emissions reductions and additional improvements in local air quality compared to the proposed ICT regulation, which lead to additional health benefits. Figure F2 summarizes the total WTW GHG, tailpipe NOx and $PM_{2.5}$ emissions under the baseline and the "current conditions," the proposed ICT regulation, and Alternative 1. The cumulative GHG emission reductions for Alternative 1 relative to the baseline and the "current conditions" are 16.2 MMT CO_2e and 17.3 MMT CO2e respectively from 2020 to 2043. Compared to the proposed ICT regulation, this is an increase in anticipated cumulative GHG reductions of around 4.1 MMT CO2e.

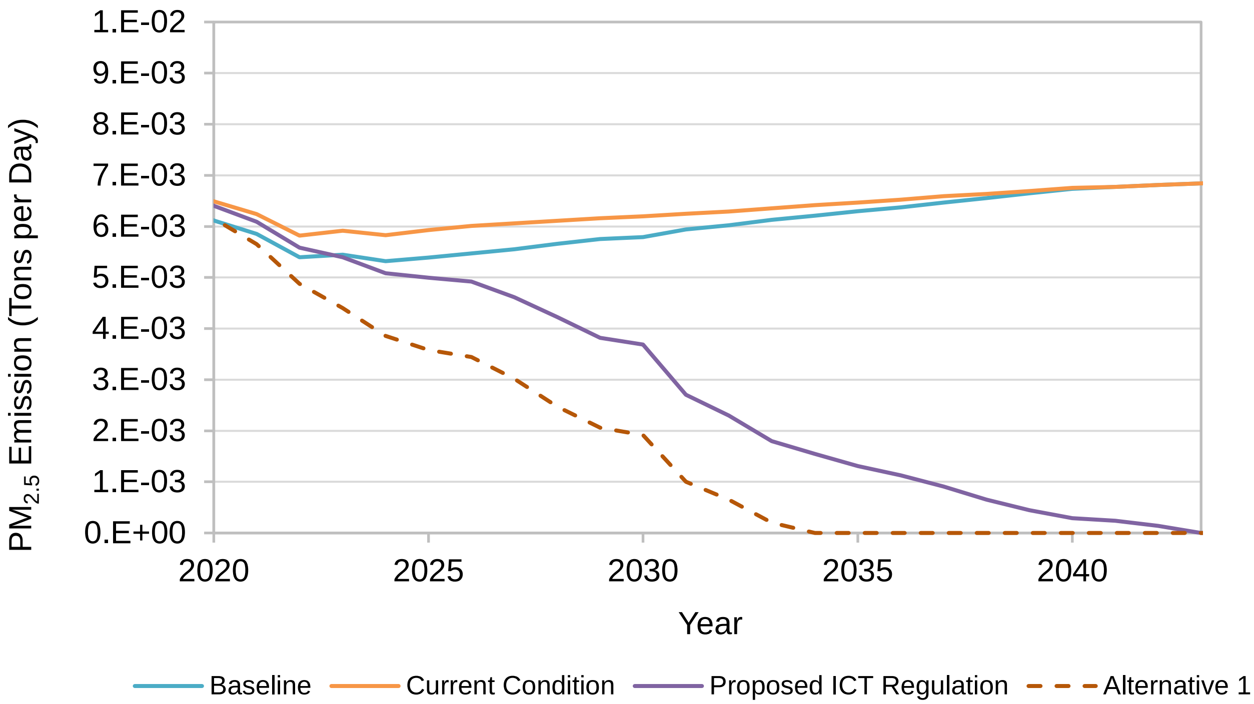
For tailpipe NOx and $PM_{2.5}$, Alternative 1 is expected to deliver an estimated 4,633 tons and 33 tons emission benefits from 2020 to 2043 when compared with the baseline, and 4,950 tons and 36 tons when compared with the "current conditions". When compared to the proposed ICT regulation, Alternative 1 is expected to further reduce NOx emissions by about 474 tons and $PM_{2.5}$ emission by about 8 tons cumulatively from 2020 to 2043.

Figure F2: Estimated WTW GHG, and Tailpipe NOx and $PM_{2.5}$ Emissions under the Baseline, the Current Conditions, the Proposed ICT Regulation, and Alternative 1





(c) Tailpipe $PM_{2.5}$ Emissions



c. *Economic Impacts*

Alternative 1 results in higher costs to transit agencies in the early years of implementation, with higher cumulative cost savings as a result of operating a larger proportion of ZEBs sooner than the phase-in requirements outlined in the proposed ICT regulation. Under Alternative 1, GSP is estimated to grow slower in all years of the assessment, as the more stringent purchase requirement increases operating costs for transit agencies under the baseline and "current conditions" scenarios. Growth in personal income and employment are estimated to be roughly the same or slightly worse off under Alternative 1. Private investment follows the same trend as GSP, likely resulting from REMI's assumption that most buses and their associated charging infrastructure are imported from out of state manufacturers. Health impacts are larger under Alternative 1, as emission reductions are greater as a result of more stringent purchase requirements. As modeled, the macroeconomic impacts are not considerably different from the estimated impacts under the proposed ICT regulation, and are presented in Table F1 and F2.

Table F1: Change in Growth of Economic Indicators for Alternative 1 Relative to the Baseline

		2020	2025	2030	2035	2040	2045
GSP	% Change	-0.02%	-0.01%	-0.01%	0.00%	0.00%	0.00%
	Change (2016M$)	-407.3	-280.6	-209.5	-53.7	-71.5	-120.1
Personal Income	% Change	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%
	Change (2016M$)	-300.9	-202.0	-145.8	-10.8	36.5	30.6
Employment	% Change	-0.02%	-0.01%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	-4175	-2525	-1250	825	1150	1000
Private Investment	% Change	-0.02%	-0.02%	-0.03%	-0.04%	-0.05%	-0.05%
	Change (2016M$)	-72.4	-83.7	-138.3	-231.1	-341.9	-426.8

The value in each year is interpreted as the reference year value less the baseline value in that same year. The change in jobs is rounded to the nearest 25, while the dollar values are rounded to the nearest $100,000.

Table F2: Change in Growth of Economic Indicators for Alternative 1 Relative to the Current Conditions

		2020	2025	2030	2035	2040	2045
GSP	% Change	-0.02%	-0.01%	-0.01%	0.00%	0.00%	0.00%
	Change (2016M$)	-425.5	-290.1	-207.4	-59.1	-83.3	-124.2
Personal Income	% Change	-0.02%	-0.01%	-0.01%	0.00%	0.00%	0.00%
	Change (2016M$)	-312.9	-206.0	-139.5	-9.5	30.5	27.0
Employment	% Change	-0.02%	-0.01%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	-4300	-2525	-1125	850	1075	975
Private Investment	% Change	-0.02%	-0.02%	-0.03%	-0.04%	-0.05%	-0.05%
	Change (2016M$)	-83.6	-98.1	-154.1	-246.2	-351.4	-430.5

The value in each year is interpreted as the reference year value less the baseline value in that same year. The change in jobs is rounded to the nearest 25, while the dollar values are rounded to the nearest $100,000.

d. Cost-Effectiveness

Cost-effectiveness is defined as the cost to achieve a ton of emission reduction. In the case of Alternative 1, the total cost from 2020 to 2043 is lower than the proposed ICT regulation and would achieve more emission reductions. Alternative 1 is a more cost effective alternative when compared to the proposed ICT regulation.

e. Reason for Rejecting

This Alternative 1 is rejected because it is infeasible to carry out statewide. Alternative 1 quadruples the number of ZEBs that are required in 2020 to 2023 and eliminates funding opportunities for transit agencies. Alternative 1 increases the annual costs to about $200 million per year from 2020 to 2023 and eliminates opportunities for transit agencies to act early and use incentive funding to reduce their costs; whereas, the annual costs of the proposed ICT regulation in the same time period is about $50 million per year and provides opportunities for transit agencies to lower their cost with existing funding programs. The costs of Alternative 1 in combination with limited access to funding programs make unlikely for transit agencies to find sufficient funds to continue normal bus purchase patterns.

Ensuring that transit agencies have adequate opportunities to secure capital funds minimize the potential for transit agencies to keep high emitting buses longer or for service to be reduced. The emissions impact from continuing the use of older engines could be counter-productive to the goal of reducing emissions because older engines have much higher NOx and PM emissions than new engines. Alternative 1 is deemed to be infeasible due to the initial costs. Alternative 1, is rejected because the early costs would likely result in extending the use of dirty engines or reductions in transit service which would delay emissions reductions.

2. Alternative 2: Low NOx CNG bus and renewable natural gas purchase requirement starting 2020

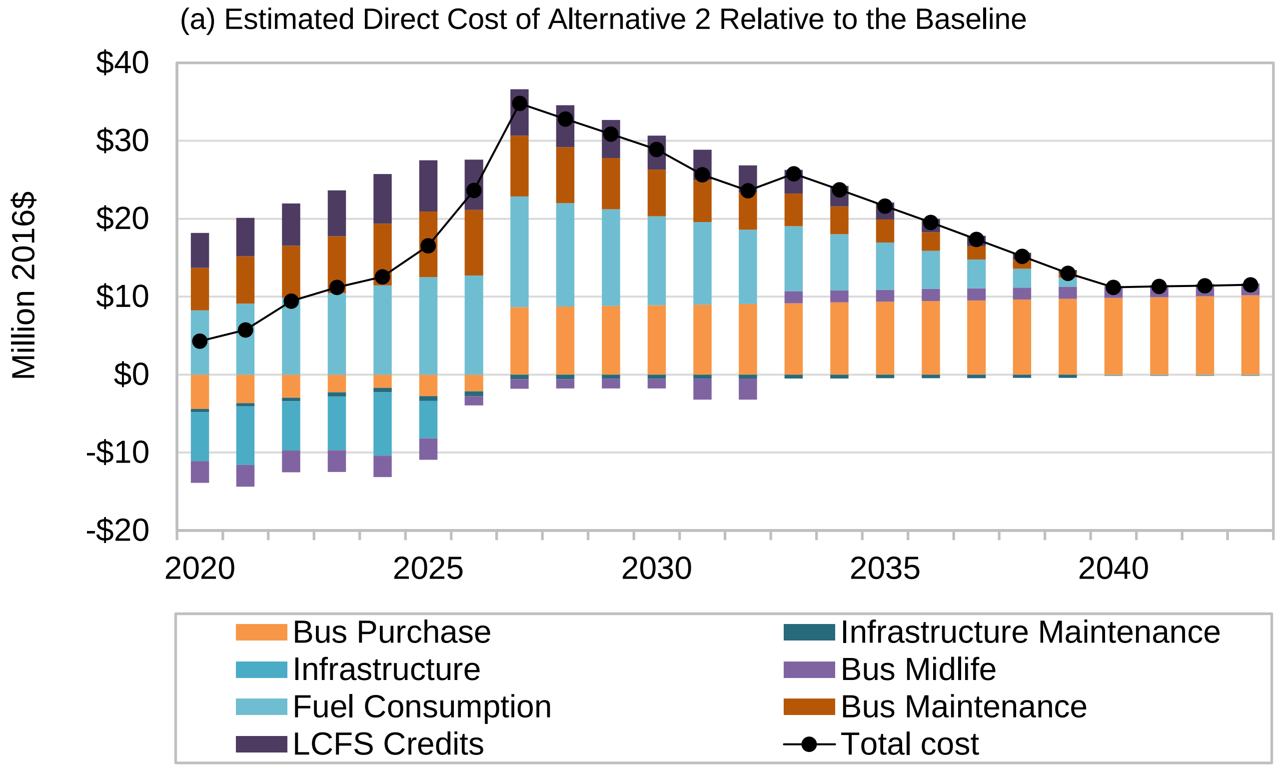
Alternative 2 only includes a low NOx CNG bus purchase requirement starting in 2020, and does not include a ZEB purchase requirement. Under this alternative, starting in 2020, all CNG fleets are required to purchase low NOx CNG engines when bus purchases are made. In addition, large transit fleets are required to use renewable natural gas (RNG) but would not increase the amount of RNG used in California than is already expected with the LCFS regulation.

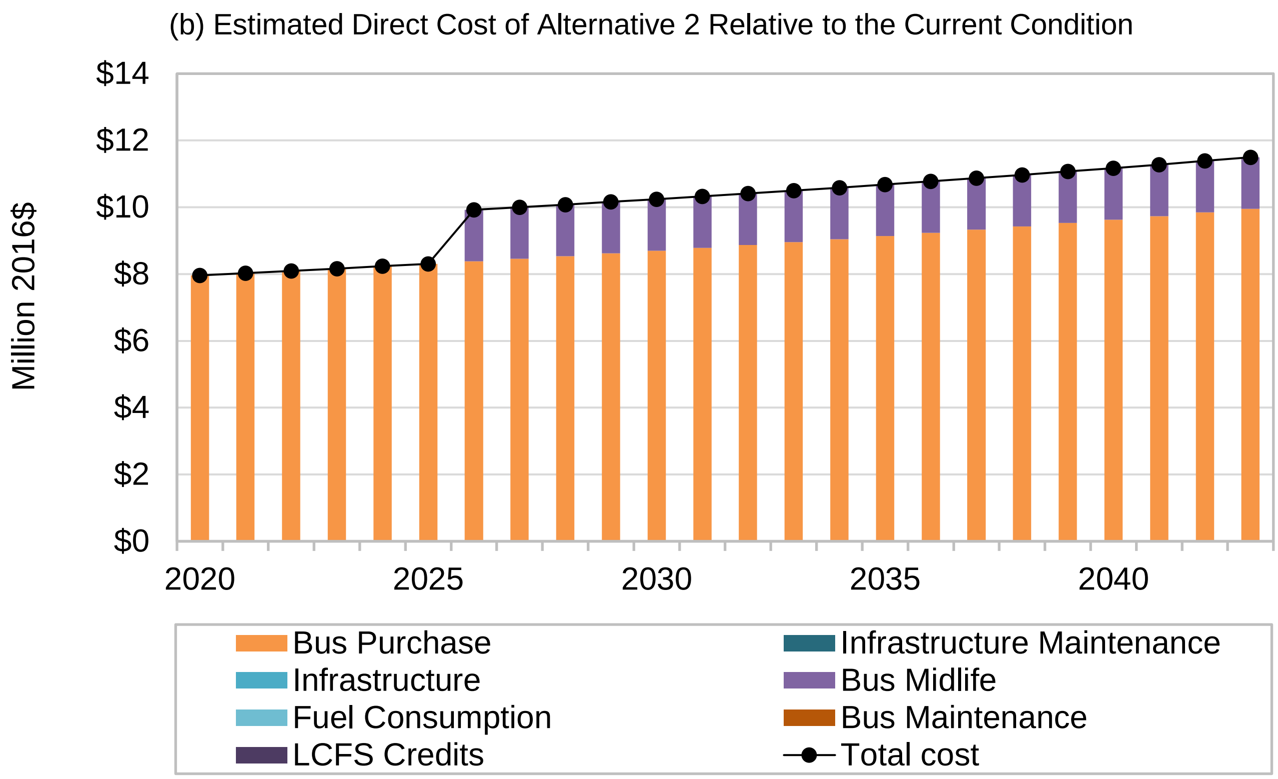
a. Costs (Total and Incremental)

The total direct cost to transit agencies for Alternative 2 is the summation of the cost of bus purchase, midlife, maintenance, fuel consumption, infrastructure, and LCFS credit. Figure F5 provides a breakdown of the estimated annual direct costs to transit agencies.

From 2020 through 2043, Alternative 2 is estimated to cost $442 million more relative to the baseline, and would cost $241 million more relative to the “current conditions”.

Figure F5: Estimated Total Direct Costs of Alternative 2 to Transit Agencies Relative to the Baseline and the Current Conditions (million 2016$)





b. Benefits (Total and Incremental)

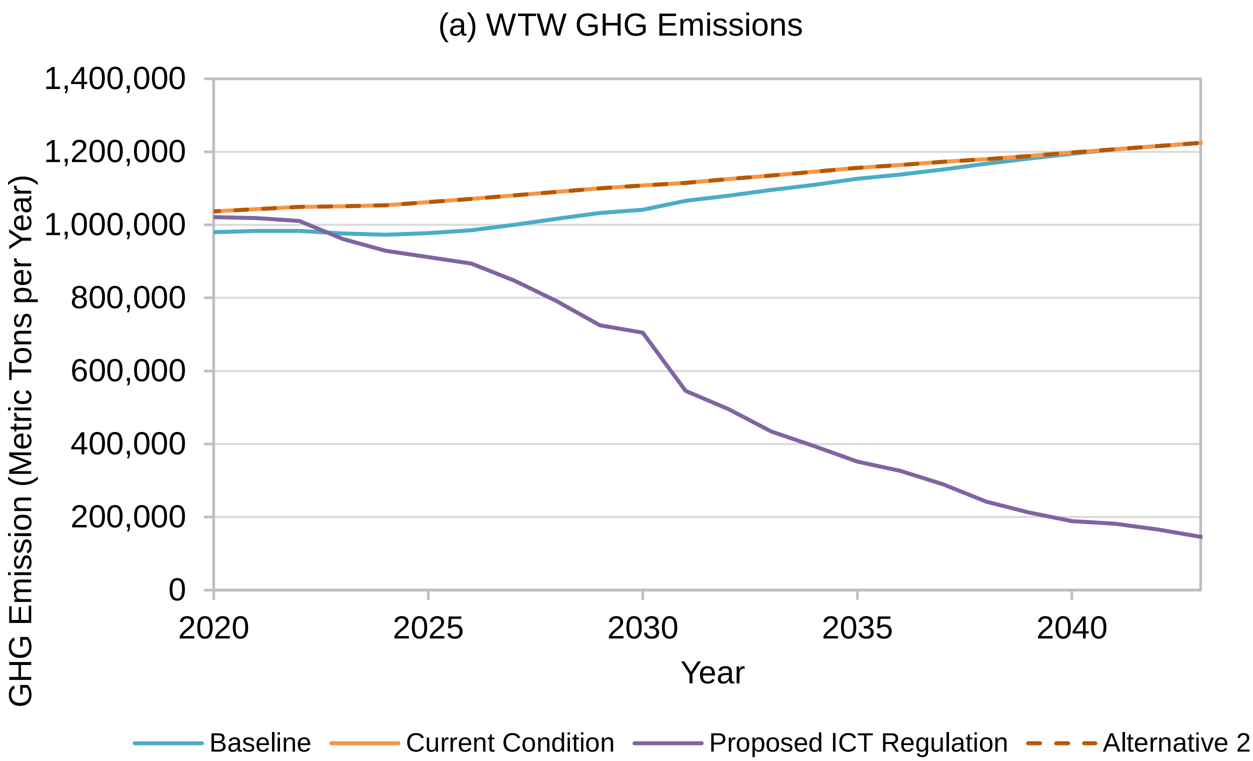
Alternative 2 reduces NOx but does not reduce GHG emissions nor $PM_{2.5}$ emissions. The WTW GHG and $PM_{2.5}$ emissions are estimated to be higher under this alternative than under the baseline. However, the tailpipe NOx emissions reduction benefits are lower than that of the proposed ICT regulation. Figure F6 summarizes the total WTW GHG, tailpipe NOx and $PM_{2.5}$ emissions under the baseline, the “current conditions,” the proposed ICT regulation, and Alternative.

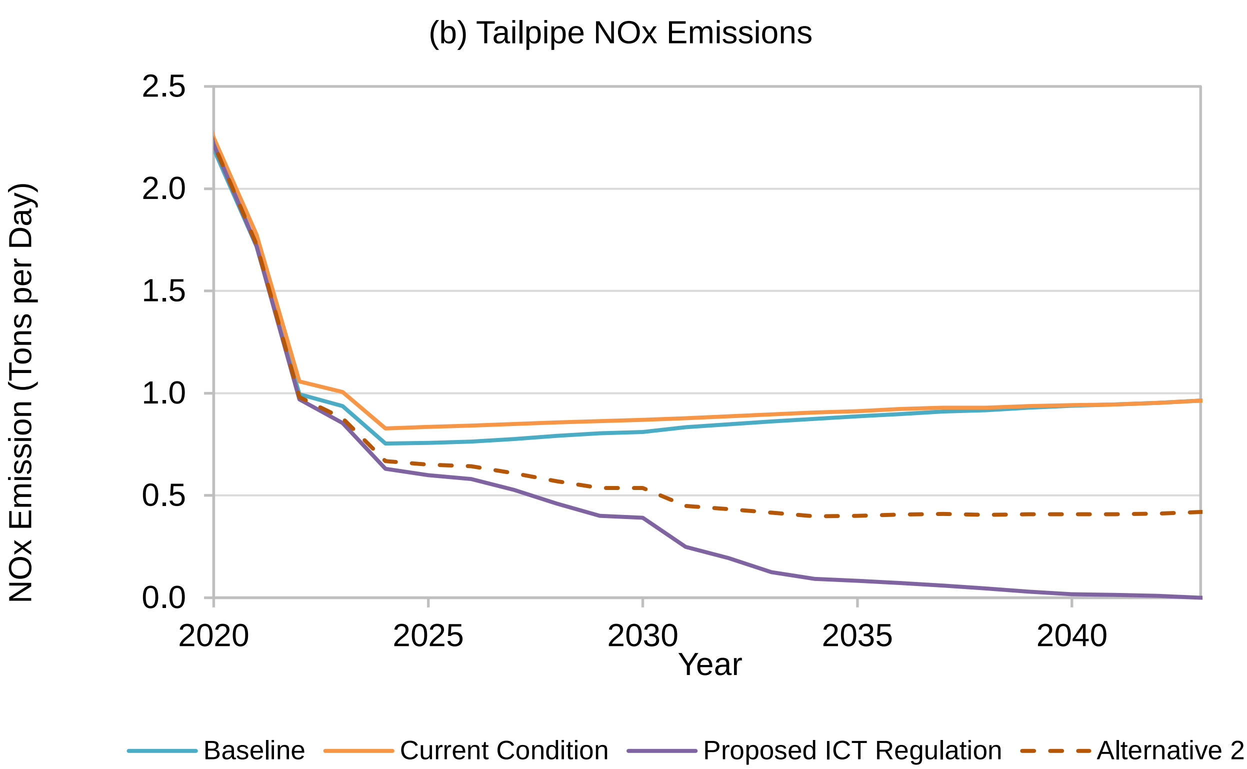
The cumulative WTW GHG emissions from 2020 to 2043 for Alternative 2 will be 1.1 MMT CO2e higher than the baseline, and remains the same when compared to the “current conditions”. This alternative does not achieve any GHG reduction, when the proposed ICT regulation would reduce cumulative GHG emissions by about 13.2 MMT CO_2e.

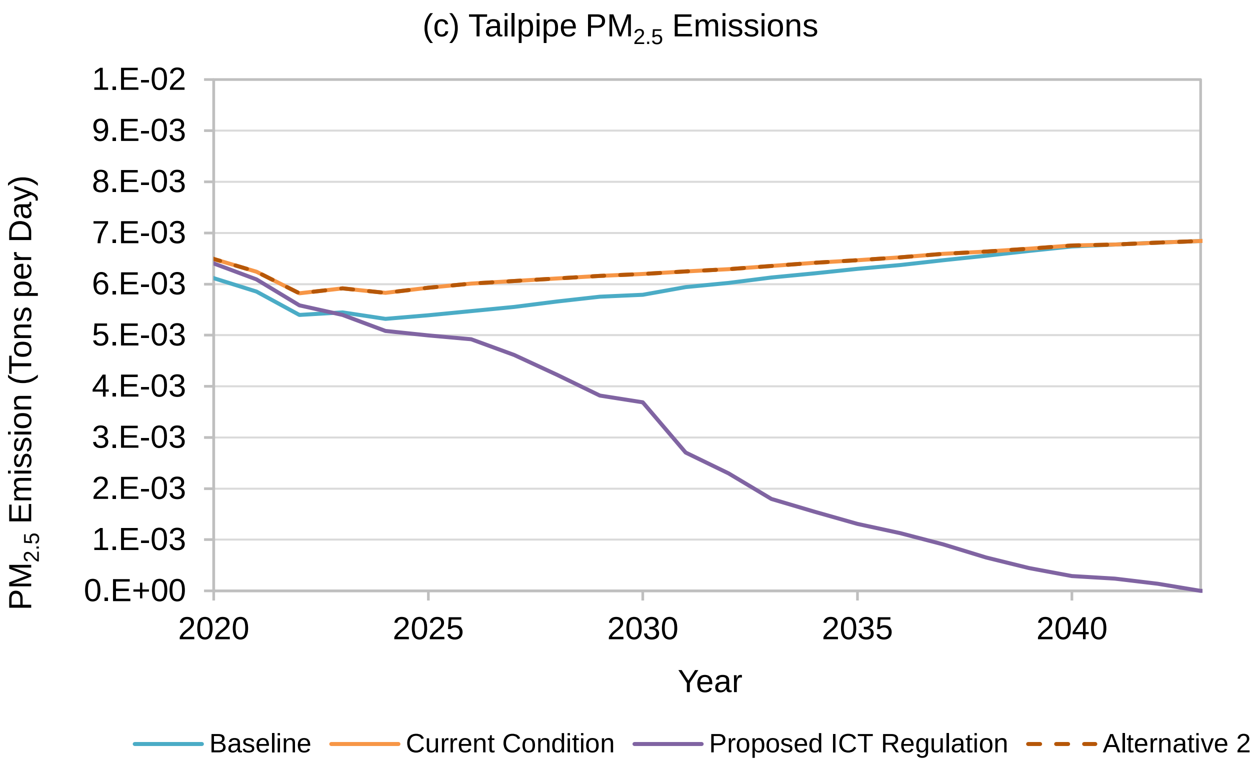
For tailpipe NOx, Alternative 2 is expected to deliver an estimated 2,507 tons emission benefits from 2020 to 2043 when compared with the baseline, and 2,824 tons when compared with the “current conditions”. The cumulative emissions reduction of Alternative 2 for NOx and from 2020 to 2043 is expected to be lower than that of the proposed ICT regulation by 1,652 tons.

For tailpipe $PM_{2.5}$, CARB estimates that the cumulative emissions from 2020 to 2043 for Alternative 2 will be 2 tons higher than the baseline, and remains about the same when compared to the “current conditions”. Compared to the proposed ICT regulation, this is a decrease in anticipated cumulative tailpipe $PM_{2.5}$ reduction of 27 tons.

Figure F6: Estimated WTW GHG, and Tailpipe NOx and $PM_{2.5}$ Emissions under the Baseline, the Current Conditions, Proposed ICT Regulation, and Alternative 2







c. Economic Impacts

Alternative 2 results in negligible declines across all economic indicators, relative to both the baseline and the "current conditions". As seen in Table F3 and F4, the absence of the operational savings due to ZEB technologies does not encourage higher economic growth under this alternative, but results in an overall slowing of growth throughout all years of the analysis relative to both the baseline and the "current conditions". Conventional bus manufacturers would still see an increase in demand under this alternative, but fewer industries that support ZEB technologies would benefit as a result of Alternative 2. While individuals will experience health benefits resulting in cost savings for hospital and ER visits, these costs-savings are significantly lower than under the proposed ICT regulation.

Table F3: Change in Growth of Economic Indicators for Alternative 2 Relative to the Baseline

		2020	2025	2030			
GSP	% Change	0.00%	0.00%	0.00%			
	Change (2016M$)	-16.2	-47.7	-67.1			
Personal Income	% Change	0.00%	0.00%	0.00%			
	Change (2016M$)	-13.0	-33.8	-49.1			
Employment	% Change	0.00%	0.00%	0.00%			
	Change in Jobs	-175	-450	-600			
Private Investment	% Change	0.00%	0.00%	0.00%			
	Change (2016M$)	-1.5	-10.5	-12.0			

The value in each year is interpreted as the reference year value less the baseline value in that same year. The change in jobs is rounded to the nearest 25, while the dollar values are rounded to the nearest $100,000.

Table F4: Change in Growth of Economic Indicators for Alternative 2 Relative to the Current Conditions

		2020	2025	2030	2035	2040	2045
GSP	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-17.1	-16.4	-19.3	-20.2	-21.4	-21.4
Personal Income	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-12.5	-11.9	-14.8	-16.2	-17.7	-19.2
Employment	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	-175	-150	-175	-175	-175	-175
Private Investment	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-3.3	-2.9	-2.3	-2.1	-2.2	-2.4

The value in each year is interpreted as the reference year value less the baseline value in that same year. The change in jobs is rounded to the nearest 25, while the dollar values are rounded to the nearest $100,000.

d. Cost-Effectiveness

In the case of Alternative 2, the total cost from 2020 to 2043 is more than the total cost of the proposed ICT regulation and would result in fewer emissions reductions. Alternative 2 is a less cost effective alternative when compared to the proposed ICT regulation.

e. Reason for Rejecting

The proposed ICT regulation is identified as a SIP strategy and is designed to help achieve a range of California’s air quality and climate protection goals. Alternative 2 with low NOx CNG bus purchase requirement and no ZEB purchase requirement would not decrease GHG emissions, will not achieve the maximum NOx reduction possible, and will not advance the adoption of heavy duty zero emission technology. Alternative 2 is rejected because it will not reduce GHG emissions, which is a key goal of the regulation and will not help the State to achieve the long term air quality and climate protection goals.

G. MACROECONOMIC APPENDIX

1. Detailed REMI Input Data

The estimated economic impacts of the proposed ICT regulation is sensitive to modeling assumptions made by CARB. The proposed ICT regulation is simulated in REMI by adjusting local government spending to reflect anticipated changes in expenditures due to incremental changes in the operating costs of California transit agencies. Secondary industries are those that see an incremental change in demand as a result of the spending changes by transit agencies. Additional impacts include monetized health benefits and additional staff resources for CARB to monitor and implement the proposed ICT regulation.

The input data is separated into the following components: ZEB purchases, midlife expenditures, changes in maintenance and fuel costs, charging infrastructure, installation, and maintenance costs, LCFS credit generation, health benefits, and additional CARB resources. Costs, as outlined in the cost section previously, are translated into REMI inputs as illustrated in Table G1 and G2, and described below:

a. Change in Local Government Spending

The local government spending variable is used to model the anticipated spending changes incurred by California transit agencies as a result of the proposed ICT regulation. ZEB purchase requirements will impose a suite of incremental costs to transit agencies, compared to baseline operations with conventional buses. These include incremental capital costs for ZEBs and their charging infrastructure, infrastructure installation and maintenance, as well as the cost to upgrade existing maintenance bays.

Changes to ongoing expenditures include increases in electricity and hydrogen demand, which is partially offset by fuel and maintenance savings. Transit agencies will have the opportunity to generate LCFS credits for operating BEBs and FCEBs, reducing annual operating expenditures for all years of the analysis.

The response of local government to changes in costs as a result of the proposed ICT regulation is difficult to predict. With increasing costs, local government could increase their budget (through taxes or some other mechanism) to cover the difference or could reallocate the existing budget and spend less in another areas. Due to lack of information about how local government could increase their budget, and the overall cost-savings of the proposed ICT regulation, this analysis assumes that local government does not change their existing budget. In early years when the proposed ICT regulation results in a net cost to local government, it is assumed they spend less in other areas contracting the macroeconomic benefits of public sector spending. In later years with net cost-savings it is assumed the excess income results in more spending, expanding the macroeconomic benefits of public sector spending.

b. Change in Government Demand

The government demand variable[76] is used to simulate changes in demand faced by industries as an indirect impact of the proposed ICT regulation. All expenditure changes made by California transit agencies are offset by a change in government demand for affected industries.

Manufacturers of buses compliant with the proposed ICT regulation are anticipated to see a significant increase in demand, as purchases shift from conventional buses to ZEBs. This is modeled as a cumulative increase in demand, where the incremental cost of ZEBs over their conventional counterparts is multiplied by the quantities purchased in each year. This value represents the increase in output demanded by transit agencies from ZEB manufacturers. Transit agencies will increase their spending on charging infrastructure, increasing demand for manufacturers of electrical equipment. Demand will decrease for conventional fuels as more ZEBs are phased in, increasing demand for electricity and hydrogen. Finally, demand for engineering services will increase during the installation and modification of maintenance bay upgrades.

c. Health Benefits

The decrease in acute respiratory, cardiovascular, and asthma related hospital and emergency room visits result in less household spending in the healthcare industry. This decrease in consumer spending allows for an increase in spending in all other consumption categories.

d. State Government Spending and Employment

There is an anticipated need for additional CARB staff resources to implement and monitor the amendments to the Transit Fleet Rule. This is simulated in REMI as a decrease in State government spending. This assumes the State budget will not increase as a result of this additional staff and accounts for the opportunity costs of decreasing spending in other spending categories. The incremental spending is calculated as the difference between one CARB person year and the wage assumption that REMI makes about public sector employees. This is due to the low wage assumptions REMI uses for State employees. This value changes by year and ranges from $43,000 to $63,000 depending on the year, as seen in Table G1 and G2. One employee is added using the State Government Employment variable beginning in 2019.

[76] REMI defines the government demand variable as the demand for goods and services induced by government expenditures, and is a component of industry demand (which also includes intermediate, consumption, and investment).

Table G1: REMI Inputs Relative to The Baseline

REMI Variable	REMI Category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Local Government Spending	Local Government Spending (2016M$)	-70.20	-45.78	-42.22	-107.96	-86.62	-84.01	-149.10	-124.33	-91.75	-122.90	-96.89	-63.88	-42.96	-11.87	46.87	65.90	81.42	133.89	160.32	185.95	231.89	239.19	255.20	285.52
State Government Spending	State Government Spending (2016M$)	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.04	-0.04	-0.04
State Government Employment	State Government Employment (Individuals)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Secondary Industries																									
Motor Vehicle Manufacturing	Government Demand (2016M$)	29.83	28.63	27.53	70.72	67.73	74.74	117.99	122.92	117.57	147.31	157.72	156.00	154.31	152.65	151.02	149.43	147.87	146.33	144.83	143.36	141.91	140.50	139.11	137.75
Other Electrical Equipment Component Manufacturing	Government Demand (2016M$)	-5.08	-5.08	-5.08	-5.08	-5.08	-5.08	9.10	9.10	9.10	30.28	30.28	39.23	67.83	74.38	74.38	99.63	122.33	122.33	122.33	122.33	122.33	122.33	122.33	122.33
Motor Vehicle Parts Manufacturing	Government Demand (2016M$)	2.31	2.31	2.31	2.31	2.31	2.31	-2.89	-2.89	-2.89	-13.05	-13.05	-13.05	-23.73	-26.04	-26.04	-35.32	-35.32	-35.32	-35.32	-35.32	-35.32	-35.32	-35.32	-35.32
Automobile Repair and Maintenance	Government Demand (2016M$)	3.93	2.97	2.01	-1.30	-4.61	-8.02	-14.46	-21.51	-28.56	-37.73	-46.91	-56.09	-65.26	-74.44	-82.05	-89.66	-97.27	-102.53	-107.79	-113.06	-115.79	-117.92	-120.05	-120.05
Oil and Gas Extraction	Government Demand (2016M$)	2.41	0.32	-1.91	-9.18	-16.60	-25.04	-38.49	-53.18	-67.18	-86.53	-106.91	-127.61	-149.03	-168.68	-186.87	-204.52	-224.62	-235.91	-247.92	-261.41	-268.31	-273.82	-278.47	-278.75

Electric Power Generation, Transmission, and Distribution	Government Demand (2016M$)	-3.53	-2.15	-0.67	4.51	9.80	15.52	25.68	36.29	46.91	60.35	73.73	87.30	100.86	113.89	124.45	135.12	145.39	152.25	158.96	165.56	168.57	171.06	173.64	172.94
Basic Chemical Manufacturing	Government Demand (2016M$)	14.97	-0.13	-0.08	5.08	0.13	0.25	0.41	0.58	0.76	1.04	1.32	1.60	1.88	7.21	2.36	2.57	2.77	2.92	3.07	3.23	3.35	8.50	3.56	3.56
Natural Gas Distribution	Government Demand (2016M$)	7.02	6.02	5.00	1.32	-2.40	-6.30	-14.71	-28.00	-39.29	-54.03	-68.58	-84.75	-99.77	-114.71	-127.40	-140.44	-153.57	-162.76	-171.69	-181.06	-186.16	-189.87	-194.23	-195.44
Electrical Equipment Manufacturing	Government Demand (2016M$)	7.34	5.25	5.95	19.99	19.30	21.04	38.19	38.19	37.49	50.64	50.98	49.94	51.33	50.64	41.39	41.74	41.39	28.04	26.64	27.69	12.80	12.45	12.80	0.00
Support Activities for Transportation	Government Demand (2016M$)	7.00	5.58	6.15	21.32	21.08	22.87	41.55	42.05	42.05	56.51	57.43	57.34	59.01	59.17	49.95	50.75	51.04	37.00	36.36	37.48	22.35	22.27	22.68	9.14
Architectural, Engineering, and Related Services	Government Demand (2016M$)	1.08	0.19	0.19	0.71	0.71	0.71	1.40	1.37	2.12	1.86	1.78	2.58	1.84	1.81	2.26	1.45	1.53	0.99	1.71	1.04	0.41	0.49	0.44	0.00
Oil and Gas Extraction	Production Cost (2016M$)	-2.92	-1.87	-0.81	2.46	5.76	8.99	14.65	20.59	26.33	33.74	40.91	48.60	56.30	64.00	70.32	76.64	82.95	87.23	91.51	95.78	98.04	99.86	101.68	101.68
Health Benefits																									
Consumer Spending Hospitals	Consumer Spending (2016M$)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02

REMI input values are rounded to the nearest $10,000. Values for the local government spending variable are representative of the net of multiple costs, and a negative value indicates an increased cost. Positive values for secondary industries are representative of absolute increases in demand.

Table G2: REMI Inputs Relative to Current Conditions

REMI Variable	REMI Category	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Local Government Spending	Local Government Spending (2016M$)	-73.87	-48.05	-40.89	-104.93	-82.29	-75.77	-135.39	-99.54	-69.05	-102.18	-78.25	-48.57	-29.75	3.39	59.99	76.83	90.17	140.38	164.53	187.87	231.92	239.22	255.23	285.55
State Government Spending	State Government Spending (2016M$)	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.06	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.05	-0.04	-0.04	-0.04
State Government Employment	State Government Employment (Individuals)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Secondary Industries																									
Motor Vehicle Manufacturing	Government Demand (2016M$)	42.20	40.32	38.57	81.17	77.67	85.82	128.52	122.71	117.37	147.11	157.52	155.79	154.10	152.44	150.82	149.22	147.66	146.13	144.63	143.15	141.71	140.29	138.91	137.54
Other Electrical Equipment Component Manufacturing	Government Demand (2016M$)	0.00	0.00	0.00	0.00	0.00	0.00	14.18	14.18	14.18	35.35	35.35	45.78	74.38	74.38	74.38	99.63	122.33	122.33	122.33	122.33	122.33	122.33	122.33	122.33
Motor Vehicle Parts Manufacturing	Government Demand (2016M$)	-1.57	-3.13	-4.70	-8.61	-12.52	-16.44	-22.88	-29.32	-35.76	-44.33	-52.90	-61.47	-70.05	-78.62	-85.62	-92.62	-99.63	-104.29	-108.94	-113.60	-115.73	-117.86	-119.99	-119.99
Automobile Repair and Maintenance	Government Demand (2016M$)	-1.57	-3.13	-4.70	-8.61	-12.52	-16.44	-22.88	-29.32	-35.76	-44.33	-52.90	-61.47	-70.05	-78.62	-85.62	-92.62	-99.63	-104.29	-108.94	-113.60	-115.73	-117.86	-119.99	-119.99
Oil and Gas Extraction	Government Demand (2016M$)	-2.61	-5.37	-8.33	-16.23	-24.27	-32.89	-46.45	-60.71	-74.12	-92.95	-112.83	-133.01	-153.88	-172.92	-190.53	-207.56	-227.07	-237.72	-249.09	-261.94	-268.20	-273.71	-278.35	-278.64

Electric Power Generation, Transmission, and Distribution	Government Demand (2016M$)	2.05	4.26	6.72	12.96	19.00	25.26	35.63	45.54	55.47	68.14	80.78	93.63	106.49	118.79	128.63	138.59	148.15	154.31	160.32	166.24	168.57	171.06	173.64	172.94
Basic Chemical Manufacturing	Government Demand (2016M$)	15.23	0.15	0.23	5.41	0.48	0.61	0.76	0.91	1.07	1.32	1.57	1.83	2.08	7.39	2.51	2.69	2.87	3.00	3.12	3.25	3.35	8.50	3.56	3.56
Natural Gas Distribution	Government Demand (2016M$)	-2.03	-4.08	-6.13	-10.87	-15.73	-21.05	-29.77	-44.27	-54.46	-68.07	-81.36	-96.50	-110.25	-123.89	-135.30	-147.07	-158.90	-166.76	-174.36	-182.40	-186.16	-189.87	-194.23	-195.44
Electrical Equipment Manufacturing	Government Demand (2016M$)	10.29	8.90	8.90	23.29	23.29	23.29	38.19	38.19	37.49	50.64	50.98	49.94	51.33	50.64	41.39	41.74	41.39	28.04	26.64	27.69	12.80	12.45	12.80	0.00
Support Activities for Transportation	Government Demand (2016M$)	10.64	9.76	9.88	25.34	25.64	25.94	42.14	42.63	42.62	57.07	57.97	57.87	59.52	59.68	50.44	51.22	51.51	37.45	36.80	37.91	22.35	22.27	22.68	9.14
Architectural, Engineering, and Related Services	Government Demand (2016M$)	1.19	0.30	0.33	0.82	0.85	0.80	1.40	1.37	2.12	1.86	1.78	2.58	1.84	1.81	2.26	1.45	1.53	0.99	1.71	1.04	0.41	0.49	0.44	0.00
Oil and Gas Extraction	Production Cost (2016M$)	1.53	3.05	4.58	8.34	12.11	15.56	21.12	26.50	31.71	38.60	45.25	52.51	59.77	67.04	72.92	78.81	84.69	88.53	92.37	96.22	98.04	99.86	101.68	101.68
Health Benefits																									
Consumer Spending Hospitals	Consumer Spending (2016M$)	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02	-0.02

REMI input values are rounded to the nearest $10,000. Values for the local government spending variable are representative of the net of multiple costs, and a negative value indicates an increased cost. Positive values for secondary industries are representative of absolute increases in demand.

2. Complete Macroeconomic Output Tables

The proposed ICT regulation is modeled in REMI from 2020 to 2043, simulating the impact on the California economy through 12 months post full implementation as required by SB 617. Output tables are summarized in Section E: Macroeconomic Impacts in five year intervals to broadly illustrate the impact of the proposed amendments on major economic indicators. The following tables present comprehensive annual REMI output for all macroeconomic impacts analyzed in Section E.

Table G3: Estimated Change in Employment Growth Relative to the Baseline

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Employment (Million Jobs)	23.4	23.6	23.8	24.0	24.2	24.4	24.6	24.8	25.0	25.2	25.4	25.6	25.8	26.0	26.2	26.4	26.6	26.8	27.1	27.3	27.5	27.7	27.9	28.2
% Change	-0.01%	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change in Total Jobs	-1280	-760	-720	-1860	-1400	-1390	-2460	-2020	-1540	-2110	-1750	-1360	-1180	-860	-190	-130	-110	370	550	740	1130	1050	1140	1330

The value for percent change and total change in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 50.

Table G4: Estimated Change in Employment Growth Relative to Current Conditions

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Employment (Million Jobs)	23.7	23.9	24.1	24.3	24.5	24.7	24.9	25.1	25.3	25.5	25.7	25.9	26.1	26.3	26.5	26.7	26.9	27.2	27.4	27.6	27.8	28.0	28.3	28.5
% Change	-0.01%	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change in Total Jobs	-1450	-900	-800	-1950	-1450	-1400	-2450	-1800	-1400	-2000	-1700	-1350	-1200	-850	-200	-150	-150	300	500	650	1000	950	1050	1250

The value for percent change and total change in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 50.

Table G5: Estimated Change in California Employment Growth Relative to the Baseline: Regulated Parties and Secondary Industries

Industry		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Transit Agencies																									
Local Government	% Change	-0.03%	-0.02%	-0.02%	-0.05%	-0.04%	-0.04%	-0.07%	-0.06%	-0.04%	-0.05%	-0.04%	-0.03%	-0.02%	-0.01%	0.01%	0.02%	0.02%	0.04%	0.05%	0.06%	0.07%	0.07%	0.08%	0.09%
	Change in Jobs	-560	-380	-350	-880	-710	-690	-1200	-1010	-760	-990	-790	-550	-390	-170	250	380	480	840	1010	1170	1470	1500	1600	1780
Secondary Industries																									
Motor Vehicle Manufacturing (3361)	% Change	0.06%	0.05%	0.05%	0.13%	0.12%	0.13%	0.19%	0.20%	0.18%	0.22%	0.23%	0.22%	0.21%	0.20%	0.19%	0.18%	0.17%	0.16%	0.15%	0.14%	0.13%	0.13%	0.12%	0.11%
	Change in Jobs	0	0	0	10	10	10	20	20	20	20	20	20	20	20	20	20	20	20	20	10	10	10	10	10
Other Electrical Equipment and Component Manufacturing (3359)	% Change	0.06%	-0.03%	-0.03%	0.00%	-0.03%	-0.03%	0.04%	0.04%	0.04%	0.12%	0.12%	0.15%	0.25%	0.28%	0.25%	0.32%	0.38%	0.37%	0.36%	0.34%	0.33%	0.33%	0.31%	0.30%
	Change in Jobs	10	0	0	0	0	0	10	10	10	20	20	20	30	40	30	40	50	50	50	50	50	50	40	40
Automotive Repair and Maintenance (8111)	% Change	0.00%	0.00%	0.00%	-0.01%	0.00%	0.00%	-0.01%	-0.01%	0.00%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change in Jobs	-10	0	0	-10	-10	-10	-10	-10	-10	-10	-10	-10	-10	0	0	0	0	0	0	0	0	0	0	10

Industry	Oil and Gas Extraction (211)		Electric Power Generation, Transmission, and Distribution (2211)		Basic Chemical Manufacturing (3251)		Natural Gas Distribution (2212)		Electrical Equipment Manufacturing (3353)	
	% Change	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs
2020	0.02%	10	-0.01%	0	0.00%	0	0.06%	10	0.06%	10
2021	0.02%	10	-0.01%	0	0.00%	0	0.05%	10	0.04%	0
2022	0.01%	10	0.00%	0	0.00%	0	0.04%	10	0.05%	0
2023	-0.01%	-10	0.01%	0	0.00%	0	0.00%	0	0.15%	20
2024	-0.03%	-10	0.02%	10	0.00%	0	-0.03%	0	0.14%	10
2025	-0.06%	-30	0.04%	10	0.00%	0	-0.06%	-10	0.14%	10
2026	-0.11%	-50	0.06%	20	0.00%	0	-0.14%	-20	0.25%	30
2027	-0.16%	-70	0.09%	30	0.00%	0	-0.25%	-30	0.24%	30
2028	-0.22%	-90	0.11%	30	0.00%	0	-0.34%	-40	0.23%	20
2029	-0.29%	-120	0.14%	40	0.00%	0	-0.47%	-60	0.29%	30
2030	-0.37%	-160	0.18%	50	0.00%	0	-0.59%	-70	0.29%	30
2031	-0.45%	-190	0.21%	60	0.00%	0	-0.72%	-80	0.27%	30
2032	-0.53%	-230	0.24%	70	0.00%	0	-0.84%	-90	0.27%	30
2033	-0.61%	-270	0.27%	70	0.00%	0	-0.97%	-100	0.25%	30
2034	-0.70%	-310	0.30%	80	0.00%	0	-1.07%	-110	0.20%	20
2035	-0.78%	-340	0.32%	80	0.00%	0	-1.17%	-120	0.19%	20
2036	-0.87%	-380	0.35%	80	0.00%	0	-1.28%	-130	0.18%	20
2037	-0.93%	-420	0.36%	80	0.00%	0	-1.35%	-130	0.12%	10
2038	-0.99%	-450	0.38%	90	0.00%	0	-1.41%	-130	0.11%	10
2039	-1.05%	-480	0.40%	90	0.00%	0	-1.49%	-140	0.11%	10
2040	-1.09%	-510	0.40%	90	0.00%	0	-1.52%	-140	0.04%	10
2041	-1.13%	-530	0.41%	80	0.00%	0	-1.55%	-140	0.04%	0
2042	-1.16%	-550	0.41%	80	0.00%	0	-1.58%	-130	0.04%	0
2043	-1.18%	-560	0.41%	80	0.00%	0	-1.58%	-130	-0.01%	0

Industry		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Support Activities for Transportation (488)	% Change	0.03%	0.03%	0.03%	0.10%	0.10%	0.10%	0.18%	0.18%	0.18%	0.23%	0.23%	0.22%	0.22%	0.22%	0.18%	0.18%	0.18%	0.12%	0.12%	0.12%	0.07%	0.07%	0.07%	0.03%
	Change in Jobs	40	30	30	120	110	120	220	220	220	290	290	280	290	280	240	240	230	170	160	160	100	90	100	40
Architectural, Engineering, and Related Services (5413)	% Change	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%	0.00%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%
	Change in Jobs	0	-10	-10	-10	-10	-10	-20	-20	-10	-20	-20	-10	-10	-10	-10	-10	-20	-20	-10	-20	-20	-20	-20	-30

The value for percent change and total change in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 10.

Table G6: Estimated Change in California Employment Growth Relative to Current Conditions: Regulated Parties and Secondary Industries

Industry		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Transit Agencies																									
Local Government	% Change	-0.03%	-0.02%	-0.02%	-0.05%	-0.04%	-0.03%	-0.06%	-0.04%	-0.03%	-0.05%	-0.04%	-0.02%	-0.02%	0.00%	0.02%	0.02%	0.03%	0.04%	0.05%	0.06%	0.07%	0.07%	0.08%	0.09%
	Change in Jobs	-610	-410	-350	-870	-690	-640	-1110	-830	-600	-850	-670	-450	-310	-70	340	460	540	880	1040	1190	1470	1510	1600	1780
Secondary Industries																									
Motor Vehicle Manufacturing (3361)	% Change	0.08%	0.07%	0.07%	0.14%	0.13%	0.14%	0.21%	0.19%	0.18%	0.21%	0.22%	0.21%	0.20%	0.19%	0.18%	0.17%	0.16%	0.15%	0.14%	0.14%	0.13%	0.12%	0.12%	0.11%
	Change in Jobs	10	10	10	10	10	10	20	20	20	20	20	20	20	20	20	20	20	20	10	10	10	10	10	10
Other Electrical Equipment and Component Manufacturing (3359)	% Change	0.08%	0.00%	0.00%	0.02%	0.00%	0.00%	0.06%	0.06%	0.06%	0.14%	0.14%	0.17%	0.27%	0.28%	0.25%	0.32%	0.38%	0.37%	0.35%	0.34%	0.33%	0.33%	0.31%	0.30%
	Change in Jobs	10	0	0	0	0	0	10	10	10	20	20	20	40	40	30	40	50	50	50	50	50	50	40	40

Natural Gas Distribution (2212)		Basic Chemical Manufacturing (3251)		Electric Power Generation, Transmission, and Distribution (2211)		Oil and Gas Extraction (211)		Automotive Repair and Maintenance (8111)	
Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change
0	-0.02%	0	0.00%	0	0.00%	-10	-0.01%	-10	-0.01%
-10	-0.04%	0	0.00%	0	0.01%	-10	-0.02%	0	0.00%
-10	-0.06%	0	0.00%	10	0.02%	-10	-0.03%	0	0.00%
-10	-0.10%	0	0.00%	10	0.03%	-30	-0.06%	-10	-0.01%
-20	-0.14%	0	0.00%	20	0.05%	-40	-0.09%	-10	0.00%
-20	-0.19%	0	0.00%	20	0.06%	-50	-0.12%	-10	0.00%
-30	-0.27%	0	0.00%	30	0.08%	-70	-0.18%	-10	-0.01%
-50	-0.39%	0	0.00%	30	0.11%	-100	-0.23%	-10	0.00%
-60	-0.47%	0	0.00%	40	0.13%	-120	-0.28%	-10	0.00%
-70	-0.58%	0	0.00%	50	0.16%	-150	-0.35%	-10	-0.01%
-80	-0.69%	0	0.00%	60	0.19%	-180	-0.43%	-10	0.00%
-90	-0.81%	0	0.00%	60	0.22%	-220	-0.50%	-10	0.00%
-100	-0.92%	0	0.00%	70	0.25%	-260	-0.58%	-10	0.00%
-110	-1.03%	0	0.00%	80	0.28%	-290	-0.66%	0	0.00%
-120	-1.12%	0	0.00%	80	0.31%	-330	-0.74%	0	0.00%
-120	-1.22%	0	0.00%	80	0.33%	-360	-0.82%	0	0.00%
-130	-1.31%	0	0.00%	90	0.35%	-400	-0.90%	0	0.00%
-130	-1.37%	0	0.00%	90	0.37%	-430	-0.96%	0	0.00%
-140	-1.42%	0	0.00%	90	0.38%	-470	-1.01%	0	0.00%
-140	-1.48%	0	0.00%	90	0.39%	-490	-1.07%	0	0.00%
-140	-1.51%	0	0.00%	90	0.40%	-520	-1.10%	0	0.00%
-140	-1.53%	0	0.00%	80	0.40%	-540	-1.14%	0	0.00%
-130	-1.56%	0	0.00%	80	0.41%	-560	-1.16%	0	0.00%
-130	-1.57%	0	0.00%	80	0.41%	-570	-1.18%	0	0.00%

Architectural, Engineering, and Related Services (5413)		Support Activities for Transportation (488)		Electrical Equipment Manufacturing (3353)	
Change in Jobs	% Change	Change in Jobs	% Change	Change in Jobs	% Change
-10	0.00%	60	0.05%	10	0.09%
-10	0.00%	50	0.05%	10	0.07%
-10	0.00%	50	0.05%	10	0.07%
-20	-0.01%	140	0.12%	20	0.17%
-10	0.00%	140	0.12%	20	0.17%
-10	0.00%	140	0.12%	20	0.16%
-20	-0.01%	220	0.18%	30	0.25%
-20	-0.01%	220	0.18%	30	0.24%
-10	0.00%	220	0.18%	20	0.23%
-20	-0.01%	290	0.23%	30	0.29%
-20	-0.01%	290	0.23%	30	0.28%
-10	0.00%	290	0.22%	30	0.27%
-20	-0.01%	290	0.22%	30	0.26%
-20	-0.01%	290	0.22%	30	0.25%
-10	0.00%	240	0.18%	20	0.19%
-20	0.00%	240	0.18%	20	0.19%
-20	-0.01%	240	0.18%	20	0.18%
-20	-0.01%	170	0.12%	10	0.11%
-20	0.00%	160	0.12%	10	0.10%
-20	-0.01%	170	0.12%	10	0.10%
-20	-0.01%	100	0.07%	10	0.04%
-20	-0.01%	90	0.07%	0	0.04%
-30	-0.01%	100	0.07%	0	0.04%
-30	-0.01%	40	0.03%	0	-0.01%

The value for percent change and total change in each year is interpreted as the referenced year value less the baseline value in the same year. The change in total jobs is rounded to the nearest 10.

Table G7: Estimated Change in California Output Growth Relative to the Baseline

Industry		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Motor Vehicle Manufacturing (3361)	% Change	0.06%	0.05%	0.05%	0.13%	0.12%	0.13%	0.20%	0.20%	0.18%	0.22%	0.23%	0.22%	0.21%	0.20%	0.19%	0.18%	0.17%	0.16%	0.15%	0.14%	0.14%	0.13%	0.12%	0.11%
	Change (2016M$)	4.5	4.3	4.1	10.1	9.5	10.3	16.0	16.5	15.6	19.3	20.5	20.1	19.6	19.2	18.8	18.2	17.7	17.4	16.9	16.4	16.0	15.6	15.1	14.7
Other Electrical Equipment and Component Manufacturing (3359)	% Change	0.06%	-0.03%	-0.03%	0.00%	-0.03%	-0.03%	0.04%	0.04%	0.04%	0.12%	0.12%	0.15%	0.25%	0.28%	0.25%	0.33%	0.39%	0.38%	0.36%	0.35%	0.34%	0.34%	0.32%	0.30%
	Change (2016M$	2.8	-1.5	-1.5	-0.1	-1.5	-1.5	2.4	2.4	2.4	7.9	7.9	10.2	17.6	20.5	19.1	25.3	31.0	30.9	30.8	30.7	30.7	31.9	30.6	30.5
Automotive Repair and Maintenance (8111)	% Change	0.00%	0.00%	0.00%	-0.01%	0.00%	0.00%	-0.01%	-0.01%	0.00%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$	-1.0	-0.4	-0.4	-1.3	-0.8	-0.8	-1.6	-1.2	-0.8	-1.3	-1.0	-0.8	-0.7	-0.5	0.0	-0.1	-0.1	0.3	0.3	0.4	0.7	0.6	0.6	0.8
Oil and Gas Extraction (211)	% Change	0.02%	0.02%	0.01%	-0.01%	-0.03%	-0.06%	-0.11%	-0.16%	-0.22%	-0.29%	-0.37%	-0.45%	-0.53%	-0.62%	-0.70%	-0.78%	-0.87%	-0.93%	-0.99%	-1.05%	-1.10%	-1.13%	-1.17%	-1.18%
	Change	2.0	1.9	1.4	-1.3	-3.7	-7.0	-12.6	-18.8	-25.5	-34.5	-44.2	-54.8	-66.5	-78.5	-90.3	-102.7	-115.9	-127.5	-139.1	-150.4	-160.1	-169.1	-177.2	-183.6
Electric Power Generation, Transmission, and Distribution (2211)	% Change	-0.01%	-0.01%	0.00%	0.01%	0.02%	0.04%	0.06%	0.09%	0.11%	0.14%	0.18%	0.21%	0.24%	0.27%	0.30%	0.33%	0.35%	0.37%	0.38%	0.40%	0.41%	0.41%	0.42%	0.42%
	Change (2016M$)	-3.1	-1.8	-0.9	1.8	5.7	9.5	15.5	23.0	30.3	38.9	48.1	57.4	66.5	75.4	82.9	90.0	96.9	101.8	106.4	111.0	113.2	114.9	116.7	116.4

Architectural, Engineering, and Related Services	Support Activities for Transportation (488)		Electrical Equipment Manufacturing (3353)		Natural Gas Distribution (2212)		Basic Chemical Manufacturing (3251)	
% Change	Change (2016M$)	% Change	Change (2016M$)	% Change	Change (2016M$)	% Change	Change (2016M$)	% Change
0.00%	6.5	0.03%	1.1	0.06%	5.1	0.06%	-0.4	0.00%
0.00%	5.3	0.03%	0.7	-0.03%	4.5	0.05%	-0.2	0.00%
0.00%	5.9	0.03%	0.8	-0.03%	3.7	0.04%	-0.2	0.00%
0.00%	20.7	0.10%	2.7	0.00%	0.4	0.00%	-0.4	0.00%
0.00%	20.7	0.10%	2.6	-0.03%	-2.4	-0.03%	-0.2	0.00%
0.00%	22.5	0.10%	2.7	-0.03%	-5.5	-0.06%	-0.2	0.00%
-0.01%	41.0	0.18%	4.8	0.04%	-12.6	-0.14%	-0.4	0.00%
-0.01%	41.7	0.18%	4.7	0.04%	-23.0	-0.25%	-0.2	0.00%
0.00%	41.9	0.18%	4.6	0.04%	-31.8	-0.34%	-0.1	0.00%
-0.01%	56.4	0.24%	6.0	0.12%	-43.8	-0.47%	-0.1	0.00%
-0.01%	57.5	0.23%	6.0	0.12%	-55.3	-0.59%	0.0	0.00%
0.00%	57.6	0.23%	5.8	0.15%	-68.0	-0.73%	0.2	0.00%
0.00%	59.4	0.23%	5.9	0.25%	-80.0	-0.85%	0.3	0.00%
0.00%	59.8	0.22%	5.7	0.28%	-91.9	-0.97%	0.4	0.00%
0.00%	50.7	0.19%	4.6	0.25%	-101.9	-1.07%	0.5	0.00%
0.00%	51.6	0.18%	4.6	0.33%	-112.4	-1.18%	0.5	0.00%
-0.01%	52.0	0.18%	4.5	0.39%	-123.0	-1.29%	0.5	0.00%
-0.01%	37.9	0.13%	3.0	0.38%	-130.3	-1.36%	0.6	0.00%
0.00%	37.4	0.12%	2.8	0.36%	-137.5	-1.43%	0.6	0.00%
-0.01%	38.6	0.12%	2.9	0.35%	-145.0	-1.50%	0.6	0.00%
-0.01%	23.4	0.07%	1.3	0.34%	-149.1	-1.53%	0.6	0.00%
-0.01%	23.3	0.07%	1.2	0.34%	-152.2	-1.56%	0.5	0.00%
-0.01%	23.8	0.07%	1.2	0.32%	-155.7	-1.59%	0.5	0.00%
-0.01%	10.0	0.03%	-0.1	0.30%	-156.8	-1.60%	0.5	0.00%

		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
	Change (2016M$)	-0.8	-1.0	-0.9	-2.5	-1.9	-2.0	-3.4	-3.0	-1.8	-3.4	-3.3	-2.3	-3.1	-3.1	-2.0	-3.1	-3.7	-3.8	-3.5	-4.4	-4.8	-5.5	-6.0	-6.6

The value in each year is interpreted as the referenced year less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table G8: Estimated Change in California Output Growth Relative to Current Conditions

Industry		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Motor Vehicle Manufacturing (3361)	% Change	0.08%	0.07%	0.07%	0.14%	0.13%	0.14%	0.21%	0.19%	0.18%	0.22%	0.23%	0.22%	0.20%	0.19%	0.18%	0.17%	0.16%	0.16%	0.15%	0.14%	0.13%	0.12%	0.12%	0.11%
	Change (2016M$)	6.4	6.0	5.6	11.5	10.8	11.7	17.3	16.4	15.5	19.1	20.3	19.9	19.4	19.0	18.6	18.0	17.5	17.1	16.7	16.2	15.8	15.4	14.9	14.6
Other Electrical Equipment and Component Manufacturing (3359)	% Change	0.09%	0.00%	0.00%	0.02%	0.00%	0.00%	0.06%	0.06%	0.06%	0.14%	0.14%	0.17%	0.27%	0.28%	0.25%	0.33%	0.39%	0.37%	0.36%	0.35%	0.34%	0.34%	0.31%	0.30%
	Change (2016M$)	4.4	0.0	0.0	1.3	-0.1	-0.1	3.8	3.8	3.8	9.3	9.3	12.0	19.5	20.7	19.2	25.5	31.2	31.1	31.0	30.9	30.9	32.1	30.8	30.7
Automotive Repair and Maintenance (8111)	% Change	-0.01%	0.00%	0.00%	-0.01%	0.00%	0.00%	-0.01%	0.00%	0.00%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Change (2016M$)	-1.1	-0.5	-0.5	-1.3	-0.8	-0.8	-1.6	-1.0	-0.8	-1.3	-1.0	-0.8	-0.7	-0.5	-0.1	-0.1	-0.1	0.2	0.3	0.4	0.6	0.5	0.6	0.7

Electrical Equipment Manufacturing (3353)	Natural Gas Distribution (2212)		Basic Chemical Manufacturing (3251)		Electric Power Generation, Transmission, and Distribution (2211)		Oil and Gas Extraction (211)	
% Change	Change (2016M$)	% Change	Change (2016M$)	% Change	Change (2016M$)	% Change	Change (2016M$)	% Change
0.09%	-2.1	-0.02%	-0.3	0.00%	0.5	0.00%	-1.4	-0.01%
0.07%	-3.5	-0.04%	-0.1	0.00%	2.3	0.01%	-2.3	-0.02%
0.07%	-5.1	-0.06%	-0.1	0.00%	4.0	0.02%	-3.5	-0.03%
0.17%	-9.3	-0.10%	-0.3	0.00%	7.4	0.03%	-6.9	-0.06%
0.17%	-13.0	-0.14%	-0.2	0.00%	11.8	0.05%	-10.2	-0.09%
0.16%	-17.3	-0.19%	-0.1	0.00%	16.0	0.06%	-14.1	-0.12%
0.25%	-24.6	-0.27%	-0.3	0.00%	22.2	0.08%	-20.2	-0.18%
0.24%	-35.9	-0.39%	-0.1	0.00%	29.3	0.11%	-26.6	-0.23%
0.23%	-43.9	-0.47%	0.0	0.00%	36.2	0.13%	-33.4	-0.28%
0.30%	-55.1	-0.59%	-0.1	0.00%	44.3	0.16%	-42.3	-0.35%
0.29%	-65.6	-0.70%	0.0	0.00%	53.0	0.19%	-51.9	-0.43%
0.27%	-77.6	-0.82%	0.2	0.00%	61.8	0.22%	-62.4	-0.50%
0.27%	-88.6	-0.93%	0.3	0.00%	70.5	0.25%	-73.7	-0.58%
0.26%	-99.5	-1.04%	0.4	0.00%	79.0	0.28%	-85.4	-0.66%
0.20%	-108.5	-1.13%	0.5	0.00%	86.0	0.31%	-96.8	-0.74%
0.19%	-118.0	-1.22%	0.5	0.00%	92.7	0.33%	-108.8	-0.82%
0.18%	-127.6	-1.32%	0.5	0.00%	99.1	0.35%	-121.5	-0.90%
0.12%	-133.8	-1.38%	0.5	0.00%	103.6	0.37%	-132.6	-0.96%
0.11%	-140.0	-1.44%	0.5	0.00%	107.7	0.38%	-143.7	-1.02%
0.11%	-146.5	-1.50%	0.5	0.00%	111.8	0.40%	-154.4	-1.07%
0.05%	-149.5	-1.52%	0.5	0.00%	113.7	0.40%	-163.5	-1.11%
0.04%	-152.6	-1.55%	0.5	0.00%	115.3	0.41%	-172.1	-1.14%
0.04%	-156.1	-1.58%	0.4	0.00%	117.2	0.41%	-179.9	-1.17%
0.00%	-157.2	-1.58%	0.4	0.00%	116.9	0.41%	-186.1	-1.19%

Architectural, Engineering, and Related Services (5413)		Support Activities for Transportation (488)		
Change (2016M$)	% Change	Change (2016M$)	% Change	Change (2016M$)
-1.2	0.00%	10.1	0.05%	1.5
-1.4	0.00%	9.5	0.05%	1.3
-1.2	0.00%	9.6	0.05%	1.2
-2.8	-0.01%	24.8	0.12%	3.2
-2.3	0.00%	25.3	0.12%	3.1
-2.3	0.00%	25.7	0.12%	3.0
-3.8	-0.01%	41.7	0.19%	4.8
-3.2	-0.01%	42.5	0.18%	4.8
-2.0	0.00%	42.7	0.18%	4.6
-3.7	-0.01%	57.2	0.24%	6.1
-3.7	-0.01%	58.3	0.23%	6.0
-2.8	0.00%	58.3	0.23%	5.8
-3.7	-0.01%	60.1	0.23%	5.9
-3.6	-0.01%	60.5	0.22%	5.8
-2.5	0.00%	51.4	0.19%	4.6
-3.7	-0.01%	52.2	0.18%	4.6
-4.3	-0.01%	52.6	0.18%	4.5
-4.4	-0.01%	38.4	0.13%	3.0
-4.1	-0.01%	37.9	0.12%	2.8
-5.0	-0.01%	39.1	0.12%	2.9
-5.4	-0.01%	23.3	0.07%	1.3
-6.1	-0.01%	23.3	0.07%	1.2
-6.6	-0.01%	23.8	0.07%	1.2
-7.1	-0.01%	10.0	0.03%	-0.1

The value in each year is interpreted as the referenced year less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table G9: Estimated Change in Gross Domestic Private Investment Growth Relative to the Baseline

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Investment (2016B$)	382.7	395.3	409.0	419.6	433.3	446.1	454.4	466.6	480.3	494.5	508.5	523.1	537.0	553.1	572.6	590.8	608.5	625.3	643.5	660.4	677.1	696.7	716.6	737.5
% Change	0.00%	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.03%	-0.03%	-0.03%	-0.03%	-0.04%	-0.04%	-0.04%	-0.04%	-0.05%	-0.05%
Change (2016M$)	-15.9	-12.6	-11.9	-32.6	-30.1	-31.3	-53.8	-58.4	-59.6	-80.4	-91.4	-102.5	-118.4	-134.6	-146.5	-169.2	-196.4	-215.8	-239.1	-262.2	-280.0	-304.8	-327.2	-346.2

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table G10: Estimated Change in Gross Domestic Private Investment Growth Relative to Current Conditions

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Investment (2016B$)	391.4	404.2	417.8	428.1	441.6	454.3	462.6	474.9	488.9	503.4	517.7	532.6	546.8	563.2	583.2	601.8	619.8	637.0	655.6	673.0	690.0	710.0	730.4	751.7
% Change	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.02%	-0.03%	-0.03%	-0.03%	-0.03%	-0.03%	-0.04%	-0.04%	-0.04%	-0.04%	-0.04%	-0.05%	-0.05%
Change (2016M$)	-27.5	-24.6	-23.8	-45.6	-44.3	-46.9	-70.3	-73.3	-75.6	-97.7	-109.8	-122.3	-138.7	-153.9	-165.5	-187.5	-214.0	-232.5	-254.9	-277.2	-294.4	-318.8	-340.8	-359.2

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table G11: Estimated Change in Personal Income Growth Relative to the Baseline

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Personal Income (2016B$)	2329.7	2382.8	2446.6	2492.8	2541.7	2600.5	2656.1	2715.0	2772.6	2832.1	2893.9	2958.0	3026.3	3100.1	3177.4	3257.5	3340.0	3422.0	3507.6	3597.7	3690.7	3790.8	3890.4	3993.7
% Change	0.00%	0.00%	0.00%	-0.01%	0.00%	0.00%	-0.01%	-0.01%	0.00%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2016M$)	-90.6	-40.0	-46.8	-135.8	-93.8	-103.2	-191.1	-152.2	-127.1	-183.7	-154.9	-134.0	-129.0	-108.8	-61.0	-66.0	-65.1	-23.2	-13.0	3.8	39.8	31.7	43.9	62.9

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table G12: Estimated Change in Personal Income Growth Relative to Current Conditions

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
Personal Income (2016B$)	2,337.7	2,392.3	2,457.9	2,505.9	2,556.6	2,616.7	2,673.0	2,732.3	2,790.2	2,850.0	2,912.1	2,976.5	3,045.2	3,119.4	3,197.2	3,277.9	3,361.1	3,443.8	3,530.2	3,621.0	3,714.9	3,815.6	3,915.9	4,019.8
% Change	0.00%	0.00%	-0.01%	0.00%	0.00%	-0.01%	-0.01%	0.00%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2016M$)	-103.9	-52.1	-55.5	-145.1	-102.3	-109.8	-194.8	-141.4	-121.9	-180.2	-153.4	-136.5	-132.5	-108.8	-62.8	-67.6	-67.7	-26.6	-16.7	-1.9	31.3	22.5	34.3	53.3

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table G13: Estimated Change Gross State Product Growth Relative to the Baseline

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
GSP (2016B$)	2616.2	2678.9	2755.6	2825.3	2896.9	2966.6	3034.2	3106.2	3182.9	3261.4	3341.6	3423.2	3509.7	3597.5	3687.4	3779.5	3874.2	3971.1	4070.4	4172.8	4277.8	4385.0	4495.1	4607.9
% Change	0.00%	0.00%	0.00%	-0.01%	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2016M$)	-121.0	-70.3	-68.2	-187.4	-142.6	-144.8	-263.9	-225.8	-183.0	-256.5	-228.9	-198.8	-192.1	-169.7	-108.1	-117.0	-130.4	-87.6	-82.1	-73.4	-38.0	-59.8	-59.8	-45.4

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

Table G14: Estimated Change Gross State Product Growth Relative to Current Conditions

	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043
GSP (2016B$)	2,647.6	2,711.6	2,789.3	2,859.8	2,932.3	3,002.9	3,071.3	3,144.2	3,221.8	3,301.3	3,382.4	3,465.0	3,552.6	3,641.5	3,732.5	3,825.7	3,921.5	4,019.7	4,120.2	4,223.9	4,330.1	4,438.7	4,550.2	4,664.4
% Change	-0.01%	0.00%	0.00%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	-0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Change (2016M$)	-141.5	-89.0	-82.6	-202.9	-158.0	-158.5	-274.2	-217.0	-180.3	-258.0	-234.6	-210.9	-206.2	-179.2	-119.4	-128.8	-143.8	-102.1	-97.4	-90.5	-57.1	-78.3	-77.5	-61.9

The values for changes in each year are interpreted as the referenced year value less that baseline value in the same year. The values presented above are rounded to the nearest $100,000.

References

The following documents are the technical, theoretical, or empirical studies, reports, or similar documents relied upon in proposing these regulatory amendments, identified as required by Government Code, section 11346.2, subdivision (b)(3). Additionally, each appendix references the documents upon which it relies, as required by Government Code, section 11346.2, subdivision (b)(3).

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Appendix B-2

DOF Comments to the ICT SRIA and CARB Responses

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Addressing Department of Finance Comments

1. **Battery disposal will increasingly be an issue once this proposed regulation is fully implemented. Either transit agencies will face disposal costs, or there will be environmental costs. The SRIA must include one or the other to fully cover regulatory impacts.**

All batteries have a finite life time. Proper disposal at the end of battery life is important for environmental protection. However, the batteries used by zero-emission buses (ZEBs) are expected to outlast the transit buses and the cost of recycling may not be incurred by the transit agencies.

Batteries used by zero-emission technologies are rechargeable and have a longer life span compared to conventional batteries. Though the energy capacity of the batteries used in ZEBs will degrade over time, when used properly, the battery life can often outlast the bus life. According to a study conducted by the National Renewable Energy Laboratory (NREL), it is anticipated that the batteries will retain approximately 70 percent of their initial capacity, and potentially operate for 10 years after bus retirement when treated properly.[1, 2] Some ZEB manufacturer(s) even provide a 12-year battery warranty. A transit agency can choose to recondition a battery to extend its useful life. The average bus life in California is about 14 years. Upon the retirement of a transit bus, if the battery still has remaining useful life, the battery can be reconditioned and resold or repurposed for other uses, such as energy storage, which does not have as severe demand on the battery.

NREL suggested that used batteries could replace grid-connected combustion turbine peaker plants, and provide peak-shaving services.**Error! Bookmark not defined.** The NREL study concluded that the battery's second use can "eliminate end-of-service costs for automotive battery owner and provide low- to zero-emission peaking services to electric utilities, reducing cost, use of fossil fuels, and greenhouse gas emissions … the overall benefit to society can be quite large."**Error! Bookmark not defined.**

If a battery continues to be used after bus retirement, it will not incur a disposal cost to the transit agencies. On the contrary, it could become a new revenue source for the transit agencies when these batteries are repurposed for different uses. However, the cost of battery disposal has to be paid at the certain point of its lifetime. This new revenue source from battery repurposing could be used to pay for the disposal cost. Staff does not have enough data regarding the residual value of the batteries after they are retired from buses because battery electric buses have not yet reached the end of life stage. However, some lithium-ion battery manufacturers do provide an attractive

[1] National Renewable Energy Laboratory (NREL). Battery Second Use for Plug-In Electric Vehicles Analysis. Available: https://www.nrel.gov/transportation/battery-second-use-analysis.html. Accessed July 6, 2018.

[2] National Renewable Energy Laboratory (NREL) (2015). Identifying and Overcoming Critical Barriers to Widespread Second Use of PEV Batteries. February 2015. Available: https://www.nrel.gov/docs/fy15osti/63332.pdf.

residual value to customers upon the retirement of a battery.[3] Therefore, staff believes that the residual value can offset the recycling cost and does not include a residual battery value in the economic analysis for the transit agencies.

[3] EnerDel applies a 25% of residual value to retired batteries. Available: http://enerdel.com/services/guaranteed-residual-value/. Accessed July 6, 2018.

2. **The SRIA must have growth in the number of buses over time that is at least proportional to population growth, rather than assuming that the total remains at 2016 levels.**

   The 2029 population is projected to be more than 10 percent larger than the 2016 population. Economic trends suggest that growth is more urban, and with limited road capacity, the demand for public transportation will likely rise. The SRIA notes that the relative costs per bus will remain the same no matter the total, but a higher total will increase electricity demand and demand for low-carbon fuels. A key assumption is that renewable fuel prices decrease, with hydrogen prices falling to around 30 percent of current levels, and greater demand could either stimulate production or stress supplies and raise prices. There is a great deal of inherent uncertainty about how markets will develop, but the current static assumption will likely understate the scale of changes. Not keeping up with population growth also understates the health benefits of reducing emissions in urban areas.

In the SRIA, a static population based on the National Transit Database (NTD) 2016 was used for cost analysis.[4] The total number of buses may increase over time as human population and/or passenger mile grows. The cost analysis in the ISOR has been updated to incorporate growth of bus population, which represents Metropolitan Planning Organizations' (MPOs) forecasts and human population increase. As shown in the CARB's mobile source emissions inventory, EMFAC 2017, the statewide growth rates of urban buses, ranging from 0.7 percent to 1.4 percent per year between 2020 and 2050. This forecast is based on MPOs' vehicle miles traveled (VMT) targets and human population growth. For areas governed by a MPO that forecasts transit growth in target years of the Regional Transportation Plan/Sustainable Communities Strategy, the growth rate is generated by linear interpolation of the growth between the base year and target years; for areas that are not covered by a MPO, or where a local MPO does not provide transit growth, the county-level human population growth rate published by the Department of Finance were used as surrogate for transit growth.[5]

This growth will increase the number of ZEBs in the proposed ICT regulation as well as the number of conventional internal combustion buses in current conditions. The vehicle number growth will then have an effect on the associated cost for both the proposed ICT regulation and current conditions. The growth impact on cost is modeled and included for ZEB infrastructure with the proposed ICT regulation because all infrastructure will be new. However, it is difficult to model for the infrastructure for buses with internal combustion engines due to limited or no information. For instance, it is uncertain which transit agencies will need to have major infrastructure expansion, like

[4] National Transit Database (2016). 2016 Annual Database Revenue Vehicle Inventory. Available: https://www.transit.dot.gov/sites/fta.dot.gov/files/Revenue%20Vehicle%20Inventory_0.xlsx.

[5] California Air Resources Board (CARB) (2018). EMFAC2017 Volume III – Technical Documentation. March 1, 2018. Available: https://www.arb.ca.gov/msei/downloads/emfac2017-volume-iii-technical-documentation.pdf.

adding a new facility, or whether existing fueling infrastructure and space will need to be upgraded or expanded to accommodate such growth. For example, a depot yard that is servicing 100 buses may have a capacity of 110 buses. Therefore, the increase of fueling infrastructure for buses with internal combustion engines is not included in the current conditions, which will result in a lower total cost. If total costs in the current conditions is a lower estimate, the incremental costs in the proposed ICT regulation relative to current conditions will be a higher estimate. This assumption results in a conservative assumption for total costs in the proposed ICT regulation.

The bus population growth was accounted for in the emission reduction modeling and the infrastructure for ZEBs. Therefore, there is no change on emission reductions and health benefit. This growth will also not change the fuel prices for conventional fossil fuels and electricity. The prices of compressed natural gas, gasoline and diesel are based on the energy prices for the transportation sector in the Energy Information Administration (EIA)'s Annual Energy Outlook 2018 (Reference case and Pacific region). Compared with other vehicles in the transportation sector, transit buses consume a small amount of the total energy. A population increase of 0.7 to 1.4 percent is not expected to impact fuel prices. Electricity price is determined by rate schedules and is also not anticipated be impacted by minor changes in the bus population.

Hydrogen price, however, is more dependent on station throughput. The higher the throughput is, the lower the hydrogen price. It is possible that an increase in the population of buses that use hydrogen could result in a decrease in the price of hydrogen. Given the lack of hydrogen market history, the price impact of this change in bus population is difficult to predict and was not estimated as part of the economic analysis. The current assumption without incorporating bus growth for hydrogen price is conservative, and the costs may be lower than presented.

3. **Public transit is no longer the only option to personal vehicles for individuals, and some private companies are now providing bus service, for their employees, as an alternative to public buses. If transit agencies raise prices to cover higher initial costs of this proposed regulation, such alternatives may be even more attractive, and undercut the estimated benefits. The SRIA could usefully add a discussion of these dynamics.**

There will be upfront capital costs associated with ZEBs and their infrastructure due to the proposed ICT regulation. This might raise concerns that transit agencies may pass on the incremental costs to individuals through changes in service or fares. The State is aware of these concerns and is committed to providing incentives to help ease the transition to zero-emission technologies. In fact, the proposed ICT regulation is structured to provide opportunities for transit agencies to take advantage of substantial incentive funding that is being prioritized to ensure a successful transition to zero-emission technologies. These funding opportunities should substantially offset the upfront capital costs.

There are several major funding programs established to reduce the incremental costs associated with zero-emission technologies, such as Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP). For fiscal year (FY) 2017-2018, the budget allocated up to $180 million for the HVIP program with a minimum of $35 million set aside to fund ZEBs exclusively. An additional $125 million has been allocated to the HVIP program per Senate Bill 856 for the FY 2018-2019. Transit agencies can use state and federal grant funding to reduce or eliminate most of the initial incremental capital costs of the proposed regulation. In addition, staff estimated that, in the long-term, the cost savings outweigh the capital costs of adding ZEBs. Therefore, the likelihood of transit agencies raising fares to cover the higher initial cost is low. If a transit agency considers a fare increase, any increase has to be approved by the board of a transit agency.

Transit systems are evolving, and there could be many innovative alternatives to public transit in the near future. Some alternatives, such as private shuttle and ride-hailing services, have become popular in recent years. This would be the case with or without the proposed ICT regulation. Alternatives that might arise to supplant public transit cannot be easily predicted. In addition, the emissions impacts of those replacements could be minimal because other transportation modes are transitioning to low- and zero-emission pathways. The proposed ICT regulation itself is not anticipated to significantly alter the dynamic between public transit and other personal/private alternatives. Staff views any significant change in fares by transit agencies to cover initial capital costs as unlikely, given that the proposed regulation is structured to provide ample funding for transit agencies to offset those costs. In addition, the proposed ICT regulation contains a Zero-Emission Mobility program option that can synergistically work with these alternatives to increase accessibility to the entire transit system.

Reference List B-2

The following documents are the technical, theoretical, or empirical studies, reports, or similar documents relied upon in proposing these regulatory amendments, identified as required by Government Code, section 11346.2, subdivision (b)(3). Additionally, each appendix references the documents upon which it relies, as required by Government Code, section 11346.2, subdivision (b)(3).

Note: Each "Explanatory Footnote" is a footnote containing explanatory discussion rather than referencing specific documents relied upon.

1. National Renewable Energy Laboratory (NREL). Battery Second Use for Plug-In Electric Vehicles Analysis. Available: https://www.nrel.gov/transportation/battery-second-use-analysis.html. Accessed July 6, 2018.

2. National Renewable Energy Laboratory (NREL) (2015). Identifying and Overcoming Critical Barriers to Widespread Second Use of PEV Batteries. February 2015. Available: https://www.nrel.gov/docs/fy15osti/63332.pdf.

3. EnerDel applies a 25% of residual value to retired batteries. Available: https://enerdel.com/services/guaranteed-residual-value/. Accessed July 6, 2018.

4. National Transit Database (2016). 2016 Annual Database Revenue Vehicle Inventory. Available: https://www.transit.dot.gov/sites/fta.dot.gov/files/Revenue%20Vehicle%20Inventory_0.xlsx.

5. California Air Resources Board (CARB) (2018). EMFAC2017 Volume III – Technical Documentation. March 1, 2018. Available: https://www.arb.ca.gov/msei/downloads/emfac2017-volume-iii-technical-documentation.pdf.