Appendix I

Cost Updates

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I. INTRODUCTION

This document provides details on updates of cost input assumptions used in statewide direct cost calculations described in Appendix B, the Standardized Regulatory Impact Assessment (SRIA). This document also summarizes the updated assumptions of statewide population and its projection, which is the other significant factor to determine the direct cost for transit agencies. The cost methodology is discussed in the ISOR Chapter VIII and in the SRIA (Appendix B-1).

The statewide direct costs of the proposed ICT regulation to deploy ZEBs are determined by cost input assumptions for each unit bus, such as bus capital cost ($/bus) and maintenance cost ($/mile), as well as bus population by different powertrains. The cost analysis has been mainly updated in the following areas:

(1) *ZEB phase-in schedule.* With comments and feedback from stakeholders, CARB staff is proposing additional time to implement the ZEB purchase requirements to provide flexibility to transit agencies. This change means a three-year push back on the starting date for the ZEB purchase requirement, now proposed to start in 2023 for large transit agencies and in 2026 for small transit agencies.

In the SRIA, all bus types are phased in using the same purchase schedule. In the current staff proposal, cutaway, articulated, and over-the-road buses will not be required for purchase until 2026 or when technologies are commercially available, whichever is later. This proposal will change the corresponding costs and emission reduction benefits in early years. The statewide cost saving will be observed in the same way because the 100 percent purchase requirement is still in the same year (2029) as previously proposed. The cumulative emission reductions will be the same because the vehicle numbers are the same. However, the annual emission reductions before 2029 will be distributed differently; i.e. emission reductions will begin in 2023 instead of 2020.

(2) Waiver of ZEB purchases. A new voluntary option is introduced to allow for up to a two-year waiver of initial purchase requirements in 2023 and 2024 if at least 1,000 ZEBs are purchased by the end of 2020 and 1,150 ZEBs are purchased by the end of 2021. This option provides transit agencies great flexibility to access available funding and plan for their own ZEB deployment without a regulatory constraint. All ZEBs purchased to meet the waiver targets can be used to meet the purchase obligation starting 2025. This wavier option will not change the total number of ZEBs to be bought under the proposed ICT regulation. When the waiver option is utilized, ZEB purchases will occur much earlier than

otherwise required which is expected to result in substantial early emissions reductions. The potential impacts of the waiver option are discussed in more detail below.

(3) *Impacts of bonus credits.* Statewide, transit agencies are estimated to have earned 132 bonus credits, which can be used to meet the ZEB purchase requirements for 132 ZEBs. This effect is modeled for both emission reductions and cost analysis. The bonus credits would likely result in fewer ZEBs in early years, reducing both the costs and emission benefits as analyzed below. Bonus credits are issued to award early adopters that took a risk and made enormous effort to demonstrate the feasibility and conduct trouble shooting of the new zero-emission technologies. The intrinsic value of the demonstration of technology viability is far higher than the face value of these bonus credits.

(4) *Base and growth of vehicle population.* In this updated analysis, the inventory of buses has been updated to more accurately reflect bus GVWR. In addition, per the Department of Finance's (DOF) suggestion, a vehicle growth rate is now applied while a static bus population was assumed in the SRIA analysis. The statewide growth rates of urban buses from EMFAC2017 (0.7 to 1.4 percent per year) are used in this analysis to project future bus populations. EMFAC2017 assumes the increase of bus numbers is a result of population growth and metropolitan planning organizations (MPO) strategies. This growth will increase the number of buses needed each year and increase the infrastructure needed in the economic analysis. EMFAC2017 (including bus population growth) was already used in the SRIA to determine emissions and health impacts. As such, this change has no impact on emissions.

(5) *Separation of cutaway buses and other non-standard buses*. In the SRIA, all buses were treated as standard buses with the same lifetime and bus cost information. With comments from stakeholders, cutaway buses have been separated as a group and assigned with shorter lifetime and lower bus prices in this updated analysis. Cutaway buses are less costly and typically operated for 10 instead of 14 years. The cost analysis now considers both the accurate upfront cost, and the lifetime of this bus category. The separation of cutaway buses from standard buses decreases overall costs. This separation in the cost analysis will not change emission or health benefits as cutaway buses were already considered separately in the emission inventory.

(6) *Cost input assumptions.* A number of adjustments were made to more accurately reflect costs:

a. *Timing gap between bus purchases and delivery*. It usually takes approximately one year for transit agencies to get vehicles delivered after their purchases. The payment for vehicle capital cost, fuel consumption and maintenance, as well as emission reductions occur when vehicles are in service. A one-year delay between vehicle purchase and delivery was added to more accurately reflect expenditures and emissions.

b. *Prices for oil and natural gas.* Prices for diesel, gasoline and CNG were updated with the latest information from Energy Information Administration (EIA)'s Annual Energy Outlook 2018 (AEO2018). In the SRIA, information from AEO2017 was used.

c. *Electricity costs*. Based on comments from transit agencies, the charger size was increased from 60 kW used in the SRIA to 80 kW to better match expected charging times for longer range buses. This results in a minor increase in electricity costs. As explained in Appendix D for Total Fuel Cost in Initial Statement of Reasons (ISOR), the growth rate of electricity costs for the commercial sector was used instead of the electricity costs for the transportation sector.

d. *Energy use for BEBs.* Energy use for BEBs were changed from 2.1 kWh/mile in the SRIA to 2.3 kWh/mile to account for energy loss during charging. This change will increase total electricity use by BEBs, and it will increase total electricity cost and Low Carbon Fuel Standard (LCFS) credits earned.

e. *LCFS credits.* LCFS assumptions have been updated to be consistent with the ISOR[1] released along with the Board hearing on April 27, 2018.

f. *Other associated costs for ZEB deployment.* Deployment of a new technology requires operational adjustments including but not limited to operator and technician training, purchase and update of software, and the need for additional spare parts. In the SRIA, these costs were not considered but have been accounted for here resulting in an increase in the total cost.

[1] California Air Resources Board (CARB) (2018). Public Hearing to Consider Proposed Amendments to the Low Carbon Fuel Standard Regulation and to the Regulation on Commercialization of Alternative Diesel Fuels. March 6, 2018. Available: https://www.arb.ca.gov/regact/2018/lcfs18/isor.pdf.

g. *Rollout Plan cost.* To effectively and efficiently deploy ZEBs, a transit agency must perform some upfront planning and site assessment. To ensure this planning effort is carried out in a thoughtful way, a Rollout Plan requirement has been added since the SRIA. This cost is actually part of the "other associated cost for ZEB deployment" but discussed separately to provide more clarity. The cost associated with developing the Rollout Plan and associated planning for a zero-emission fleet has been added and will increase the total costs.

h. *Reporting costs.* The reporting cost was not included in the SRIA. In this updated analysis that reflects the current staff proposal, the cost associated with reporting requirements is added, and results in a small increase in total costs.

(7) <u>*Baseline and timeframe of analysis*</u>*.* In the SRIA, the economic impact of the proposed ICT regulation is evaluated against two separate baselines developed in consultation with DOF. The "baseline" reflects full compliance with the existing regulation, and the "current conditions" analysis reflects the real world conditions of the Board's direction to delay the purchase requirement and CARB's advisory, and how the proposed regulations would impact current conditions. In this updated analysis, the economic impact of the proposed ICT regulation relative to the "current conditions" is shown in the main content of ISOR, and the analysis relative to the "baseline" is shown in this Appendix. In the SRIA, the costs and benefits are analyzed through 2043 to signify the full implementation of ZEB purchases, which is 12-months after full implementation. In this updated analysis, the timeframe has been extended to 2050 to include all reporting costs and better account for the emissions benefits and cost savings associated with the required ZEB purchases.

II. UPDATES OF COST INPUT ASSUMPTIONS

The estimated direct costs of the proposed ICT regulation and baselines in the cost analysis include:

- Upfront capital costs for bus purchases, charging or fueling infrastructure, as well as maintenance bay upgrades; and
- Annual maintenance costs for bus and infrastructure, as well as annual costs for fuel consumption.

Some of the updated cost inputs apply to both standard buses and cutaway buses and they are treated as general costs to be discussion in Section A below. Some cost inputs only apply to standard buses or cutaway buses and they are discussed separately in Sections B and C. At the end, the costs for regulatory reporting are discussed.

A. General Costs

General costs for all types of ZEBs include fuel price, LCFS credit values (which are cost savings from the use of fuels with lower carbon intensities (CI)) and other cost associated with ZEB deployment apply to both standard buses and cutaway buses. They are discussed in the section of general costs.

1. Time Gap

It usually takes one year or so for transit agencies to get vehicles delivered after their purchases. The payment for vehicle capital cost, fuel consumption and maintenance, as well as emission reductions actually occur when vehicles are in service. Therefore, in this updated analysis, a one-year delay between vehicle purchase and delivery is added.

2. Fuel Price

CNG and diesel fuel prices have been updated to be based on Energy Information Administration (EIA)'s Annual Energy Outlook 2018 (AEO2018) [2] and start at \$1.13/dge[3] and \$2.29/dge, respectively in 2016. Gasoline prices have been added to this updated cost analysis, starting at \$2.68/dge in 2016. The EIA commercial natural gas prices are consistent with the total pump price paid by California transit agencies per responses to the 2016 CARB transit agency survey and are used in this analysis. Future gasoline, diesel, and CNG prices in AEO2018 are shown in Figure 1. Electricity cost per kWh varies by electric utility service areas and charging strategy[4], as shown in the SRIA and in Section II.B and Section II.C.5. of this document. The growth rate of electricity prices has been updated to be based on electricity prices for the commercial sector in AEO2018, as shown in Figure 2 and is applied to the values shown in Table 1 for future projections.

Assumptions for hydrogen prices are kept the same as in the SRIA. Hydrogen prices are highly dependent on station throughputs and are expected to decrease when more

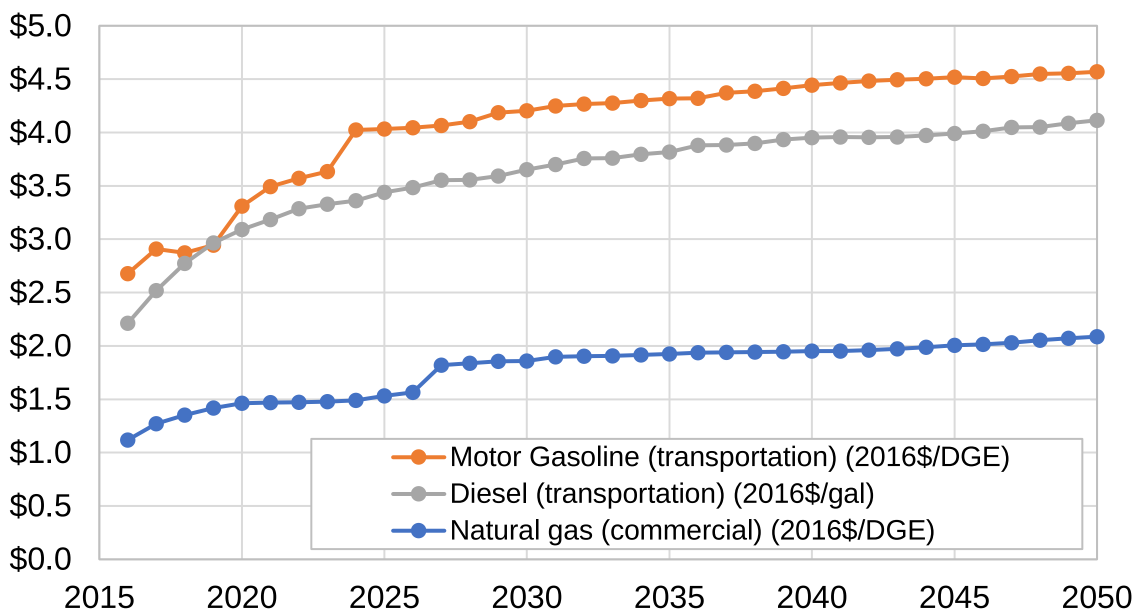
[2] Energy Information Administration (EIA) (2018). Annual Energy Outlook 2018. Table 3. Energy Prices by Sector and Source (Reference case for the Pacific Region).

[3] DGE: Diesel Gallon Equivalent.

[4] California Air Resources Board (CARB, 2017), Draft Battery Electric Truck and Bus Charging Calculator. Updated June 20, 2017. Available: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626chargecostcalcv3.xlsm.

FCEBs are in use. This analysis uses \$8.00/kg as the 2016 hydrogen price[5] and assumes the future hydrogen price will decrease to \$4.00/kg in 2020.[6]

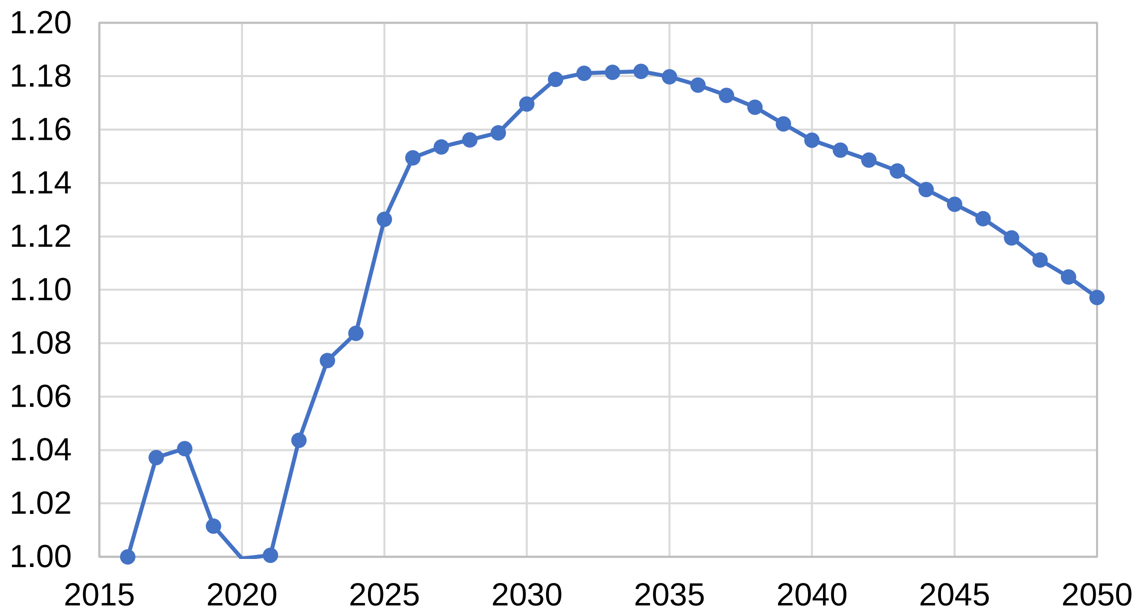
Figure 1: Gasoline, Diesel, and Natural Gas Fuel Price from AEO2018



[5] National Renewable Energy Laboratory (NREL) (2015). American Fuel Cell Bus Project Evaluation: Second Report. September, 2015. Available: http://www.nrel.gov/docs/fy15osti/64344.pdf.

[6] U.S. Department of Energy Hydrogen and Fuel Cells Program (U.S. DOE) (2016). 2016 Annual Merit Review and Peer Evaluation Meeting, page 11: DOE Cost Targets and Status. June 6, 2016. Available: https://www.hydrogen.energy.gov/pdfs/review16/02_satyapal_plenary_2016_amr.pdf.

Figure 2: Growth Rates of Electricity Costs for the Commercial Sector in AEO2018 (Year 2016 = 1)



3. LCFS Credit Value

As discussed in the SRIA, 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. The credits can be sold to regulated parties to reduce operating costs for transit fleets. In the SRIA, proposed carbon intensity (CI) benchmarks and the proposed CIs for fuels from the LCFS SRIA document dated November 16, 2017 are used to estimate the amount of credits that can be earned by transit agencies.[7] LCFS program released an ISOR[8] on March 6, 2018 and had a public hearing[9] on April 27, 2018 with updated CI benchmarks and CI values for the fuel pathways in the lookup table. In this updated analysis, CI

[7] California Air Resources Board (CARB) (2017). Low Carbon Fuel Standard 2018 Amendments, Standard Regulatory Impact Assessment (SRIA), date of submission: November 16, 2017. Available: http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/documents/LCFS_SRIA_CARB_11-16-17.pdf

[8] California Air Resources Board (CARB) (2018). Proposed Amendments to the Low Carbon Fuel Standard Regulation and Regulation on Commercialization of Alternative Diesel Fuels. Staff Report: Initial Statement of Reasons. March 6, 2018. Available: https://www.arb.ca.gov/regact/2018/lcfs18/isor.pdf.

[9] California Air Resources Board (CARB) (2018). Presentation for Public Hearing of 2018 Proposed Amendments to the Low Carbon Fuel Standard Regulation and Regulation on Commercialization of Alternative Diesel Fuels. April 27, 2018. Available: https://www.arb.ca.gov/board/books/2018/042718/18-3-5pres.pdf?_ga=2.124200649.272832539.1526594435-103739339.1519860243.

benchmarks and CI values for fuels have been updated to be consistent with LCFS ISOR document (Table 2 and Table 7-1 in Appendix A[10]).

4. Other Costs

In addition to direct capital costs and operational and maintenance costs on buses and supporting infrastructure, a transition to a new technology often has costs associated with deploying the technology and changing operational and maintenance practices. These associated costs, such as operator and technician trainings, purchase and upgrade of software, and possible spare parts, are recurring.

Planning costs are upfront and need to be spent even before bus procurement or infrastructure construction. The proposed ICT regulation requires a Rollout Plan from each transit agency and its associated cost is discussed in the section for Rollout Plan cost.

However, limited information is available for this type of transitional cost. After discussing these topics with stakeholders, no consensus on an appropriate estimate has been achieved. During the public discussion of the workgroup meeting in June 2017, CARB staff assumed that these "other costs" associated with ZEB deployment is equivalent to be 2.5 percent of bus prices for all powertrains and discussed that the costs should go down over time for ZEBs as they become more common.[11] This method is based on the assumption that the Cost Subgroup used to reflect estimated soft costs for conventional internal combustion engine buses.[12]

In the SRIA, these other associated cost for ZEB deployment were not included. In this updated cost analysis, these transitional costs are estimated to be 2.5 percent of bus prices reflecting a higher cost for ZEBs when compared to a conventional internal combustion engine bus and assumed to be equal to conventional internal combustion engine buses by 2029 when all bus purchases must be ZEBs. The decline in costs reflects that with longer range buses expected in the future, bus operation and dispatch would be similar to conventional internal combustion engine buses, and transit agencies will not need to prepare bids for different technology buses. In addition, technician training for advanced technologies is already available and is expected to become

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[10] California Air Resources Board (CARB) (2018). Proposed Regulation Order of Low Carbon Fuel Standard. March 6, 2018. Available: https://www.arb.ca.gov/regact/2018/lcfs18/appa.pdf.

[11] California Air Resources Board (CARB) (2018). Presentation for 5th Innovative Clean Transit Workgroup Meeting. June 26, 2017. Available: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626_wg_pres.pdf.

[12] Transit Agency Subcommittee-Lifecycle Cost Modeling Subgroup (2017). Report of Findings, April 2017.

commonplace at colleges. Technicians will be able to specialize on ZEB drivetrain repair after a significant number of ZEBs are deployed at a location.

The cost for battery recycling at the end of battery life is not included here, because this cost could potentially be offset to some degree by the residual value of the battery at the end of bus life. The energy capacity of the batteries used in ZEBs will naturally degrade over time and will need replacements. When battery capacity is not sufficient for meeting daily range needs for a bus, it is expected that there will be a second life for the batteries. For example, batteries can be repurposed for different usage, such as stationary energy storage. Repurposing these batteries for different uses could become a new revenue source for the transit agencies. Any cost recovery from battery repurposing could be used to offset disposal costs. 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 residual value to customers upon the retirement of a battery.[13] Therefore, staff believes that the residual value can offset the recycling cost but does not include a residual battery value in the economic analysis for the transit agencies.

5. Rollout Plan Cost

The cost associated with developing the Rollout Plan and associated planning for a zero-emission fleet is added and will increase the total cost of the ICT proposal. With comments and feedback from stakeholders, CARB staff is proposing to require a Zero-Emission Bus Rollout Plan (Rollout Plan) for large transit agency in 2020 and for small transit agencies in 2023. The Rollout Plan would need to describe how a transit agency is planning to achieve a full transition to zero-emission technologies and would need to be approved by the transit agency board.

Similar to "other cost," there is limited information publicly available for this kind of Rollout Plan cost, and most agencies are still in the early stages of consideration and planning. The estimated cost include professional services for planning, designing and managing ZEB deployment, and staff time to prepare a recommendation to the Board. Consulting services for this kind of planning in the Rollout Plan could cost around tens to hundreds of thousands dollars depending on fleet size. For example, North County Transit District intends to spend around $1 million on as-needed specialized consulting

[13] EnerDel applies a 25% of residual value to retired batteries http://enerdel.com/services/guaranteed-residual-value/. Accessed July 10, 2018.

service to support planning, evaluation, and procurement of ZEB technology.[14] North County Transit District has two depots with more than 200 buses in total.

For this analysis, CARB staff assumed that the total cost of the Rollout Plan would average about $500,000 per depot (approximately 200 buses). The average cost is approximately $2,500 per bus. This amount is expected to vary among transit agencies. Some transit agencies already have plans to deploy ZEBs. Some may choose to hire consultants to evaluate a wide range of options for their fleet, and others may be able to take advantage of other transit agencies' experiences. The average cost is allocated based on the bus fleet size reflecting lower costs for small fleets compared to larger ones. Further, it is also assumed that this cost is upfront and occurs in the year that transit agencies are required to submit the Rollout Plan, which is 2020 for large transit agencies and 2023 for small transit agencies.

B. Costs for Standard Buses

For standard buses, upfront capital costs (including costs for bus purchase, fueling and charging infrastructure, and maintenance bay upgrades) as well as most of the operational and maintenance costs (including costs for bus midlife and maintenance, and infrastructure maintenance) are kept the same as in the SRIA. In this updated analysis, electricity costs per kWh for depot charging BEBs in different utility areas have been revised with a higher charging rating, from 60 kW to 80 kW. This change will represent a shorter charging time, especially with the considering of longer range BEBs in the future.

Electricity cost per kWh varies by electric utility service areas and charging strategy[15]. For this updated cost analysis, it is assumed that 90 percent of BEBs will utilize depot charging with managed charging, 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. The assumptions associated with this charging scenario have been explained in the footnote of Table C10 in the SRIA.

In the SRIA, it is assumed that 60 kW chargers are used to charge BEBs at a depot facility. Considering the long charging hours and potential increase of battery sizes for longer range, this updated cost analysis has revised the charging rating to 80 kW. Note that charger cost does not change accordingly and it is likely that 80 kW chargers would

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[14] North County Transit District (2017). Board Meeting on September 21, 2017, Agenda Item #17. Available: https://lfportal.nctd.org/weblink/ElectronicFile.aspx?docid=83560&dbid=0.

[15] California Air Resources Board (CARB) (2017). Draft Battery Electric Truck and Bus Charging Calculator. Updated June 20, 2017. Available: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626chargecostcalcv3.xlsm.

be more expensive than 60 kW ones. Yet without sufficient charger cost information, the cost for 60 kW charger is used instead. The electricity costs by utility are updated accordingly, as shown in Table 1.

The energy use for a BEB is based on the data from Foothill Transit[16] with an overall average energy use of 2.1 kWh/mile, or 0.48 mile/kWh. While this represents the energy use from the vehicle, considering an energy loss of about 10 percent during charging,[17] the energy use from the grid would be 2.3 kWh/mile, which is consistent with "grid-side" energy use for BEBs evaluated at King County Metro.[18] Other assumptions for this managed depot charging scenario are the same as in the SRIA. The growth rates of electricity costs for the commercial section in AEO 2018 (as shown in Figure 2) are applied to the values shown in Table 1 to project electricity costs for depot charging in the future years.

Table 1: Electricity Costs for Managed Depot Charging by Utility (2016$)

Utility	Managed Depot Charging ($/kWh)*	Rate Schedules
PG&E	$0.18	E-20
SCE	$0.10	TOU-8 Option A
LADWP	$0.10	A2 (B) TOU
SDG&E	$0.21	AL-TOU (above 500 kW)

* Represents a scenario where charging in the depot reduces maximum demand by 50 percent through decreased charge power, sequential bus charging, or other means. Vehicles charged at 80 kW. Assumptions used: 100-bus fleet; 130 miles/day; 2.1 kWh/mile; 90 percent charging efficiency; "Evening" (7p-6a) charging.

C. Costs for Cutaway Buses

1. Vehicle Capital Cost

Cutaway buses represent a wide variety of vehicles types and lengths.[19] Vehicle prices vary among different vehicle types and lengths. The California Association for

[16] National Renewable Energy Laboratory (2016). Foothill Transit Agency Electric Bus Demonstration Results, released in January 2016. Available: https://www.nrel.gov/docs/fy16osti/65274.pdf

[17] National Renewable Energy Laboratory (NREL) (2017). Foothill Transit Battery Electric Bus Demonstration Results: Second Report. June, 2017. Available: https://www.nrel.gov/docs/fy17osti/67698.pdf.

[18] Federal Transit Administration (FTA) (2018). Zero-Emission Bus Evaluation Results; King County Metro Battery Electric Buses. February, 2018. Available: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/115086/zero-emission-bus-evaluation-results-king-county-metro-battery-electric-buses-fta-report-no-0118.pdf.

[19] Federal Transit Administration (2007). An Evaluation of the Market for Small-to-Medium-Sized Cutaway Buses. Final Report. FTA Project Number: MI-26-7280.07.1. December 21, 2007. Available:

Coordinated Transportation (CalACT)/the Morongo Basin Transit Authority (MBTA) Vehicle Purchasing Cooperative (the Cooperative) offers a variety with the Americans with Disabilities Act (ADA) compliant vehicles.[20] The purchasing schedule offered by the Cooperative includes class A to class G cutaway buses and minivans from multiple vendors. The median price for a class C gasoline cutaway bus (16 passengers, rear lift) is around $65,000. The length for larger cutaway buses (class E) ranges from 27-ft to 40-ft. The median price for a 27-ft to 29-ft cutaway bus is around $89,000. Staff uses class C cutaway buses in the cost analysis.

Staff assumes the incremental cost of a CNG cutaway bus over a gasoline cutaway bus is $20,000.[21] Staff has limited information of the price of a battery electric cutaway bus, and assumes the incremental cost with a 100 kWh battery is $100,000 over that of a CNG cutaway bus.[22]

The vehicle price projection follows the same method as the 40-ft transit buses discussed in the section C.1.a. in the SRIA and Appendix F-2 of ISOR. For conventional internal combustion engine cutaway buses, a constant 4.4 percent annual increase is assumed to project future prices.

Staff used a 150 kWh battery to project future prices for battery electric cutaway buses because cutaway buses will be purchased after 2026, and it is expected that longer range vehicles will be available. As described in Appendix F-2, while there is a lack of information about explicit relationships between production volume and battery cost for heavy-duty vehicle applications, CARB staff estimates that battery costs for buses will decrease over time and they are $725/kWh in 2015, $405/kWh in 2020, and $218/kWh in 2030 for batteries used in depot-charging buses, as shown in Figure 4 of staff's discussion document about battery costs (Appendix E)[23]. To calculate battery electric cutaway bus prices in 2016 constant dollars, these battery unit costs are deescalated by using 2 percent inflation rate and the values in years between are estimates by using exponential interpolation. Finally, battery electric cutaway bus price is estimated by

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https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/AnEvaluationofMarketforSmalltoMediumSizedCutawayBuses.pdf.

[20] California Association for Coordinated Transportation (CalACT) . CalACT/MBTA 15-03 Purchasing Schedule. Available: https://www.calact.org/assets/Price%20Information%20RFP%2015-03%20Rev%2008302017%20sep17.xlsx.

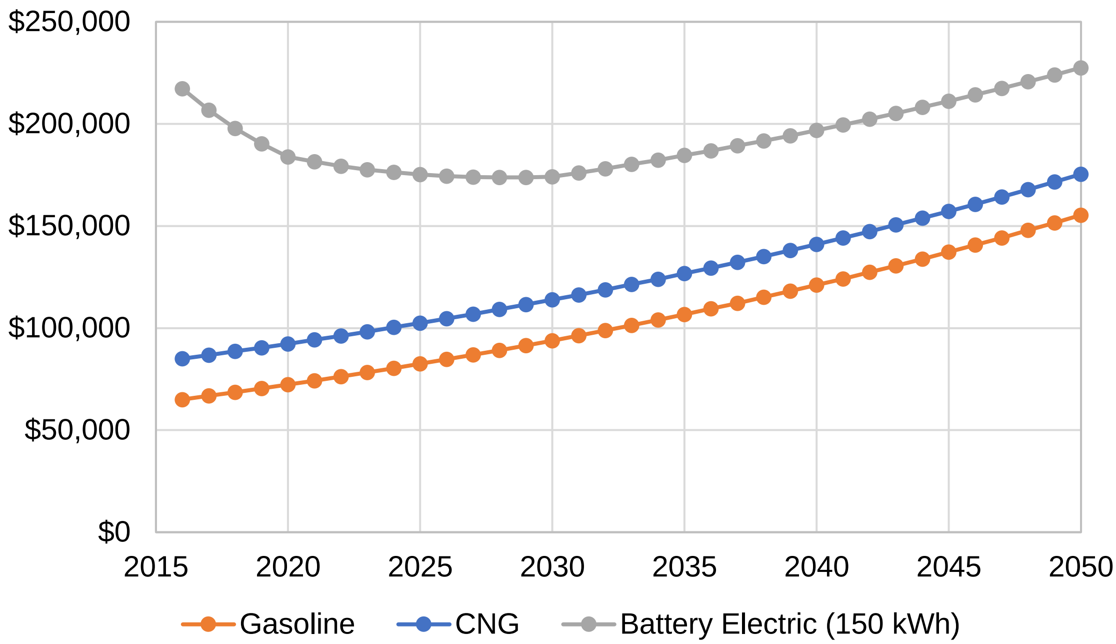
[21] Staff's estimate is based on the price difference between a gasoline cutaway and a CNG cutaway in the CalACT/MBTA 15-03 Purchasing Schedule, and an estimate provided by the Morongo Basin Transit Authority in January 2018.

[22] Staff's estimate is based on the incremental cost of recent Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) applications, and communication with vehicle manufacturers.

[23] California Air Resources Board (CARB) (2017). Battery Cost for Heavy-Duty Electric Vehicles. August 14, 2017. Available: https://www.arb.ca.gov/msprog/bus/battery_cost.pdf.

adding incremental cost to the projected conventional cutaway bus prices and deducting cost reduction from batteries. The cutaway bus prices and projections are shown in Figure 3.

Figure 3: Cutaway Bus (Class C) Price Projections (2016$)



2. Vehicle Maintenance Cost

For gasoline cutaway bus maintenance cost, staff uses $0.26/mile, which is estimated by the Access Services Los Angeles.[24] Staff assumes the maintenance cost for a CNG cutaway bus is similar to a gasoline cutaway bus.[25,26] For a battery electric cutaway bus, staff assumes a maintenance cost of $0.20/mile. This is calculated based on the same percentage of maintenance savings of a battery electric bus over a diesel bus, as shown in Appendix G. In the SRIA, staff estimates the maintenance cost of a battery

[24] Access Services. Access Services Projected Fleet Costs for the Service Fleet in Los Angeles Paratransit Services. Available: https://www.sacog.org/sites/main/files/file-attachments/access_la_life_cycle.pdf.

[25] Based on the information provided to staff by Phoenix Motorcars in November 2017, the maintenance cost for a gasoline cutaway is the same as CNG cutaway (exclude engine replacement).

[26] Phoenix Motorcars (2017). Email communication with Tarek Helou, Director of Sales, on November 1, 2017.

electric bus is about 76 percent of that of a diesel bus (*see*, e.g., Appendix B-1, p. 29, and Appendix G).[27,28]

3. Vehicle Midlife Cost

Based on information provided by Phoenix Motorcars, the engine replacement frequency for a gasoline cutaway bus is every 150,000 miles, and every 75,000 miles for a CNG cutaway bus. The engine replacement cost for a gasoline cutaway bus and a CNG cutaway bus is around $6,000 and $7,000 respectively.[29] In this updated analysis, it is assumed that the CNG bus would have one midlife overhaul with a cost of $21,000. For battery electric cutaway buses, the midlife cost would be the cost for one battery replacement.

4. Fuel Efficiency

For a class C gasoline cutaway bus, the Access Services in Los Angeles County estimates the fuel efficiency to be around 6 miles/gallon.[30] The reported overall fuel efficiency from an Altoona bus testing report for a 32-ft CNG cutaway bus is 1.26 miles/lb, or 50.58 miles/MMBtu, which is about 6.4 miles/DGE (or 5.8 miles/GGE).[31,32] For the cost analysis, staff use a fuel efficiency of 6 miles/ DGE for both gasoline and CNG cutaway buses. For a battery electric cutaway, based on the data from 16 electric shuttle buses[33] operating between a parking facility and the airport terminals at the Los Angeles International Airport, the average overall vehicle energy consumption is 1.23 kWh/mile, which includes all energy consumed during driving, idling and operation of

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[27] Diesel bus maintenance cost is estimated to be around $0.8/mile. Staff estimates that there is a $0.19/mile maintenance cost saving for a BEB over a diesel bus due to $0.11/mile regenerative brake cost savings and $0.08/mile for propulsion related saving. The maintenance cost of a battery electric cutaway is $0.26*(1-$0.19/$0.80) = $0.20/mile.

[28] California Air Resources Board (CARB) (2016). Literature Review on Transit Bus Maintenance Cost. August, 2016. Available: https://www.arb.ca.gov/msprog/bus/maintenance_cost.pdf.

[29] Phoenix Motorcars (2017). Email Communication with Tarek Helou, Director of Sales, on November 1, 2017.

[30] Access Services. Access Services Projected Fleet Costs for the Service Fleet in Los Angeles Paratransit Services. Available: https://www.sacog.org/sites/main/files/file-attachments/access_la_life_cycle.pdf.

[31] Bus Testing and Research Center (2011). STURAA Test, 7 Year, 200,000 Mile Bus from Supreme Corp/Startrans Bus - Model Senator HD Cutaway. April 2011. Available: http://altoonabustest.psu.edu/buses/reports/379.pdf?1329832711.

[32] Staff converted the value to miles/DGE, and miles/GGE.

[33] The electric shuttle buses are Class 3 cutaway. The energy consumption for a class 3 and class 4 is similar based on staff's communication with Phoenix Motorcars in 2017.

utilities (e.g., HVAC unit).[34] The energy consumption from the grid is about 1.45 kWh/mile with charging efficiency incorporated.

5. Electricity cost

Staff uses the CARB electricity cost calculator to estimate the electricity cost for depot charging cutaway buses.[35] The electricity rates in different utility areas are summarized in Table 2. The weighted average of electricity cost (with 50 percent 19 kW chargers and 50 percent 50 kWh chargers) is used for the cost analysis. The growth rates of electricity costs for the transportation section in AEO 2018, shown in Figure 2, are applied to the values shown in Table 2 to project electricity costs for depot charging cutaway buses in the future years.

Table 2: Electricity Costs for Cutaway Buses with Managed Depot Charging

Utility Name	Managed Depot (19 kW) ($/kWh)[a]	Managed Depot (50 kW) ($/kWh)[b]	Weighted Average ($/kWh)
PG&E	$0.18	$0.21	$0.20
SCE	$0.11	$0.11	$0.11
LADWP	$0.10	$0.11	$0.11
SDG&E	$0.21	$0.25	$0.23
SMUD	$0.12	$0.12	$0.12

[a] Assumptions used in the calculator: vehicles charged with 19 kW charger; 40 vehicles at a meter location; 100 miles/day/vehicle; vehicle energy use 1.23 kWh/mile; charging efficiency is 85 percent.

[b] Assumptions used in the calculator: vehicles charged with 50 kW charger; 40 vehicles at a meter location; 200 miles/day/vehicle; vehicle energy use 1.23 kWh/mile; charging efficiency is 85 percent.

6. Infrastructure Cost

Staff includes two types of chargers in the cost analysis, and assumes that 50 percent of the cutaway buses would use 19 kW chargers, which are compatible with Level II charging, and 50 percent would use 50 kW chargers. It is estimated that the cost of a

[34] Phoenix Motorcars (2017). Case Study: Wally Park Premier – Zero Emission Utility Shuttles Fleet. July 28, 2017.

[35] California Air Resources Board (CARB) (2017). Draft Battery Electric Truck and Bus Charging Calculator. Updated June 20, 2017. Available: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626chargecostcalcv3.xlsm.

19 kW charger is $2,500, and a 50 kW depot charger is $25,000.[36] Staff assume the charger installation cost to be around $25,000 each.[37,38]

D. Costs for Regulatory Reporting

The proposed ICT regulation requires all transit agencies to report their fleet information annually starting 2021. For the initial report, transit agencies will need to report information on all active buses in the fleet as of December 31, 2017 within the scope of the regulation to determine fleet size.

In subsequent years, transit agencies would not have to re-enter vehicle information already on file in the database. Transit agencies instead would only need to add vehicle information for those newly purchased or retired vehicles that are no longer part of the fleet. In addition, transit agencies would also submit fuel contracts if renewed, and information for any mobility programs if applied.

Staff estimates that the proposed reporting requirements would require a larger time commitment in the first year than in subsequent years. The following assumptions are used in estimating needed time and associated costs for reporting:

- The hourly rate for a clerical employee to input data to meet the ICT reporting requirements is assumed to be $50 per hour. [39]
- Time spent on reporting would decrease by 50 percent in subsequent years.
- Transit agencies would need 20 minutes per vehicle in the first year and 10 minutes per vehicle in subsequent years.

The total reporting costs are estimated to be about $225,000 in the first year and about $135,000 each year, thereafter until 2050.

III. UPDATED OF STATEWIDE COST

In addition to cost variable inputs, the statewide direct cost is also determined by the bus population and its technology composition, which depends on bus turnover rate and ZEB phase-in schedules. Considering separation of cutaway buses from standard buses, the bus population distribution by vehicle type, fuel type, and agency size has

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[36] Staff's communication with Phoenix Motorcars in November 2017.

[37] Installation cost varies depending on sites. Staff's estimate is based on the data provided by Phoenix Motorcars in November 2017 from an off-airport parking company electrification project.

[38] Phoenix Motorcars (2017). Email communication with Tarek Helou, Director of Sales, on November 28, 2017.

[39] California Air Resources Board (CARB) (2008). Technical Support Document: Proposed Regulation for In-Use Road Diesel Vehicles. October, 2008. Available: https://www.arb.ca.gov/regact/2008/truckbus08/tsd.pdf.

been updated. With the updated cost input assumption in Section II, and bus population revision due to separation of cutaway buses, the total direct costs are updated at the same time and discussed at the end of this section.

A. Bus Base Population

1. Data Source

As described in the SRIA, the bus population for the direct cost estimates is based on the National Transit Database (NTD) in 2016. [40] Transit agencies report to NTD about their vehicle fleet by mode[41] and vehicle type.[42] To calculate the total bus population for the cost analysis, modes of bus (MB), commuter bus (CB), bus rapid transit (RB), and demand response (DR) are included, and vehicle types of bus, articulated bus, over-the-road bus, double decker bus, and cutaway bus are included. Redundant reporting of vehicles that support multiple modes in NTD are excluded.

2. Vehicle Type

In the SRIA, all vehicles with the above modes and vehicle types are treated as standard buses and included for the cost estimates. In this updated analysis, buses are separated by vehicle type. Without GVWR information in NTD, vehicle length is used as a proxy to estimate vehicle weight classes. Vehicles with the length of 23-ft or less are excluded. Based on the manufacturer and model in NTD, these vehicles are very likely to fall into the category of Class 3 with GVWR less than 14,000 lbs., which is out of the scope of the proposed ICT regulation. Note that during the implementation of the ICT regulation, vehicle length will not be used to determine compliance.

3. Fuel Type

In the SRIA, fuel types with similar powertrains are regrouped into four categories: CNG, diesel, hybrid diesel, and ZEBs. In this updated analysis, these four categories stay the same for standard buses. For cutaway buses with fuel types in the NTD, 62 percent are powered by gasoline engines, 24 percent are powered by CNG engines, and the rest are powered by diesel, diesel hybrid, and gasoline hybrid engines. For the ease of analysis, cutaway buses are simply grouped into two categories: CNG and gasoline which includes gasoline, gasoline hybrid, diesel and diesel hybrid. Without fuel

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

[41] 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.

[42] According to NTD Glossary, “Vehicle Type” is defined as “The form of passenger conveyance used for revenue operations”

type data for rural agencies, their bus distributions among fuel types in this analysis are assumed to be the same as urban agencies.

4. Agency Size

In the SRIA, CARB staff proposed to group transit agencies into three different sized categories. The proposed ICT regulation, after taking transit communities' comments, groups the transit agencies into two categories: a large transit agency is defined as a transit agency with 100 or more buses, while a small transit agency represents the rest.

B. Bus Distribution in Utility Areas

Transit agencies are in different utility service territories. Utilities have different rate schedules, which affect the electricity cost when charging BEBs or compressing hydrogen. Using only one uniform electricity rate to calculate the statewide cost cannot reflect the electricity cost variation across transit agencies. To analyze the diverse electricity costs, the bus population is further grouped and allocated to different utility areas.

For standard buses, the assumptions are the same as in the SRIA:

- *Pacific Gas and Electric Company (PG&E)*: all the diesel and diesel hybrid buses are assumed to be operated in the PGE territory.
- *San Diego Gas and Electric (SDG&E)*: CNG buses operating in San Diego Metropolitan Transit System (SD MTS) and North County Transit District (NCTD) are assigned to the SDG&E territory.
- *Los Angeles Department of Water and Power (LADWP)*: 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 LADWP territory.
- *Southern California Edison (SCE)*: the remaining CNG buses are assumed to be operated in the SCE territory.

For cutaway buses, the following assumptions are made in this updated analysis:

- *PG&E*: 40 percent of gasoline cutaway buses are assumed to be operated in the PG&E territory. It is assumed that the percentage of cutaway buses in PG&E territory is the same as that of standard buses.
- *SCE*: all CNG cutaway buses and the rest of gasoline cutaway buses are assumed to be operated in the SCE territory

Table 3 shows standard bus and cutaway bus allocations to different utility territories according to the assumptions in this section.

Table 3: Bus Distribution in Utility Areas

Bus Type	Agency Size	Utility	Diesel	Diesel Hybrid	CNG	Gasoline	Total
Standard Bus& Articulated and Over-the-road Bus	Large	PG&E	2,892	320			3,212
		SCE			2,741		2,741
		LADWP			1,907		1,907
		SDG&E			630		630
	Small	PG&E	1,222	213			1,435
		SCE			1,270		1,270
		LADWP					0
		SDG&E					0
Cutaway Bus	Large	PG&E				169	169
		SCE			50	204	254
		LADWP					0
		SDG&E					0
	Small	PG&E				418	418
		SCE			388	240	628
		LADWP					0
		SDG&E					0
Total			4,114	533	6,986	1,031	12,664

C. Bus Lifetime and Turnover

A 14-year average lifetime for standard buses (the same as the SRIA), and 10-year average lifetime for cutaway buses are assumed in this updated analysis. This assumption is consistent with the existing practices of most transit fleets.

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.[43] Typically transit agencies operate standard buses for additional 2 years beyond the minimum requirements. While the statewide bus fleet is comprised of a variety of bus types and sizes, with diverse minimum service lifespans, 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. Medium-duty and purpose-built buses, and heavy-duty cutaway buses have a 7-year minimum life requirement and transit agency usually operate them for around 10 years.

[43] Federal Transit Administration (FTA) (2007). Useful Life of Transit Buses and Vans (Report No. FTA VA-26-7229-07.1). April, 2007. Available: https://www.transitwiki.org/TransitWiki/images/6/64/Useful_Life_of_Buses.pdf.

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 standard bus population, and on average 10 percent (=1/10) of cutaway bus population, will be replaced by new ones in each year.

D. Bus Population Projection

The future of bus population and technology splits are determined by (1) total bus population, (2) phase-in of ZEBs, (3) replacement of conventional buses.

1. Growth of Bus Population

The total bus population is expected to increase with the growth of human population and updates of metropolitan planning organizations' (MPO) Regional Transportation Plan (RTP).

In EMFAC2017, for areas governed by a MPO that forecasts transit growth in target years of the Regional Transportation Plan/Sustainable Communities Strategy (RTP/SCS), 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 an MPO or where a local MPO does not provide transit growth, the county-level human population growth rate published by the Department of Finance was used as surrogate for transit growth. The statewide growth rates of urban buses, ranging from 0.7 percent to 1.4 percent per year from 2016 to 2050, from EMFAC2017 are used to project future bus population in this analysis. With the growth rates, the total bus number would increase from over 12,000 in 2016 to over 17,000 in 2050.

With the growth of bus population, there would be potential expansion of fuel stations for CNG, diesel, and gasoline buses in current conditions. Since there is a lack of information concerning the capacity of current fueling stations, it is challenging to quantify when, where and how many stations to include in the current conditions; for this reason this estimate was not included. Without considering the growth impact on fueling stations, the overall cost in the current conditions in likely underestimated. This means that the incremental cost of the proposed ICT regulation could be lower than reported here.

2. ZEB Phase-In Schedule

The ZEB phase-in schedule, or the percentage of ZEBs required in each new purchase, determines the number of ZEBs that enter bus fleets annually. Table 4 shows ZEB phase-in schedules for the current conditions and the updated ICT regulation.

Under the updated ICT regulation, the start date of ZEB purchase requirements is delayed from originally 2020 to 2023 for large transit agencies and from 2023 to 2026 for small transit agencies. Under the updated proposal, 25 percent of ZEBs start to be purchased by large transit agencies beginning in 2023 and by small transit agencies beginning in 2026. More time is provided to cutaway, articulated, and over-the-road buses and the purchase requirements will start in 2026 or later.

Table 4: ZEB Phase-In Schedules for the Current Condition, and the Proposed ICT Regulation

Year[a]	Current Conditions	Proposed ICT Regulation			
	All agencies	Standard Bus		Cutaway Bus and Other Non-standard Buses	
		Large Agency	Small Agency	Large Agency	Small Agency
2020	0%	0%	0%	0%	0%
2021	0%	0%	0%	0%	0%
2022	0%	0%	0%	0%	0%
2023	0%	25%	0%	0%	0%
2024	0%	25%	0%	0%	0%
2025	0%	25%	0%	0%	0%
2026	0%	50%	25%	50%	25%
2027	0%	50%	25%	50%	25%
2028	0%	50%	25%	50%	25%
2029	0%	100%	100%	100%	100%

[a] The ZEB phase-in schedules are shown from 2020 to 2029. After 2029, ZEB purchase percentages are the same as the ones in 2029.

a. Bonus Credits

The early bonus credit provision also impacts ZEB populations in the proposed ICT regulation. It is assumed some transit agencies will obtain early bonus credits resulting in fewer ZEBs in early years. This would change costs and emissions benefits and the impacts are presented in this updated cost and emission analysis. The number of bonus credits generated by transit agencies were estimated based on the number of ZEBs in service in individual transit agencies (Table 5).[44] With the consideration of bonus ZEB credits, 95 and 37 fewer ZEBs are required to be purchased by large transit agencies in 2023 and by small transit agencies in 2026, respectively.

[44] California Air Resources Board (CARB) (2018). Battery and Fuel Cell Electric Buses in California. May, 2018. Available: https://arb.ca.gov/msprog/ict/zbusmap.pdf.

Table 5: Bonus ZEB Credits Earned by Large and Small Transit Agencies

Agency Size	ZEB Technology	Bonus Credits
Large	BEB	47
	FCEB	48
	Subtotal	***95***
Small	BEB	17
	FCEB	20
	Subtotal	***37***
Total		132

b. ZEB Technology Splits

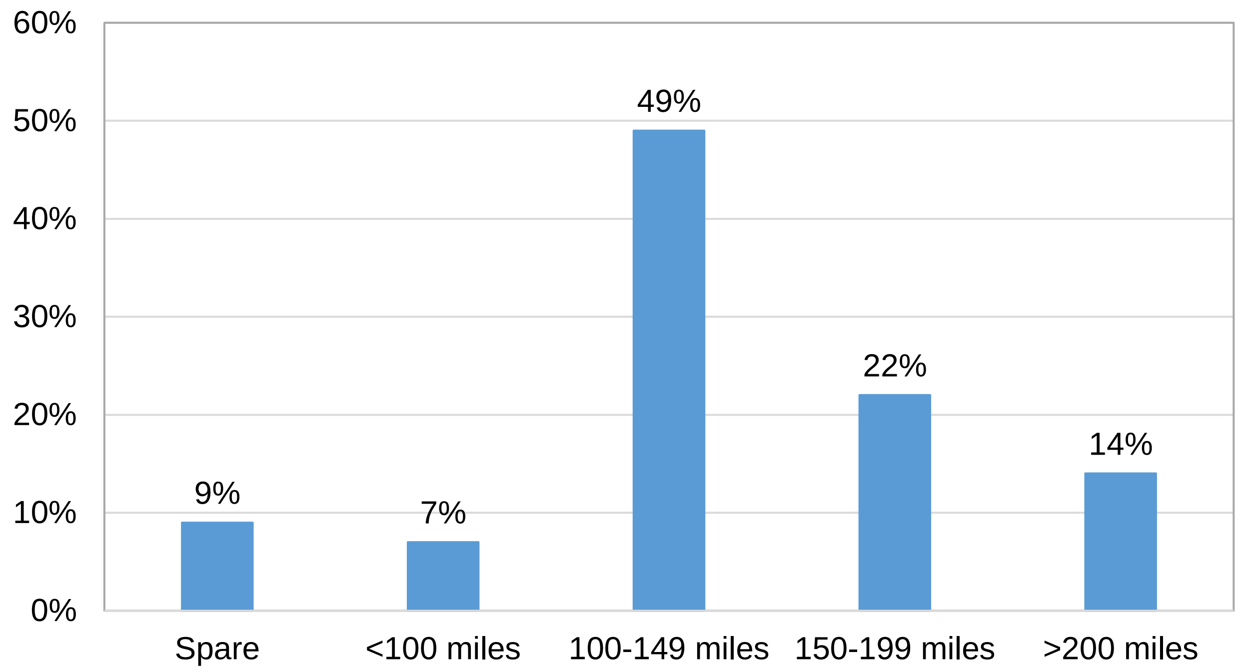
Transit agencies can choose different pathways and zero-emission technologies to comply with the ZEB purchase requirements. Though it is difficult to predict transit agencies' choice of zero-emission technologies, a majority of ZEBs currently in the fleet are BEBs. More fleets are expected to charge overnight in depots, especially as battery technology improves and daily bus ranges becomes longer, rather than relying on on-route charging strategies.

This updated analysis assumes that among the ZEB purchases (excluding cutaway buses), 99 percent will be BEBs and 1 percent will be FCEBs. Out of the total BEB purchase, 90 percent of the BEBs will be depot charging and 10 percent of the BEBs will be on-route charging. This split is based on the cost of technology deployment and current purchase trend. It also assumes that all zero-emission cutaway buses would be charging at depots. In the real ZEB deployment, transit agencies choose different zero-emission technologies. While it is hard to predict transit agencies' future choice, the actual statewide cost for ZEB deployment may be different based on the charging method used at depot facilities. This analysis also assumes that all the zero-emission cutaway bus purchases are depot charging battery electric cutaway buses, as this is the only available zero-emission technology for cutaway buses.

Additionally, for depot charging BEBs, the range is expected to be lower in early years due to technology advancement. More buses are becoming available with higher daily range as technology continues to improve, battery costs come down, and battery energy density improves. Most depot charging BEBs are currently within a range of 150 miles per day. This capacity, with a discounted range due to the use of heat, ventilation, and air conditioning (HVAC) and other electronic devices on board, would only meet transit agencies needs in the early years to apply to their short-range bus service. Some bus manufacturers have developed models with ranges over 200 or 300 miles per charge to meet transit agencies' needs and provide more operation flexibility.

To better understand transit agencies' operation such as range needs, staff conducted a survey in 20016. The summary of survey results was shared with stakeholders at the third Workgroup meeting on August 29, 2016, and posted on the program website.[45] The survey data from transit fleets is highlighted in Figure 4, showing that for 40-foot buses, about fifty percent of buses operate less than 150 miles per day, and about eighty-five percent of buses operate less than 200 miles per day.[46]

Figure 4: Survey Statistics of Daily Standard Bus Mileage Distribution



For the statewide analysis, staff assume 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. In this updated cost analysis, short-range buses with 330 kWh or up to 150 nominal miles per charge are purchased from 2020-2025. Mid-range buses with 440 kWh batteries or approximately 200 nominal miles per charge are purchased from 2026-2028, and longer range buses with an average of approximately 550 kWh batteries or 250 nominal miles per charge from 2029 and afterwards.

[45] California Air Resources Board (CARB) (2016). Transit Agency Survey Preliminary Results. ACT Workgroup Meeting. August 29, 2016. Available: https://www.arb.ca.gov/msprog/bus/transit_survey_summary.pdf.

[46] California Air Resources Board (CARB) (2016) Transit Agency Survey Preliminary Results, ACT Workgroup Meeting on August 29, 2016. Available: https://www.arb.ca.gov/msprog/bus/transit_survey_summary.pdf.

For the depot charging battery electric cutaway buses, most of the current available models have a battery size around 100 kWh, which can provide a nominal range of 100 miles per charge. For example, Phoenix offers 105 kWh[47] and Motiv ranges from 85-127 kWh[48].

3. **Waiver of ZEB purchases**

To provide further flexibility to the transit agencies and to encourage early emission reductions in local communities, staff is proposing to waive the 2023 and 2024 purchase requirements if a large number of ZEBs are voluntarily purchased early. The waiver would be in effect only if the following criteria are met:

- 2023 purchase requirements would be waived if California transit agencies collectively purchase 1,000 or more ZEBs by December 31, 2020.
- 2024 purchase requirements would be waived if California transit agencies collectively purchase 1,150 or more ZEBs by December 31, 2021

If transit agencies meet the voluntary waiver target, it is assumed they would do so because it is in their best financial interest. It is likely that transit agencies would make this choice because of the availability of incentives or other funding.

Table 6 illustrates the possible cumulative ZEB purchases with and without the waiver. This estimate is conservative in that it assumes no ZEB purchases after the waiver conditions are met unless required by the regulation.

[47] Phoenix Motorcars. Specs of Phoenix Zeus Electric Shuttle Bus. Available: http://www.phoenixmotorcars.com/products/#1505308787607-7f8c2c3b-0cf2.

[48] Motiv (2018). Motiv-Powered All-Electric Shuttle Bus Chassis Specifications. Available: http://www.motivps.com/motivps/wp-content/uploads/2018/03/Motiv_M132_DS_EPIC4_Dearborn_E450_Shuttle_20180319.pdf.

Table 6: Illustration of Cumulative ZEB Purchases with and without a Waiver

Year	Without Waiver	With Waiver
2020	0	1000
2021	0	1150
2022	0	1150
2023	140	1150
2024	282	1150
2025	426	1150
2026	884	1150
2027	1347	1150
2028	1816	1534
2029	2929	2647
2030	4055	3773

With the waiver, 1,150 ZEBs are purchased at least three years earlier than would otherwise be required by the proposed ICT regulation. This would result in significant early emissions benefits. A majority of large transit agencies in all major regions of California including the South Coast, Bay Area, and Central Valley are indicating they are planning to purchase ZEBs early so it is reasonable to expect overall emissions benefits in all regions if the conditions for the waiver are met. However, the cumulative emission reductions for the proposed ICT regulation are the same with or without the waiver. An early emission reduction means a change of emission reduction distribution in later years.

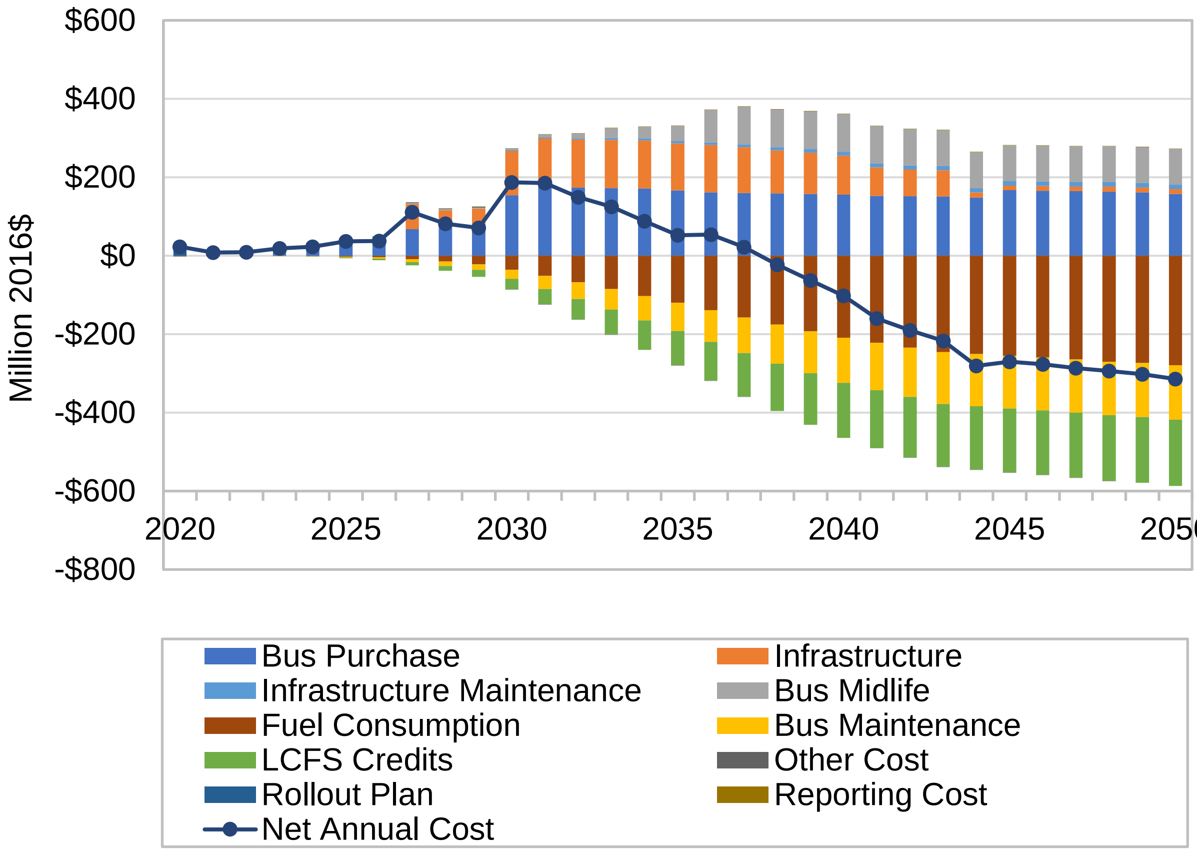
4. Non-ZEB Purchases

In the baselines, the non-ZEB purchases are replaced by conventional buses of the same fuel type. For example, diesel buses are replaced by diesel buses, and CNG buses are replaced by CNG buses. 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. Similarly, this analysis does not consider low NOx propane or gasoline engines purchases.

E. Statewide Cost

With the updates of cost inputs, the ICT regulation is expected to result in a total cost saving of $1.5 billion, compared to current conditions, from 2020 through 2050 for transit agencies. As shown in Figure 5, at the beginning of the ICT regulation adoption (2020-2030), the annual costs are positive and increase over time relative to current conditions, mainly because of the gradual phase-in of ZEBs and associated service upgrades and infrastructure installation. After 2038, the annual savings begin to outweigh the higher incremental cost of ZEBs due to savings in ZEB maintenance, fuel, credits from LCFS program, and because ZEB replacements begin and need much fewer infrastructure or electrical service upgrades than early years.

Figure 5: Estimated Total Direct Costs of the Proposed ICT Regulation to Transit Agencies Relative to Current Conditions (million 2016$)

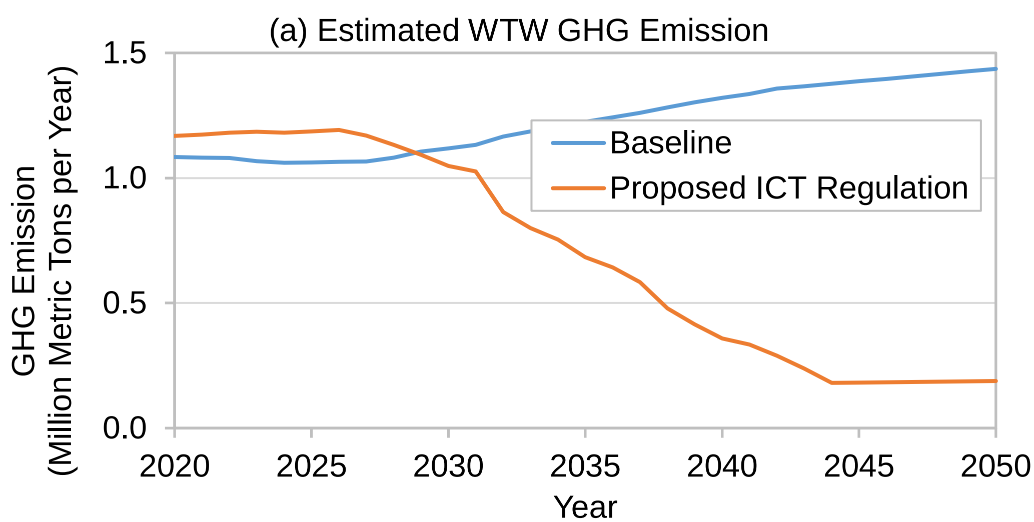


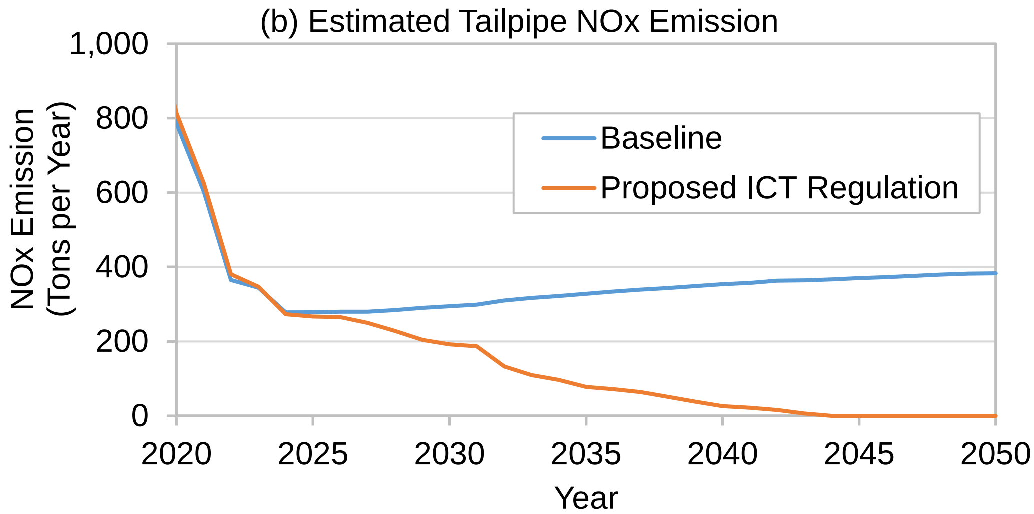
IV. BENEFITS AND COSTS ANALYSIS RELATIVE TO THE BASELINE

In the SRIA, the economic impact of the proposed ICT regulation is evaluated against two separate baselines developed in consultation with DOF. The "baseline" reflects full compliance with the existing regulation, and the "current conditions" reflects the real world conditions of the Board's direction to delay the purchase requirement and CARB's advisory. In the main content of ISOR, the emission benefits and cost impacts of the proposed ICT regulation relative to the “current conditions” is shown. The analysis relative to the “baseline” is shown here.

As shown in Figure 6, the regulation is expected to cumulatively reduce GHG emissions relative to the baseline by 16.6 million metric tons of carbon dioxide equivalent (MMT CO_2e) from 2020 to 2050. For tailpipe NOx and $PM_{2.5}$, the ICT regulation is expected to result in an estimated 6,651 tons and 34.8 tons of emission reductions, respectively. Overall, less emission reductions are achieved by the proposed ICT regulation relative to the baseline than relative to current conditions, because the baseline incorporates the existing rule and assumes the 15 percent ZEB purchase requirements were in place. Before the sunset date of the existing rule, emissions for the baseline are even lower than the proposed ICT regulation, since there are more ZEBs in the baseline.

Figure 6: Emission projections of WTW GHG, and tailpipe NOx and $PM_{2.5}$ under the Baseline and Proposed ICT Regulation





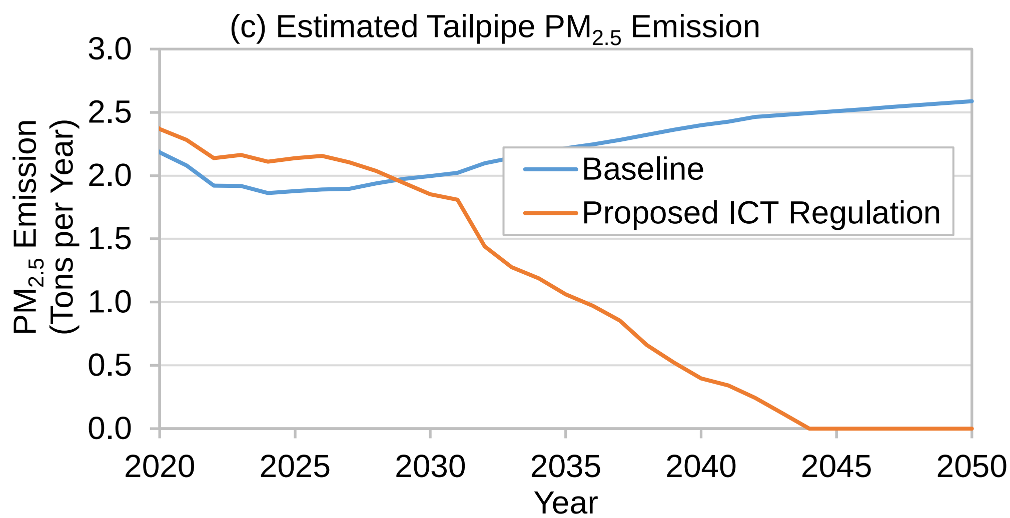
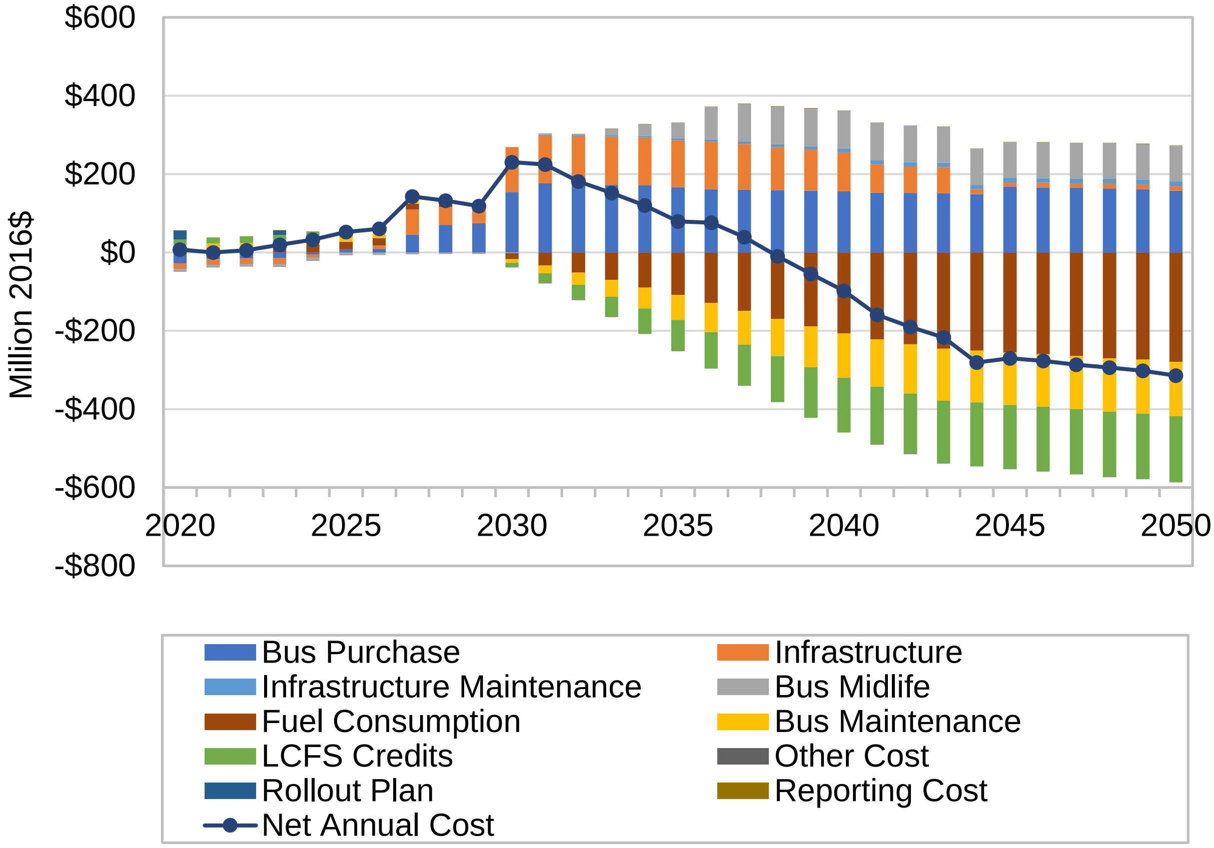


Figure 7 shows estimated total cost of the proposed ICT regulation to transit agencies relative to the baseline. From 2020 to 2050, the net cost-savings is $1.1 billion. The trend of annual cost is similar to the case when compared with current conditions, except that there are some fluctuations in early years because of the ZEB purchase requirement under the existing rule in the baseline.

Figure 7: Estimated Total Direct Costs of the Proposed ICT Regulation to Transit Agencies Relative to the Baseline (million 2016$)



V. REFERENCE

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. California Air Resources Board (CARB) (2018). Public Hearing to Consider Proposed Amendments to the Low Carbon Fuel Standard Regulation and to the Regulation on Commercialization of Alternative Diesel Fuels. March 6, 2018.Available: https://www.arb.ca.gov/regact/2018/lcfs18/isor.pdf.

2. Energy Information Administration (EIA) (2018). Annual Energy Outlook 2018. Table 3. Energy Prices by Sector and Source (Reference case for the Pacific Region).

3. Explanatory Footnote

4. California Air Resources Board (CARB, 2017), Draft Battery Electric Truck and Bus Charging Calculator, Updated June 20, 2017. Available: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626chargecostcalcv3.xlsm.

5. National Renewable Energy Laboratory (NREL) (2015). American Fuel Cell Bus Project Evaluation: Second Report. September, 2015. Available: http://www.nrel.gov/docs/fy15osti/64344.pdf.

6. U.S. Department of Energy Hydrogen and Fuel Cells Program (U.S. DOE) (2016). 2016 Annual Merit Review and Peer Evaluation Meeting, page 11: DOE Cost Targets and Status. June 6, 2016. Available: https://www.hydrogen.energy.gov/pdfs/review16/02_satyapal_plenary_2016_amr.pdf.

7. California Air Resources Board (CARB) (2017). Low Carbon Fuel Standard 2018 Amendments, Standard Regulatory Impact Assessment (SRIA), date of submission: November 16, 2017. Available: http://www.dof.ca.gov/Forecasting/Economics/Major_Regulations/Major_Regulations_Table/documents/LCFS_SRIA_CARB_11-16-17.pdf

8. California Air Resources Board (CARB) (2018). Proposed Amendments to the Low Carbon Fuel Standard Regulation and Regulation on Commercialization of

Alternative Diesel Fuels. Staff Report: Initial Statement of Reasons. March 6, 2018. Available: https://www.arb.ca.gov/regact/2018/lcfs18/isor.pdf.

9. California Air Resources Board (CARB) (2018). Presentation for Public Hearing of 2018 Proposed Amendments to the Low Carbon Fuel Standard Regulation and Regulation on Commercialization of Alternative Diesel Fuels. April 27, 2018. Available: https://www.arb.ca.gov/board/books/2018/042718/18-3-5pres.pdf?_ga=2.124200649.272832539.1526594435-103739339.1519860243.

10. California Air Resources Board (CARB) (2018). Proposed Regulation Order of Low Carbon Fuel Standard. March 6, 2018. Available: https://www.arb.ca.gov/regact/2018/lcfs18/appa.pdf.

11. California Air Resources Board (CARB) (2018). Presentation for 5th Innovative Clean Transit Workgroup Meeting. June 26, 2017. Available: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626_wg_pres.pdf.

12. Transit Agency Subcommittee-Lifecycle Cost Modeling Subgroup (2017). Report of Findings, April 2017.

13. EnerDel applies a 25% of residual value to retired batteries http://enerdel.com/services/guaranteed-residual-value/. Accessed: July 10, 2018.

14. North County Transit District (2017) Board Meeting on September 21, 2017, Agenda Item #17. Available: https://lfportal.nctd.org/weblink/ElectronicFile.aspx?docid=83560&dbid=0.

15. California Air Resources Board (CARB) (2017). Draft Battery Electric Truck and Bus Charging Calculator. Updated June 20, 2017. Available: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626chargecostcalcv3.xlsm..

16. National Renewable Energy Laboratory (2016). Foothill Transit Agency Electric Bus Demonstration Results, released in January 2016. Available: https://www.nrel.gov/docs/fy16osti/65274.pdf

17. National Renewable Energy Laboratory (NREL) (2017). Foothill Transit Battery Electric Bus Demonstration Results: Second Report. June, 2017. Available: https://www.nrel.gov/docs/fy17osti/67698.pdf.

18. Federal Transit Administration (FTA) (2018). Zero-Emission Bus Evaluation Results; King County Metro Battery Electric Buses. Available: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/research-innovation/115086/zero-emission-bus-evaluation-results-king-county-metro-battery-electric-buses-fta-report-no-0118.pdf. Accessed June 2018.

19. Federal Transit Administration (2007). An Evaluation of the Market for Small-to-Medium-Sized Cutaway Buses. Final Report. FTA Project Number: MI-26-7280.07.1. December 21, 2007. Available: https://www.transit.dot.gov/sites/fta.dot.gov/files/docs/AnEvaluationofMarketforSmalltoMediumSizedCutawayBuses.pdf. Accessed May 2018.

20. California Association for Coordinated Transportation (CalACT). CalACT/MBTA 15-03 Purchasing Schedule. Available: https://www.calact.org/assets/Price%20Information%20RFP%2015-03%20Rev%2008302017%20sep17.xlsx.

21. Explanatory Footnote

22. Explanatory Footnote

23. California Air Resources Board (CARB) (2017). Battery Cost for Heavy-Duty Electric Vehicles. August 14, 2017. Available: https://www.arb.ca.gov/msprog/bus/battery_cost.pdf.

24. Access Services. Access Services Projected Fleet Costs for the Service Fleet in Los Angeles Paratransit Services. Available: https://www.sacog.org/sites/main/files/file-attachments/access_la_life_cycle.pdf.

25. Explanatory Footnote

26. Phoenix Motorcars (2017). Email communication with Tarek Helou, Director of Sales, on November 1, 2017.

27. Explanatory Footnote

28. California Air Resources Board (CARB) (2016). Literature Review on Transit Bus Maintenance Cost. Available: https://www.arb.ca.gov/msprog/bus/maintenance_cost.pdf. Accessed May 2018.

29. Phoenix Motorcars (2017). Email Communication with Tarek Helou, Director of Sales, on November 1, 2017.

30. Access Services. Access Services Projected Fleet Costs for the Service Fleet in Los Angeles Paratransit Services. Available: https://www.sacog.org/sites/main/files/file-attachments/access_la_life_cycle.pdf.

31. Bus Testing and Research Center (2011). STURAA Test, 7 Year, 200,000 Mile Bus from Supreme Corp/Startrans Bus - Model Senator HD Cutaway. April 2011. Available: http://altoonabustest.psu.edu/buses/reports/379.pdf?1329832711.

32. Explanatory Footnote

33. Explanatory Footnote

34. Explanatory Footnote

35. California Air Resources Board (CARB) (2017). Draft Battery Electric Truck and Bus Charging Calculator. Updated June 20, 2017. Available: https://arb.ca.gov/msprog/ict/meeting/mt170626/170626chargecostcalcv3.xlsm

36. Explanatory Footnote

37. Explanatory Footnote

38. Phoenix Motorcars (2017). Email communication with Tarek Helou, Director of Sales, on November 28, 2017.

39. California Air Resources Board (CARB) (2008). Technical Support Document: Proposed Regulation for In-Use Road Diesel Vehicles. October, 2008. Available: https://www.arb.ca.gov/regact/2008/truckbus08/tsd.pdf.

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

41. Explanatory Footnote

42. Explanatory Footnote

43. Federal Transit Administration (FTA) (2007). Useful Life of Transit Buses and Vans (Report No. FTA VA-26-7229-07.1). April, 2007. Available: https://www.transitwiki.org/TransitWiki/images/6/64/Useful_Life_of_Buses.pdf

44. California Air Resources Board (CARB) (2018). Battery and Fuel Cell Electric Buses in California. May, 2018. Available: https://arb.ca.gov/msprog/ict/faqs/zbusmap.pdf.

45. California Air Resources Board (CARB) (2016). Transit Agency Survey Preliminary Results. ACT Workgroup Meeting. August 29, 2016. Available: https://www.arb.ca.gov/msprog/bus/transit_survey_summary.pdf.

46. California Air Resources Board (CARB) (2016). Transit Agency Survey Preliminary Results, ACT Workgroup Meeting on August 29, 2016. Available: https://www.arb.ca.gov/msprog/bus/transit_survey_summary.pdf.

47. Phoenix Motorcars. Specs of Phoenix Zeus Electric Shuttle Bus. Available: http://www.phoenixmotorcars.com/products/#1505308787607-7f8c2c3b-0cf2.

48. Motiv (2018). Motiv-Powered All-Electric Shuttle Bus Chassis Specifications. Available: http://www.motivps.com/motivps/wp-content/uploads/2018/03/Motiv_M132_DS_EPIC4_Dearborn_E450_Shuttle_20180319.pdf.