aggregators that have started to emerge and assume a leading role (e.g., goelectricdrive.com); however, as previously stated, awareness about PEVs remains low, an indication that content and traffic to these sites could be improved.

5.4.2 Potential Solutions

Utility as trusted advisor in the PEV market

Utilities have a critical role to play when communicating with consumers about the benefits of PEVs. As PEVs can be part of greater customer engagement about their energy consumption, utilities should expand their advisory role in this area. Utilities have a 30-plus year history of serving as trusted advisors with other end-users, including in the deployment of energy efficient technologies (e.g., air conditioners, lighting, refrigerators, etc.). Furthermore, the Electric Power Research Institute (EPRI) reports that a synthesis of multiple surveys of potential PEV drivers indicates that there is a strong belief that it is the utility's role to develop charging infrastructure and educate consumers.[74]

Most utilities in California are already engaged in initiatives related to PEV deployment – including through coordination with Clean Cities groups, involvement with the California Plug-in Electric Vehicle Collaborative, or with other local/regional efforts. Continuing engagement in these types of initiatives is critical to the success of PEV adoption. Furthermore, it helps bolster the case for utilities to serve as a trusted advisor. Utilities should continue involvement with existing initiatives and identify new opportunities where available. Of particular note, the Bay Area's MTC recently launched the EV Outreach Program under the Climate Initiatives Program with the intent to encourage Bay Area residents to experience PEVs first-hand via two dozen ride-and-drive events while integrating with social media.

While many utilities[75] are educating customers about PEVs, the previously mentioned CPUC ruling limits the scope of education and outreach activities by IOUs with a prohibition of "mass marketing" and a requirement "to target customers with an interest in Electric Vehicle" (rather than the broader segment of automobile intenders). This ruling effectively prevents IOUs from engaging in broader educational initiatives aimed at the general public regarding PEVs and the benefits of fueling vehicles from the grid.

In addition to the information utilities already provide (e.g., PEV rates, environmental and societal benefits), utilities could provide critical and reliable tools about PEVs (e.g., to help customers

[74] Multiple EPRI reports including: a) Characterizing Consumers' Interest in and Infrastructure Expectations for Electric Vehicles: Research Design and Survey Results (2010), b) Southern Company Electric Vehicle Survey: Consumer Expectations for Electric Vehicles (2011), c) TVA Electric Vehicle Survey: Consumer Expectations for Electric Vehicles (2011), and d) Texas Plugs In: Houston and San Antonio Residents' Expectations of and Purchase Intentions for Plug-In Electric Vehicles (2012).

[75] It is worth noting that as part of the requirements for utilities earning credits under California's LCFS (participation in the LCFS program is voluntary), utilities must commit to educating the "public on the benefits of EV transportation (including environmental benefits and costs of EV charging as compared to gasoline)." The regulation suggests public meetings, EV dealership flyers, utility customer bill inserts, radio and/or television advertisements, and webpage content.

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understand the total cost of ownership or choose the charging level needed based on their driving behavior). As noted in the Ernst & Young report, when utilities decide where they want to sit in the emerging ecosystem (and in the case of IOUs, where they are *allowed* to sit), a stable value chain is likely to emerge. As such, the long-term success of (light-duty) vehicle electrification depends on meaningful utility engagement. Plus, considering that a typical call to a utility's call center about PEVs may lead to a conversation about rates, metering, billing, information resources, PEVs at homes with solar energy and other related topics, the utility is ideally suited as the "first stop" for a PEV inquiry.

Engage with PEV ecosystem partners

Outside of existing initiatives, utilities should continue to seek opportunities to engage with PEV ecosystem partners to educate consumers about the benefits of PEV ownership. These include engagement with automobile manufacturers (OEMs), dealers, and private and public fleets, government agencies, and PEV charging industry market participants.

5.5 Vehicle Features

5.5.1 Identification of the Gaps and Barriers

Limited offerings

Over the last several years, about 63% of Californians' new light duty vehicle purchases have been automobiles, with the balance characterized as light trucks. In 2013, the top ten selling vehicles in California were the Toyota Prius, Honda Civic, Honda Accord, Toyota Camry, Toyota Corolla, Ford F-Series, Honda CRV, Nissan Altima, Toyota Tacoma, and the BMW 3-Series.[76] The PEVs available today are in somewhat similar vehicle classes as these top-ten sellers, with a focus on the subcompact segment (e.g., the Toyota Prius) and the standard midsize (e.g., Honda Accord). There are fewer offerings in the larger vehicle classes, including sedans, vans, pickup trucks and SUVs, with the Toyota RAV4 PEV the only offering outside of the light-duty automobile category.

These types of limitations on PEV options, such as vehicle size and payload capacity, restrict potential purchasing opportunities. Consumers tend to purchase new vehicles that are similar to those that they are replacing and PEV equivalents are limited across many market segments.

5.5.2 Potential Solutions

Modify Zero Emission Vehicle Program

CARB's ZEV Program (as of 2018) uses a system of credits generated by OEMs based on the range of the vehicle. The number of credits are awarded based on the zero emission miles that can be traveled – with a minimum of 50 miles (on Urban Dynamometer Driving Schedule, UDDS) earning 1 credit and 350 miles (UDDS) earning 4 credits. Transitional ZEVs, like PHEVs, can earn up to 1.25 credits, depending on the zero emission VMT potential of the vehicle.

[76] CNCDA, California Auto Outlook, Vol 10, Number 1, February 2014.

Although the success of the ZEV program is ultimately driven by VMT with no tailpipe emissions, basing the program's accounting system exclusively on vehicle range may preclude the development of PEVs in some vehicle classes. The market reality is that consumers do not buy vehicles because of their range – they buy vehicles because of their attributes. To incentivize OEMs to produce vehicles outside of the traditional PEV market segments (e.g., subcompact or midsize sedans), CARB might consider a multiplier for ZEV credits in market segments that are underrepresented in various vehicle offerings. CARB has taken significant measures in the updated regulatory proceedings to simplify the ZEV program; as a result, a simple multiplier based on a multi-year (e.g., 3 years) market assessment of vehicle segments may be advisable. Additionally CARB might consider encouraging PHEVs with substantial electric VMT capability as a way to expand ZEV offerings.

Appendix A: Calculation Methodology and Assumptions for Detailed Forecasting, Fuel Consumption and Emissions of TEA Segments

The first step in calculating the electricity consumption societal benefits is to estimate the future populations of each electric drive technology. The population forecasting included an extensive literature review of current and future market conditions, contacting industry and government experts (including CARB, CEC and EPA) and using a utility work group to review the electrification forecasts prior to calculation of benefits and costs. As discussed in Section 2, the future populations and electricity consumption were estimated for three cases, described as:

- "In Line with Current Adoption" is a low case based on anticipated market growth, expected incentive programs, and compliance with existing regulations. For technology that could potentially not be built, like HSR and I710, build/no-build scenarios were considered.
- "Aggressive Adoption" is a high case based on aggressive new incentive programs and/or regulations. "Aggressive adoption" cases are not simply the hypothetical maximum, but are tangibly aggressive.
- "In Between" is a medium case that will fall somewhere in the middle of the low and high cases and will vary by technology. For some technologies it will simply be half-way while for some technologies while other technologies have more direct medium cases.

After developing population forecasts, it is necessary to determine consumption levels for electricity and conventional fuels displaced. These consumption levels are used to determine GHG and criteria pollutant emission reductions. For gasoline, diesel, CNG and electricity, it is necessary to also take into account the upstream criteria pollutant emissions from electricity and petroleum production and refining. Each technology has specific criteria pollutant combustion emission factors but the upstream factors are constant for each type of fuel. Table 32 below shows the upstream criteria pollutant emission factors for conventional fuels (AB 1007)[77] and electricity. The electricity emission factors are based on 78.7%[78] natural gas combined cycle in 2013 and 67%[79] in 2020 and 2030, with the balance being renewable electricity. GHG emission factors are from the Low Carbon Fuel Standard for each fuel except for the 2020/2030 electricity pathway which is based on 67% natural gas combined cycle and 33% renewables. These factors include the full fuel cycle and do not include emissions associated with vehicle or battery manufacturing. Electricity production outside of urban areas has much less significant impact on human health (e.g. criteria air pollutants).

[77] "Full Fuel Cycle Assessment: Well to Tank Energy Inputs, Emissions, and Water Impact", Consultant Report for the California Energy Commission, February 2007. http://www.energy.ca.gov/2007publications/CEC-600-2007-002/CEC-600-2007-002-D.PDF

[78] 78.7% based on LCFS marginal electricity pathway

[79] 67% based on RPS requirement for 33% renewables

Table 32. Upstream Emission Criteria Pollutant and GHG Emission Factors

Fuel, Unit	NOx (g/unit fuel)	ROG (g/unit fuel)	PM (g/unit fuel)	GHG (g/unit fuel)
RFG3 (E10), gallon	0.116	0.509	0.0046	11,442
Diesel, Gallon	0.188	0.471	0.0081	13,182
Natural Gas, DGE	0.094	0.027	0.017	9,144
Electricity (2013), kWh	0.041	0.0087	0.0049	377
Electricity (2020/2030), kWh	0.035	0.0074	0.0042	305

In general, emission reductions are calculated by determining the displaced emissions from the reduced petroleum consumption and subtracting the emissions from electricity production. The specific methodologies for determining the populations, electricity consumed and societal benefits for each technology are provided below.

Each type of vehicle and electrification technology has a different level of electricity consumption and efficiency compared to conventional technologies. Table 33 below shows the annual kWh consumption per unit for each technology (except for rail) analyzed in this section and the corresponding energy equivalency ratio (EER). The EER is the ratio of conventional fuel energy to electricity energy for the same work.

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Table 33. Annual Electricity Consumption and EER for Each Technology

Electrification Technology	Annual Electricity Consumption (kWh/yr)	EER
PHEV10 (PC/LT)	1,006 / 1,326 (2013)	4.05 - electric; 1.5 – gasoline (2013) 3.4 - electric; 1.5 – gasoline (2020) 3.0 - electric; 1.4 – gasoline (2030)
PHEV20 (PC/LT)	2,012 / 2,652	4.05 - electric; 1.5 – gasoline (2013) 3.4 - electric; 1.5 – gasoline (2020) 3.0 - electric; 1.4 – gasoline (2030)
PHEV40 (PC/LT)	3,079 / 4,058	4.05 - electric; 1.5 – gasoline (2013) 3.4 - electric; 1.5 – gasoline (2020) 3.0 - electric; 1.4 – gasoline (2030)
BEV (PC/LT)	2,968 / 3,912	4.05 (2013) 3.4 (2020) 3.0 (2030)
Forklift (8,000lb / 19,000 lb)	18,312 / 52,080	3.8 / 2.5
TSE (per space)	3,423	5.64
e-TRUs (Semi / bobtail / 11hp bobtail) (per TRU)	3,180 / 2,448 / 938	3.9
Shore Power – Container (per berth)*	6,136,000	2.86
Shore Power – Reefer (per berth)*	3,311,000	2.86
Shore Power – Cruise (per berth)*	28,620,000	2.86
Shore Power – Tanker (per berth)*	3,570,000	2.86
CHE – Yard Tractor	64,600	2.9
CHE – Forklift	4,075	4.5
CHE – RTG Crane	109,000	4.0
Airport GSE	4,670	2.65
Dual Mode Catenary Trucks	17,000-20,000	2.1-2.4
MD PHEV	5,500 – 6,800	3.4
MD BEV	8,200 – 11,000	3.4
HD PHEV	12,000 – 17,000	2.7
HD BEV	22,000 – 131,000	2.7
* - Assumed 60% berth occupancy		

Plug-In Electric Vehicles (PEVs). To avoid making market penetration the focus of the PEV grid benefit study, ICF and CalETC decided to choose three different existing PEV penetration scenarios: California Zero Emission Vehicle (ZEV) compliance with a 50/50 split of PEVs and fuel cell vehicles (FCV), California

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ZEV program "likely" compliance as defined by CARB, and three times the California ZEV "likely" compliance.[80] The population projections include a breakdown of PHEVs/BEVs, but ICF and CalETC further developed a breakdown of the PHEVs among PHEV10, PHEV20 and PHEV40. In addition each technology was divided between passenger cars (PCs) and light-trucks (LTs). Table 34 below shows the population percentage breakdown for PHEV and BEV between technology and class. The percentages for PHEVs and BEVs separately total 100%.

Table 34. PEV Fleet Breakdown by Technology and Class

Vehicle Class	2013	2020	2030
PHEV 10 – PC	25%	22%	16%
PHEV10 – LT	0%	4%	12%
PHEV20 – PC	25%	22%	16%
PHEV20 – LT	0%	4%	12%
PHEV40 – PC	50%	43%	31%
PHEV40 – LT	0%	5%	14%
BEV – PC	100%	93%	77%
BEV – LT	0%	7%	23%

The forecasts used for the analysis are for populations of PEVs. ICF used retirement factors from the Argonne National Laboratory VISION Model[81] for the AEO 2013 reference case to develop a fleet turnover model and determine the annual sales required by year from 2012 – 2030 to achieve the vehicle population forecasts. The combination of VISION annual fuel economy of auto ICE and LT ICE for conventional vehicles and auto HEV, LT HEV, auto EV and LT EV (PHEV gasoline VMT is assumed to be at HEV fuel economy) for each model year and population turnover model were used with the annual VMT in Table 35 to determine petroleum displaced and electricity consumed. The factors from Table 32 were combined with the vehicle fuel economies shown in Table 36 to determine fuel consumed and GHG emission reductions.

[80] The ZEV regulation does not require a certain number of ZEVs by 2030; it requires about 4,200,000 ZEV credits. ZEV credits earned per vehicle in 2030 can vary tremendously (e.g. 0.5 for some types of PHEVs and 4.0 for fuel cell EVs). This can result in many compliance pathways from fewer than 1 million cumulative PEVs in 2030 to more than 3 million.

[81] ANL VISION Model http://www.transportation.anl.gov/modeling_simulation/VISION/index.html

Table 35. Gasoline and Electric VMT and Energy Consumption

Vehicle Type	VMT		eVMT		Energy Consumption (kWh)					
					Daily			Annual		
	Daily	Annual	Daily	Annual	Res	NonRes	Total	Res	NonRes	Total
PHEV10	41	14,965	10	3,650	2.8	0.7	3.5	1,022	256	1,278
PHEV20			20	7,300	5.6	1.4	7	2,044	511	2,555
PHEV40			30.6	11,169	8.6	2.1	10.7	3,127	782	3,909
BEV	29.5	10,768	29.5	10,768	8.3	2.1	10.3	3,016	754	3,770

The VISION fuel economies are based on the fuel economies from AEO and apply an on-road loss factor for each vehicle and technology category. For example, Table 36 below shows the ICE, HEV and EV fuel economy for 2013, 2020 and 2030. The analysis for electricity and petroleum consumption utilized the fuel economies for all years from 2011 to 2030. The vehicle fuel economies in the table below combined with the annual VMT above result in slightly different annual electricity consumption, shown in the table above.

Table 36. Vehicle Fuel Economies

Fuel Economy (mi/GGE)	2013	2020	2030
Auto ICE	28.8	34.7	42.8
Auto HEV	43.0	50.9	62.0
Auto EV	117	117	129
LT ICE	21.8	25.2	31.8
LT HEV	33.6	36.7	48.9
LT EV	88.4	94.4	113

Criteria pollutant emission reductions were calculated by determining the gasoline VMT from Table 35 and vehicle population, and using LEV III emission regulations to produce grams per mile emission factors for NMOG+NOx and PM. Table 37 below shows the selected emission factors for vehicles purchased in 2013, 2020, and 2030. Emission factors were calculated for each sales year from 2011 to 2030.

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Table 37. Gasoline VMT Criteria Pollutant Emission Factors

Emissions (g/mi)	2013	2020	2030
PM	0.01	0.0051	0.001
NMOG+NOx	0.119	0.074	0.03

Forklifts. The forklift forecast is based on the ITA Market Intelligence report[82] which includes annual sales from 1988 to 2012 of electric rider (Class 1 and 2), motorized hand (Class 3), and internal combustion engine (Class 4 and 5) forklifts. Based on an estimate of 3,159 operating hours per year per forklift and an estimated lifetime of 24,000 hours for electric forklifts and 21,000 hours for conventional forklifts, forklift lifetimes of 8 and 7 years were estimated for electric and conventional forklifts, respectively. Using the sales data and the estimated lifetimes, US populations were estimated for 1997 to 2012. Based on US Census population data, California is approximately 12.12% of the United States and it is assumed that a similar percentage of US forklifts are in California. This is the same methodology used by CARB in the Low Carbon Fuel Standard to determine the quantity of electric forklifts when determining LCFS credits.

Pre-recession (1997 to 2007) annual increases in forklift (Class 1, 2, 4, and 5) sales were used to project total forklift populations from 2012 to 2020 and 2030. For the "In Line with Current Adoption" case the annual growth rate from 1997-2012 of electric rider populations was used to determine populations of electric riders in 2020 and 2030. It is also assumed that all electric forklifts are within the <120 horsepower (hp) category. For the "Aggressive Adoption" case, it was assumed that a similar mandate for shore power at the ports was instituted and 60% of Class 1, 2, 4, and 5 forklifts by 2020 and 80% by 2030 would be electric. It is assumed in the "Aggressive Adoption" case that <120 and 120 to 175 horsepower forklifts would be replaced with electric. Based on CARB 2009 forklift populations by horsepower category, the incremental populations of electric forklifts were divided between <120 hp (86.1%) and 120 to 175 hp (13.9%) where electric forklifts designated as <120 hp displaced gasoline and LPG forklifts and 120-175 hp displaced diesel forklifts. The medium case forecast was chosen as halfway in between the "In Line with Current Adoption" and "Aggressive Adoption" cases for total incremental populations and <120 hp and 120 to 175 hp populations.

Based on research into electric and conventional fueled forklifts from Nissan, CAT and Kalmar, 6,000 to 8,000 lb forklifts were chose as representative of <120 hp and 19,800 lb forklifts were chose as representative of 120 to175 hp. The 6,000 to 8,000 lb lifts had an average battery pack size of 43.6 kWh (Nissan and Crown Spec sheets) and the 19,800 lb lifts had an average battery pack size of 124 kWh (Kalmar spec sheets). In addition, Class 3 forklifts had an average battery pack size of 12.5 kWh. ICF used previous CalETC assumptions of 3,150 hours of operation (525 6 hr shifts) per year which were based on

[82] http://www.indtrk.org/wp-content/uploads/2013/04/US-Factory-Shipments-Through-2012.pdf

a 50/25/25 breakdown of single, double and triple shift forklift operation. It is assumed that each shift is 6 hours and that each battery uses 80% of its charge per shift. This resulted in 18,312 kWh per year for the 6,000 to 8,000 lb lift and 52,808 kWh per year for the 19,800 lb lifts. Displaced petroleum was calculated by taking the electricity consumed and converting it to gasoline and diesel using CARB fuel consumption factors in pounds per brake horsepower-hour (lb/bhp-hr) and the energy density of gasoline and diesel.

GHG emission reductions were calculated using the values in Table 32 and electricity consumed and gasoline and diesel displaced. Propane powers a substantial portion of the smaller forklifts and over 50% of all Class 4 and 5 forklifts, which includes all internal combustion forklifts.[83] GHG emissions for propane are assumed to be similar to gasoline since most propane consumed in California is petroleum based and requires the same crude production and refining processes. Criteria pollutant emission factors for gasoline and LPG lifts are based on the EPRI report 1007455 (consistent with the previous CalETC report) and diesel emission factors from OFFROAD 2011. The criteria pollutant emission factors are shown in Table 38 below. Electric consumed was converted to bhp and multiplied by the factors noted below to determine criteria pollutants reduced.

Table 38. Forklift Criteria Pollutant Emission Factors

	NOx (g/bhp-hr)	ROG (g/bhp-hr)	PM (g/bhp-hr)
Gasoline/LPG	0.6	0.3	0.015
Diesel – 2010	2.45	0.1	0.14
Diesel – 2020	0.27	0.05	0.01
Diesel – 2030	0.27	0.05	0.01

Truck Stop Electrification (TSE). Currently in California there are an estimated 262 electrified parking spaced as identified by the DOE Alternative Fuels Database and shorepower documentation under the DOE Shorepower Project that was funded by ARRA. Based on an SCE inventory, there are 9,282 truck parking spaces in California. The "In Line with Current Adoption" case assumes that there are still only 262 electrified parking spaces in 2020 and 2030 and also assumes that the capacity factor for each space increases from the current value of 0.28 to 0.5 in 2020 and 0.6 in 2030. The "Aggressive Adoption" case assumes a port-like mandate with 30% of spaces electrified in 2020 and 50% in 2030, and increases in the capacity factor to 0.67 in 2020 and 0.75 in 2030. The medium case is assumed to be halfway in between the "In Line with Current Adoption" and "Aggressive Adoption" cases.

The average load of 1.39 kW while plugging in (from the previous CalETC study) was combined with the value of 0.21 gallons of diesel per hour from the CARB Anti-Idling Regulation Initial Statement of Reasons (ISOR) and the number of spaces and capacity factors to determine electricity consumed and

[83] http://www.afdc.energy.gov/uploads/publication/2013_Propane_Market_Outlook_1_.pdf

fuel displaced. Based on the CARB HDV Idling Regulation ISOR combined with new LEV III regulations for PM, the following emissions factors in Table 39 were used. The factors in the ISOR for NOx+NMHC were assumed to be 95% NOx and 5% NMHC based on data from the Bay Area Air Quality Management District (BAAQMD).[84]

Table 39. TSE Criteria Pollutant Emission Factors

	NOx (g/hr)	ROG (g/hr)	PM (g/ hr)
2013	14.3	0.76	0.87
2020	14.3	0.76	0.048
2030	14.3	0.76	0.048

Transport Refrigeration Units (TRUs). The TRU forecasts are based on the CARB TRU ISOR.[85] The ISOR has projected 2013 populations of eTRUs and based on conversations with CARB staff only 1% are semis (25 to 50 hp) and the remaining are bobtails (11 to 25 hp). The ISOR also contains California-based and out-of-state TRUs. Forecasts of TEU (truck equivalent unit) from the San Pedro Bay Container Forecast[86] were used to project 2020 and 2030 TRUs. The "In Line with Current Adoption" case maintains a consistent 11% market share of eTRUs and a 99/1 ratio of bobtails to semis. The "In Between" case assumes a port-like mandate for California-based TRUs with 30% and 80% electric in 2020 and 2030. The forecast projects that 75% and 100% of bobtails will be all electric in 2020 and 2030 respectively, <11 hp TRUs will be 25% and 80% electric, and semis will be 18% and 75% electric in 2020 and 2030. The "Aggressive Adoption" case includes the same projections for California-based TRUs and adds the out-of-state TRUs which are all semis. The same percent penetrations of 18% and 75% in 2020 and 2030 as the California-based were used.

Electricity consumption calculations included average electricity loads from the previous CalETC study of 8, 6 and 2.3 kW for the 25 to 50, 11 to 25 and <11 hp categories. The annual hours of operation are based on the CARB TRU ISOR and only 30% of the hours are at the facility and have the potential for e-standby. The fuel consumption values of 0.21, 0.62 and 0.85 gal/hr for <11 hp, 11 to 25 hp and 25 to 50 hp are based on the previous CalETC study. Criteria pollutant emission factors are based on the CARB TRU database with the only adjustments made for PM emission factors to comply with LEV III and are either 0.01g/bhp-hr or 85% emission reductions, whichever is higher. The criteria pollutant emission factors are shown in Table 40.

[84] http://www.baaqmd.gov/~/media/Files/Engineering/policy_and_procedures/Engines/EmissionFactorsforDieselEngines.ashx

[85] http://www.arb.ca.gov/regact/2011/tru2011/truisor.pdf

[86] "San Pedro Bay Container Forecast Update," The Tioga Group, Inc – HIS Global Insight, July 2009. http://www.portoflosangeles.org/pdf/SPB_Container_Forecast_Update_073109.pdf

Table 40. TRU Criteria Pollutant Emission Factors

	NOx (g/bhp-hr)			PM (g/bhp-hr)			ROG (g/bhp-hr)		
	2010	2020	2030	2010	2020	2030	2010	2020	2030
25-50 hp	4.8	2.9	2.9	0.16	0.01	0.01	0.1	0.1	0.1
11-25 hp	4.8	4.37	4.37	0.19	0.029	0.029	0.1	0.1	0.1
<11 hp	4.37	4.37	4.37	0.19	0.029	0.029	0.1	0.1	0.1

Shore Power. The overall "In Line with Current Adoption", "In Between" and "Aggressive Adoption" forecasts contain individual forecasts for each type of ship that could use alternative marine power: container, reefer, cruise ships and tanker ships. Tanker ships are included in the analysis even though the only fleets affected by the regulation include those composed of container vessels, passenger vessels, or refrigerated cargo vessels. Electrification of tanker ships is only included in the "Aggressive Adoption" case. The container, reefer and cruise ship visits forecasted are consistent with CEC forecasts in the *California Energy Demand 2014-2024 Revised Forecast*[87].

The container ship forecasts are based on Wharfinger data[88] for container visits at the ports of Los Angeles/Long Beach, Oakland, and San Diego, using the San Pedro Bay Container Forecast Update to project future container ship visits out to 2020 and 2030.[89] Two current regulations and requirements are in place for shore power. The At-Berth Regulation requires fleets to meet 50% shorepower visit requirement starting 2014, 70% by 2017, and 80% by 2020. Any berths that received Prop 1b funding must exceed the At-Berth Regulation requirements and have 50% of total visits electrified in 2013, 60% by 2014, 80% by 2017 and 90% by 2020. The "In Line with Current Adoption" case assumes minimum compliance with 50%, 80% and 80% of fleet visits (approximately 74% of total visits from 2004 CARB data electrified in 2013, 2020, and 2030. The "In Between" case assumes 50%, 80% and 80% of total visits are electrified in 2013, 2020 and 2030 and the "Aggressive Adoption" case assumes 50%, 90% and 90% of total visits in 2013, 2020, and 2030 which matches the Proposition 1B funding requirements for all berths and visits..

The reefer ship visit forecasts are for Port Hueneme. Reefer ships are refrigerated cargo ships typically used to transport perishable commodities. For all three cases it is assumed that 50%, 80% and 80% of all visits will be electrified since three of the five berths at Port Hueneme have received Proposition 1B funding and have the additional requirements stated above.

[87] "California Energy Demand 2014-2024 Revised Forecast: Volume 1," CEC, September 2013. CEC-200-2013-004-SD-V1-REV

[88] Wharfinger data utilized for this study is data collected by keepers and owners of each of the wharfs identified and supplied to CARB as part of the shore power regulation. CARB supplied the data to ICF via email communication.

[89] http://www.portoflosangeles.org/pdf/SPB_Container_Forecast_Update_073109.pdf

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For cruise ships at the ports of Los Angeles (LA), Long Beach (LB), San Diego (SD) and San Francisco (SF), CEC estimates for total visits and electrification in 2013 were utilized and an estimated 5% annual increase was applied until 2030 for total cruise ship visits. In the "In Line with Current Adoption" case, it is assumed that number of electrified visits in 2013 stays the same in 2020 and 2030 for the ports of LA, LB and SD. In the "Aggressive Adoption" case, it is assumed that the number of electrified visits is increased by an annual rate of 5% from 2013 to 2020 and 2030. The "In Between" cases is halfway between the "In Line with Current Adoption" and "Aggressive Adoption" cases. For the Port of SF, it is assumed for all cases that 0, 80, and 80 electrified visits occur in 2013, 2020 and 2030 respectively based on projections made by the port staff.

For tanker ships, total visits reported in the CARB Evaluation of Cold-Ironing Vessels at California Ports[90] were escalated to 2020 and 2030 based on petroleum fuel consumption from the CEC Fuels Forecast. Electrification of tanker visits is assumed to be zero in the "In Line with Current Adoption" and "In Between" cases. In the "Aggressive Adoption" case, it is assumed that tanker ships comply with the regulation and 80% of all visits will be electrified in 2020 and 2030.

Data from the Port of Long Beach 2011 emissions inventory[91] was used to determine electrical load and berthing time for each type of ship visit. The weighted average total berth time, hoteling time and load shown in Table 41 below were used to calculate the total electricity consumption in 2013, 2020 and 2030.

Table 41. Shore Power Berth Time, Hoteling Time and Electric Load

Vessel	Total Berth Time (hrs)	Hoteling Time (hrs)	Electric Load (MW)
Container Ships	47	45	1.168
Reefer	60	58	0.630
Cruise/Passenger	14.8	12.8	5.445
Tanker	42.6	40.6	0.679

Diesel fuel consumption reductions are calculated by converting electricity consumed to diesel based on the assumption of displacing 35% efficient diesel auxiliary engines. GHG emission reductions are based on factors in Table 32. Criteria pollutant emissions are calculated based on factors from the CARB Evaluation of Cold-Ironing Vessels at California Ports[92] shown in Table 42 below.

[90] "CARB Evaluation of Cold-Ironing Vessels at California Ports (Draft Report): Appendix C," http://www.arb.ca.gov/ports/marinevess/documents/coldironing0306/execsum.pdf

[91] http://www.polb.com/civica/filebank/blobdload.asp?BlobID=10194

[92] "CARB Evaluation of Cold-Ironing Vessels at California Ports (Draft Report): Appendix C," http://www.arb.ca.gov/ports/marinevess/documents/coldironing0306/execsum.pdf

Table 42. Cold-Ironing Criteria Pollutant Emission Factors

Pollutant	Diesel Engine Emission Factor (g/kW-hr)
NOx	13.6
PM	0.25
HC (VOC)	0.4

Port Cargo Handling Equipment. Forecasts for port cargo handling equipment (CHE) were made based on three different technologies that could be electrified: yard tractors, forklifts and RTG cranes. The baseline population for these technologies for 2010 is from the 2011 cargo handling equipment information in Appendix B[93]. Forecasts for total populations in 2020 and 2030 for each of the three technologies were made using the San Pedro Bay Container Forecast Update similar to TRUs. The "In Line with Current Adoption" case assumes a 10% electric technology market penetration in 2020 and 2030 for yard tractors and forklifts and 5% in 2020 and 10% in 2030 for RTG cranes. The lower 2020 electric penetration for RTG cranes is due to increased issues around RTG expansion and planning required for their acceptance. The "Aggressive Adoption" case uses a port like mandate with 40% market penetration in 2020 and 80% in 2030. The "In Between" case is in the middle of the "In Line with Current Adoption" and "Aggressive Adoption" cases.

Fuel consumption of both conventional and electric yard hostlers (192 kWh/shift) and RTG cranes (417 kWh/shift) is based on a 2012 TIAX study[94]. The fuel consumption for forklifts is based on the forklift analysis and assumes an 8,000 lb capacity for each lift. GHG emission reductions are based on factors in Table 32. Criteria pollutant emission factors are based on the CARB cargo handling equipment inventory model (2011) and the TIAX report for average horsepower of the conventional technologies. Criteria pollutant emission factors for CHE can be found in Table 43 below.

Table 43. Port CHE Criteria Pollutant Emission Factors

	NOx (g/bhp-hr)			PM (g/bhp-hr)			ROG (g/bhp-hr)		
	2010	2020	2030	2010	2020	2030	2010	2020	2030
Yard Tractors	2.45	0.27	0.27	0.11	0.01	0.01	0.1	0.05	0.05
Forklifts	2.45	0.27	0.27	0.14	0.01	0.01	0.1	0.05	0.05
RTG Cranes	2.45	0.27	0.27	0.11	0.01	0.01	0.12	0.05	0.05

93 http://www.arb.ca.gov/regact/2011/cargo11/cargoappb.pdf

94 "Roadmap to Electrify Goods Movement Subsystems for the Ports of Los Angeles and Long Beach," Consultant Report by TIAX LLC for the Ports of LA and LB, February, 2012.

Airport Ground Support Equipment (GSE). Forecasts for total pieces of GSE in California are based on the ACRP report[95] of national GSE using the Federal Aviation Administration (FAA) national and California enplanements[96] for 2010 to scale for California GSE. The FAA enplanement data shows California had approximately 11% of total national enplanements in 2010. The FAA forecasts for national and total enplanements were used to scale the 2010 GSE population to 2020 and 2030 and the same California proportion of the national average (11%) was used to determine total California GSE. The 2010 electrified population was estimated by using the Los Angeles World Airports Sustainability Plan[97] which indicates that 100% of Ontario Airport GSE and 24% of LAX is electrified, and information from Southwest that all of its GSE at San Jose International Airport (SJC) is electrified (approximately 50% of gates and enplanements at SJC). Based on the FAA enplanement data for these three airports, approximately 15.8% of the GSE in California was electrified in 2010. The "In Line with Current Adoption" case assumes that only LAX increased its GSE population from 2010 to include 100% of push tractors, container loaders, belt loaders and baggage tractors which make up 56% of individual gate GSE. This results in a total California GSE penetration of 23.7% in 2020 and 2030. The "Aggressive Adoption" case assumes a port-like mandate with 40% of GSE being electrified in 2020 and 60% in 2030. This is consistent with EPRI's estimate that approximately 30% of airport GSE could be electrified in 2015. The "In Between" case is directly in between the other two cases.

The electricity consumption was calculated by using the EPRI Technical Update[98] of GSE electrical load for narrow-body and wide-body gates combined with the CARB OFFROAD model for activity (hrs/yr). Based on a report by The MITRE Corporation[99], only 20.8% of planes are wide body. This data was used to assume that 20.8% of gates in California are wide-body gates. ICF assumed the same proportion of narrow-body and wide-body gates GSE were electrified. The consumption per gate was escalated to 2020 and 2030 based on the ratio of increased enplanements and the assumption that there would be no new gates to handle the increased enplanements but rather higher utilization of the existing gates.

Displaced petroleum was calculated by taking the electricity consumed and converting to gasoline and diesel using CARB fuel consumption factors in lb per brake horsepower-hr (lb/bhp-hr) and the energy density of gasoline and diesel. GHG emission reductions were based on emission factors from Table 32. The weighted average of CARB emission factors by GSE horsepower share from the OFFROAD model was used to calculate criteria pollutant emissions. Criteria pollutant emission factors can be found in Table 44 below.

[95] ACRP Report 78: Airport Ground Support Equipment (GSE): Emission Reduction Strategies, Inventory, and Tutorial (2012)

[96] http://www.faa.gov/airports/planning_capacity/passenger_allcargo_stats/passenger/

[97] http://www.lawa.org/uploadedFiles/LAWA/pdf/Sustainability%20Plan%20%28Final%29.pdf

[98] EPRI Technical Update: Alternative Ground Support Equipment Electrification Analysis (2010)

[99] https://www.mitre.org/sites/default/files/pdf/bhadra_analysis.pdf

Table 44. Airport GSE Criteria Pollutant Emission Factors

	NOx (g/bhp-hr)	ROG (g/bhp-hr)	PM (g/ bhp-hr)
Gasoline, 2013-2030	1.79	0.072	0.297
Diesel - 2013	3.08	1.34	1.34
Diesel - 2020	0.17	0.01	0.01
Diesel - 2030	0.1	0.07	0.07

High Speed Rail. The forecasts for High Speed Rail were based on the 2012 Business Plan[100] with the "In Line with Current Adoption" case only taking into account the initial operating section (IOS) in 2020 and 2030, the "In Between" case including the IOS in 2020 and Bay to Basin in 2030 and the "Aggressive Adoption" case including the IOS in 2020 and the Phase 1 Blended in 2030. Figure 9 shows the high speed rail operating scenarios. The total train set miles and service were modeled using the train schedule in the business plan and the energy consumption factor of 54 kWh/train set mile for an 8 car train.[101] Passenger-miles were calculated using the estimated passengers, percent of interregional travel and the estimated amount of track (mi) in each year from the business plan.

[100] http://www.hsr.ca.gov/About/Business_Plans/2012_Business_Plan.html

[101] http://www.hsr.ca.gov/docs/programs/merced-fresno-eir/final_EIR_MerFres_TA3_06C_EnergyUse.pdf

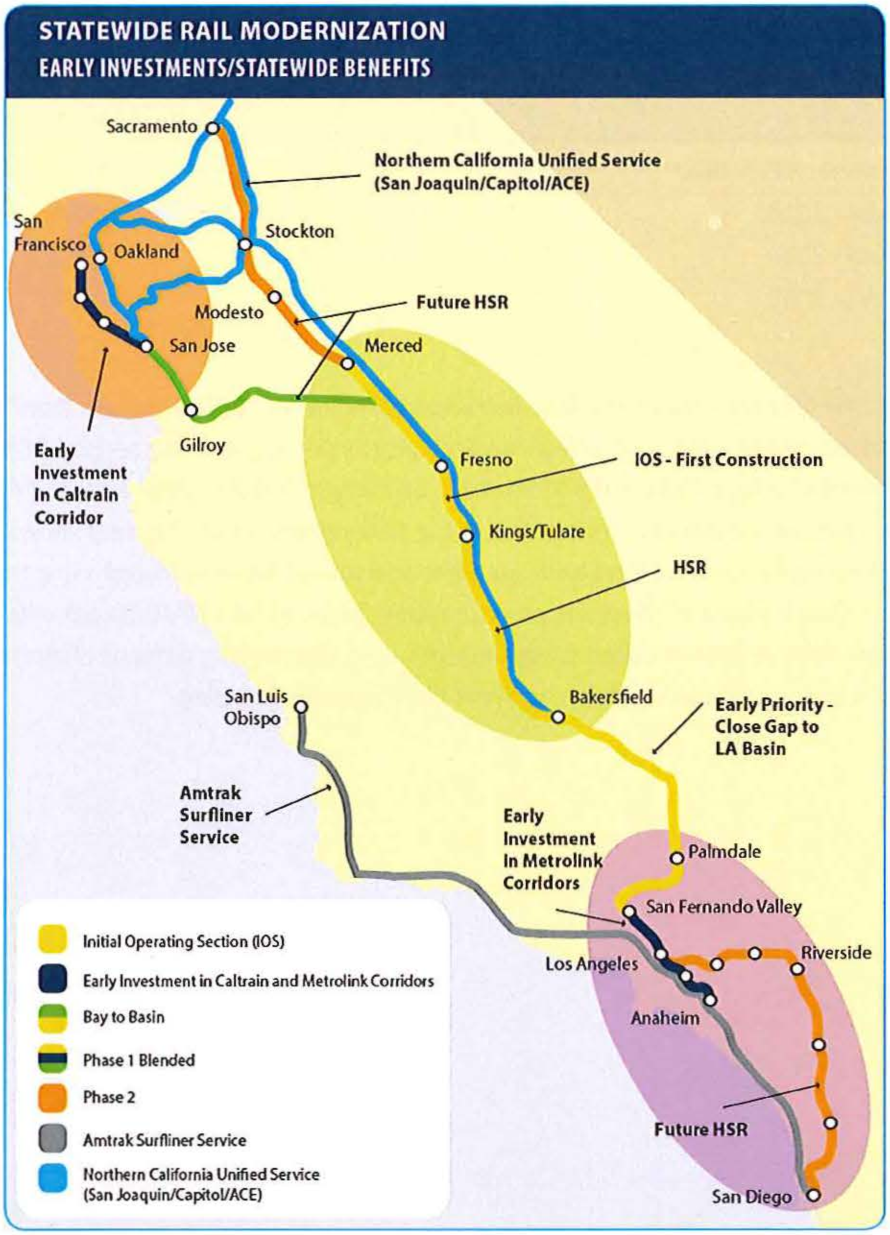

Figure 9. High-Speed Rail Operating Scenarios[102]

Petroleum (diesel) consumption displaced is calculated by assuming that high speed rail displaces transit buses and assuming that interregional buses would have 50% occupancy. The total number of passenger-miles is converted to fuel consumption by using the National Transit Database to determine the fuel consumption per passenger-mile at 50% occupancy of California buses. The factors in Table 32 were used to calculate GHG reductions. Criteria pollutant emission reductions were determined by using the factors in Table 45 below from the EMFAC model. The ratio of passenger-miles/bus-miles at 50%

[102] http://www.hsr.ca.gov/docs/about/legislative_affairs/HSR_Reducing_CA_GHG_Emissions_2013.pdf

occupancy was used to calculate the total emissions. This methodology is simpler than that used by the High Speed Rail Authority, which includes displacing airline and passenger car miles.[103] The GHG emissions reductions from this analysis are lower than those from the High Speed Rail Authority due to the assumptions for electricity production. The High Speed Rail Authority assumes all renewable electricity, while this analysis assumes marginal electricity from 33% renewables and 67% natural gas. The GHG emission reduction calculations would be similar if the same electricity mix was used.

Table 45. Transit Bus Criteria Pollutant Emission Factors

	NOx (g/mi)	ROG (g/mi)	PM (g/mi)
Transit Bus	0.586	0.0304	0.0338

Light, Heavy and Commuter Rail. Light, Heavy and Commuter Rail analysis includes the rail systems in Table 46 below.

Table 46. Rail Systems Included in the Light, Heavy and Commuter Rail Analysis

Light Rail	Heavy Rail	Commuter Rail
LA Metro – Light	BART	Electrified Caltrain
Sacramento	LA Metro Subway	
San Diego		
SF – Cable Car		
SF – Light Rail		
SF – Trolly Bus		
Santa Clara VTA		

Statistics from the National Transit Database were used to calculate the "In Line with Current Adoption", "In Between" and "Aggressive Adoption" cases for passenger-miles and resulting electricity consumption. The "In Line with Current Adoption" case for Light and Heavy Rail uses the passenger-miles per track mile from 2011 for each system and takes into account planned increases in track length in 2020 and 2030 to calculate increases in passenger-miles in 2020 and 2030. The "Aggressive Adoption" case takes into account the trends in passenger-miles per track mile from 2007 to 2011 and continues these trends when positive (if negative the 2011 passenger-miles per track mile factor is used) with the planned increases in track length shown in Table 47 below.

[103] http://www.hsr.ca.gov/docs/about/legislative_affairs/HSR_Reducing_CA_GHG_Emissions_2013.pdf

Table 47. Planned Increases in Track Length

Light/Heavy Rail Lines	Starting Track Length (miles)	Increased Track Length (miles) and Year
Los Angeles Light Rail	116.3	8.6 (2012); 6.6 (2015); 11 (2016); 8.5 (2018); 2 (2019); 1.9 (2020); 12 (2025)
Sacramento	73.4	1.1 (2012); 12.8 (2021)
San Diego	102.6	11 (2018)(
San Francisco Light Rail	103.5	1.7 (2019)
Santa Clara	79.6	10 (2018); 6 (2030)
Los Angeles Heavy Rail	34.1	
BART	267.6	3.2 (2014); 5.4 (2015); 16 (2018)

The "In Between" case is directly in between the "In Line with Current Adoption" and "Aggressive Adoption" cases. The "In Line with Current Adoption" case for commuter rail is zero, assuming that Caltrain would not be electrified. The "In Between" case scales the National Transit Database passenger-miles with the Caltrain 2014 Strategic Plan[104] estimate for passengers until 2018 (the last year in the plan) and uses the 0.8% annual growth from 2007 to 2011 to forecast the 2018 estimate of passenger-miles to 2020 and 2030. The "Aggressive Adoption" case uses a linear project of the estimated 2014 to 2018 passenger-miles to 2020 and 2030.

Electricity consumption for commuter rail is calculated using the estimated passenger-miles and the kWh/passenger-mile for the SEPTA (Southeastern Pennsylvania Transportation Authority) electrified commuter rail from the NTD. The electricity consumption for light and heavy rail is calculated using the 2011 kWh/passenger-mile from the NTD for each system and the forecasted passenger-miles. Diesel displaced by electrified commuter rail is based on the average diesel consumption per passenger-mile for 2009 to 2011 from NTD for the Caltrain and the projected passenger-miles. Displaced conventional fuel (either diesel or natural gas) is based on the average diesel or natural gas consumption per passenger-mile for the local transit bus fleet for each rail system and the projected passenger-miles.

The factors in Table 32 were used to calculate GHG reductions. Criteria pollutant emission reductions were determined by using the factors in Table 48 below from the EMFAC model for diesel urban bus. The state average ratio of passenger-miles to revenue-miles from the NTD was used convert passenger-miles to bus miles for the calculation of total criteria pollutants.

Table 48. Transit Bus Emission Factors

	NOx (g/mi)	ROG (g/mi)	PM (g/mi)
Transit Bus	0.586	0.0304	0.0338

[104] http://www.caltrain.com/projectsplans/Plans/CaltrainStrategicPlan-2014.html

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Dual Mode Catenary Trucks on I-710 / SR 60. The forecasts for electricity consumption and displacement of petroleum, GHG and criteria pollutant emissions is based on the annual average daily traffic (AADT) of heavy duty trucks from the California Department of Transportation (DOT) on I710 and SR-60[105] for 2009 to 2011. Forecasts of TEU from the San Pedro Bay Container Forecast are used to project AADT to 2020 and 2030. The "In Line with Current Adoption" case assumes that the catenary system is not built, with zero electrification. The "In Between" case only considers the potential electrification of the proportion of trucks making frequent or semi-frequent trips to the Ports of Los Angeles or Long Beach and only on the I-710. Based on Port of Long Beach data[106], this is approximately 80.7% of trips to the port and therefore is assumed to be the same percentage of AADT on the I710. The "In Between" case assumes 35% of frequent and semi-frequent truck trips are electrified in 2020 and 100% in 2030. The "Aggressive Adoption" case forecasts that all AADT have the potential to be electrified and 35% and 100% of all I-710 truck trips could be electrified in 2020 and 2030. The "Aggressive Adoption" case also forecasts that 65% of SR-60 trips will be electrified in 2030. The truck miles per AADT of 15.51 for I-710 and 32.58 for SR-60 were used to convert truck trips to truck miles.

Electricity consumption for the "In Between" case is based on the "In Line with Current Adoption" estimate of 2.7 kWh/truck-mile and the "Aggressive Adoption" case electricity consumption is based on the high estimate of 3.0 kWh/truck-mile.[107] Displaced diesel consumption is based on a fuel economy of 5.85 miles per gallon from EMFAC 2011 in 2020 and 2030 for heavy-duty class 8 trucks and forecasted truck-miles.

The factors in Table 32 were used to calculate GHG reductions. Criteria pollutant emission reductions were determined by using the factors for in-use and idling in Table 49 below from the EMFAC model for heavy-duty class 8 trucks. The weighted average of the Port of Long Beach daily trips per truck[108] was used to convert AADT to number of trucks for calculating the idling emissions.

Table 49. Heavy-Duty Class 8 Truck Criteria Pollutant Emission Factors

	NOx In-Use (g/mi)	NOx Idle (g/vehicle/day)	ROG In-Use (g/mi)	ROG Idle (g/vehicle/day)	PM In-Use (g/mi)	PM Idle (g/vehicle/day)
2020	1.002	30.49	0.136	5.87	0.0402	0.0787
2030	1.003	30.49	0.137	5.87	0.0400	0.0787

[105] http://traffic-counts.dot.ca.gov/

[106] http://www.polb.com/civica/filebank/blobdload.asp?BlobID=3371

[107] Memo from Brian Burkhard (Transpo Group) to the Gateway COG and LAMTA, "Truck Catenary System Update to Transpo Group's July 11 Memo," August 28, 2012.

[108] http://www.polb.com/civica/filebank/blobdload.asp?BlobID=3371

Medium-Duty Vehicles. The forecast of medium-duty vehicles is based on an ICF developed penetration of three EMFAC vehicle classes – including light-heavy duty trucks (two classes) and medium duty vehicles (Classes 2 and 3). The forecasts are based on an S-curve like adoption out to 2030, linked to new vehicles sales. ICF extracted vehicle populations from EMFAC and estimated annual new vehicles sales. Vehicle retirement was accounted for based on survivability profiles extracted from EMFAC. ICF made a subjective determination of the split between PHEVs and BEVs in each of the "In Line with Current Adoption"-, "In Between"-, and "Aggressive Adoption"-cases, with the latter having the most aggressive deployment of fully electric vehicles. In most cases, it was assumed that approximately 90% of vehicles deployed would be PHEVs; however, in the "Aggressive Adoption" case this was decreased to around 50%. The "In Line with Current Adoption", "In Between", and "Aggressive Adoption" cases looked to achieve 5%, 10% and 50% of sales in 2030 which would achieve 1.5%, 2.9% and 13.4% of the population.

Electricity consumption was estimated based on an EER value of 3.4, provided by CARB for medium-duty electric vehicles.

The factors in Table 32 were used to calculate GHG reductions. Criteria pollutant emission factors were weighted based on the VMT and population of each of the vehicle classes considered.

Table 50. Medium-Duty Vehicle Criteria Pollutant Emission Factors

	NOx In-Use (g/mi)	NOx Idle (g/vehicle/day)	ROG In-Use (g/mi)	ROG Idle (g/vehicle/day)	PM In-Use (g/mi)	PM Idle (g/vehicle/day)
2020	0.538	0.242	0.067	0.090	0.005	0.003
2030	0.268	0.243	0.030	0.086	0.004	0.003

Heavy-Duty Vehicles. The forecast of heavy-duty vehicles is based on an ICF developed penetration of 23 EMFAC vehicle classes – including medium-heavy duty trucks (seven vehicle classes), heavy-heavy duty trucks (11 vehicle classes) and buses (five vehicle classes). The forecasts are based on an S-curve like adoption out to 2030, linked to new vehicles sales. ICF extracted vehicle populations from EMFAC and estimated annual new vehicles sales. Vehicle retirement was accounted for based on survivability profiles extracted from EMFAC. ICF made a subjective determination of the split between PHEVs and BEVs in each of the "In Line with Current Adoption"-, "In Between"-, and "Aggressive Adoption"-cases, with the latter having the most aggressive deployment of fully electric vehicles. In most cases, it was assumed that approximately 90% of vehicles deployed would be PHEVs; however, in the "Aggressive Adoption" case this was decreased to around 50%.

The "In Line with Current Adoption" case includes port trucks and buses increasing to a 5% sales rate by 2030. The "In Between" case includes all medium-heavy and heavy-heavy duty market segments with 10% sales in port trucks and buses and 5% sales for the remaining market segments in 2030. The

"Aggressive Adoption" case includes 50% sales for buses, 25% sales for port trucks and 15% sales for the remaining segments in 2030.

Electricity consumption was estimated based on an EER value of 2.7, provided by CARB for heavy-duty electric vehicles.

The factors in Table 32 were used to calculate GHG reductions. Criteria pollutant emission factors were weighted based on the VMT and population of each of the vehicle classes considered.

Table 51. Heavy-Duty Vehicle Criteria Pollutant Emission Factors

	NOx In-Use (g/mi)	NOx Idle (g/vehicle/day)	ROG In-Use (g/mi)	ROG Idle (g/vehicle/day)	PM In-Use (g/mi)	PM Idle (g/vehicle/day)
2020	3.397	42.536	0.211	6.869	0.075	0.127
2030	1.927	43.024	0.176	7.929	0.066	0.118

Appendix B: Costing Analysis Methodology and Assumptions

This appendix lists the major assumptions and data sources for the costing analysis in addition to detailed tables showing the analysis. Analysis for each technology was done on an annualized basis to determine costs and benefits. This includes using a 5% discount rate and the corresponding vehicle life or infrastructure life to determine annualized capital costs. In each section below is a set of tables identifying the main data sources and assumptions, the annualized private cost and benefit analysis, and annual societal benefit and monetization of those benefits using the values in Table 16. The annual capital costs (costs), operating cost savings (private benefits) and monetized societal benefits (societal benefits) are then fed into the tables in Section 3 to develop the benefit-cost ratios.

PEVs. Table 52 below shows the main data sources and assumptions for the PEV cost analysis. The analysis and results in the following tables are per PEV. Table 53 and Table 55 use the values in Table 52 to develop the annualized cost and private benefits of passenger cars and light truck, respectively. Table 54 and Table 56 show the annual societal benefits per PEV and the monetization of these benefits. The cost analysis and societal benefits are for a new PEV purchased in 2013, 2020 or 2030 and are compared to a new ICE in 2013, 2020 or 2030, respectively. See Appendix A for the details on the calculation of societal benefits. The assumptions below do not apply to Section 2 and are for costing analysis only.

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Table 52. PEV Data Sources and Assumptions

Variable	Value	Source
Incremental Vehicle Costs	Various Values for PC and LT that can be found in Table 53 and Table 55	ICF with consultation from CalETC
EVSE Cost	Various Values for LEV 1 and LEV 2 charges that can be found in Table 53 and Table 55	ICF International (2013), Bay Area Plug-in Electric Vehicle Readiness Plan
Ratio of LEV1 of LEV for PHEVs and BEVs	PHEV10 – 100% LEV 1 PHEV20 – 100% LEV 1 PHEV40 – 90% LEV 1; 10% LEV 2 BEV – 30% LEV 1 and 70% LEV 2	ICF and CalETC assumption
Federal Rebate[109]	100% Value in 2013 50% Value in 2020 0% in 2030	ICF Assumption
State Rebate	$2,500/$1,500 BEV/PHEV in 2013 $1,000/$500 BEV/PHEV in 2020 $0/$0 BEV/PHEV in 2030	ICF Assumption
Vehicle/EVSE Lifetime	10 years (no battery replacement)[110] / 20 years	ICF Assumption
Discount Factor	5%	ICF Assumption
Annual VMT/eVMT	See Table 35	ICF/CalETC Assumptions and EV Project Data
Fuel Economy	New Vehicle MPG for ICE, HEV and EV – See Table 36	AEO2013
CA Average Electricity Prices – TOU and Domestic	Population weighted average of PGE, SCE, SDGE and SMUD service territories for 2013, 2020 and 2030 found in Table 53 and Table 55	Extracted from the E3 model for used in the Phase 2 report based on rates supplied by each utility
Gasoline Prices	2013 - $3.89 2020 - $4.34 2030 - $5.10	CEC IEPR 2013
Maintenance Costs	Lifetime Oil Change: ICE - $2,365.82; PHEV - $1,474.02; BEV - $0 Total Routine Maintenance: ICE - $4,591.66; PHEV - $3.677.06; BEV - $3,094.66	ORNL[111] and Tesla[112]

[109] Federal Rebate values used: $2,500 for PHEV10; $4,000 for PHEV20; $7,500 for PHEV40 and BEV

[110] Based on required battery warranty of 10yr/100,000 mi for BEV and 10yr/150,000 mi

[111] ORNL (2010), Plug-In Hybrid Electric Vehicle Value Proposition Study. Available online at: http://www.afdc.energy.gov/pdfs/phev_study_final_report.pdf

[112] Tesla Motors, 2007, "The 21st Century Electric Car", http://www.fcinfo.jp/whitepaper/687.pdf

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Table 53. PEV Passenger Car Annualized Cost Analysis

Passenger Car	Conventional			PHEV10			PHEV20			PHEV40			BEV		
() Denotes Cost Savings	2013	2020	2030	2013	2020	2030	2013	2020	2030	2013	2020	2030	2013	2020	2030
Vehicle															
Incremental Price ($)	-	-	-	$5,717	$2,524	$399	$11,434	$5,047	$798	$15,206	$6,448	$1,597	$16,380	$5,151	$197
Federal Rebate ($/car)	-	-	-	$2,500	$1,250	$-	$4,000	$2,000	$-	$7,500	$3,750	$-	$7,500	$1,875	$-
State Rebate ($/car)	-	-	-	$1,500	$500	$-	$1,500	$500	$-	$1,500	$500	$-	$2,500	$1,500	$-
Total Capital ($)	-	-	-	$1,717	$774	$399	$5,934	$2,547	$798	$6,206	$2,198	$1,597	$6,380	$1,776	$197
Annual Costs ($/yr)	-	-	-	$222	$100	$52	$768	$330	$103	$804	$285	$207	$826	$230	$26
Infrastructure															
LEV1 Percent	-	-	-	100%	100%	100%	100%	100%	100%	70%	70%	70%	10%	10%	10%
LEV2 Percent	-	-	-	0%	0%	0%	0%	0%	0%	30%	30%	30%	90%	90%	90%
LEV 1 ($/charger)	-	-	-	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200
LEV 2 ($/charger)	-	-	-	$1,757	$1,326	$1,326	$1,757	$1,326	$1,326	$1,757	$1,326	$1,326	$1,757	$1,326	$1,326
Total Capital ($)	-	-	-	$200	$200	$150	$200	$200	$150	$667	$538	$451	$1,601	$1,213	$1,053
Annual Costs ($/yr)	-	-	-	$16	$16	$12	$16	$16	$12	$54	$43	$36	$128	$97	$84
Operating Costs															
Annual Gas VMT (mi/year)	14,965	14,965	14,965	11,315	11,315	11,315	7,665	7,665	7,665	3,796	3,796	3,796	0	0	0
Annual eVMT (mi/yr)	-	-	-	3,650	3,650	3,650	7,300	7,300	7,300	11,169	11,169	11,169	10,768	10,768	10,768
Total Gasoline Consumption (GGE/yr)	520	432	350	263	222	183	178	151	124	88	75	61	0	0	0
Total Electricity Usage (kWh/yr)	-	-	-	1,006	1,007	908	2,012	2,015	1,817	3,079	3,083	2,780	2,968	2,972	2,680
TOU Grid Price ($/kWh)	-	-	-	$0.11	$0.18	$0.26	$0.11	$0.18	$0.26	$0.11	$0.18	$0.26	$0.11	$0.18	$0.26
Domestic Grid Price ($/kWh)	-	-	-	$0.18	$0.28	$0.40	$0.18	$0.28	$0.40	$0.18	$0.28	$0.40	$0.18	$0.28	$0.40
Gasoline Price ($/GGE)	$3.89	$4.34	$5.10	$3.89	$4.34	$5.10	$3.89	$4.34	$5.10	$3.89	$4.34	$5.10	$3.89	$4.34	$5.10
TOU Electricity Cost ($/yr)	-	-	-	$115	$180	$234	$231	$361	$469	$353	$552	$717	$341	$532	$691
Domestic Electricity Cost ($/yr)	-	-	-	$181	$280	$361	$362	$559	$722	$554	$855	$1,105	$534	$825	$1,065
Gasoline Cost	$2,024	$1,873	$1,783	$1,024	$964	$931	$693	$653	$631	$343	$323	$312	$-	$-	$-
Fuel Cost Avoided	$2,024	$1,873	$1,783	$2,024	$1,873	$1,783	$2,024	$1,873	$1,783	$2,024	$1,873	$1,783	$1,456	$1,348	$1,283
Incremental Fuel Cost TOU Rate	$-	$-	$-	$(885)	$(728)	$(617)	$(1,100)	$(859)	$(683)	$(1,327)	$(998)	$(753)	$(1,116)	$(816)	$(591)
Incremental Fuel Cost Dom. Rate	$-	$-	$-	$(819)	$(629)	$(491)	$(968)	$(661)	$(430)	$(1,126)	$(694)	$(365)	$(922)	$(523)	$(217)
Incremental Maint. Cost ($/lifetime)	-	-	-	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(3,863)	$(3,863)	$(3,863)
Incremental Maint. Cost ($/yr)	-	-	-	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(386)	$(386)	$(386)
Total Cost															
Annual Incremental Capital Costs	-	-	-	$238	$116	$64	$785	$346	$115	$857	$328	$243	$955	$327	$110
Annual Incremental Fuel TOU Rate Cost	-	-	-	$(885)	$(728)	$(617)	$(1,100)	$(859)	$(683)	$(1,327)	$(998)	$(753)	$(1,116)	$(816)	$(591)
Annual Incremental Fuel Dom. Rate Cost	-	-	-	$(819)	$(629)	$(491)	$(968)	$(661)	$(430)	$(1,126)	$(694)	$(365)	$(922)	$(523)	$(217)
Annual Incremental Maintenance Cost	-	-	-	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(386)	$(386)	$(386)
Total Annual Costs TOU Rate	-	-	-	$(827)	$(793)	$(734)	$(496)	$(694)	$(749)	$(651)	$(851)	$(691)	$(547)	$(875)	$(868)
Total Annual Costs Domestic Rate	-	-	-	$(761)	$(694)	$(608)	$(364)	$(495)	$(495)	$(450)	$(547)	$(303)	$(354)	$(582)	$(494)

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Table 54. PEV Passenger Car Annualized Societal and Monetized Societal Benefits

Passenger Cars	PHEV10			PHEV20			PHEV40			BEV		
	2013	2020	2030	2013	2020	2030	2013	2020	2030	2013	2020	2030
Annual Societal Benefits per Vehicle												
Petroleum Displacement (GGE/yr)	257	209	167	342	281	226	432	357	288	374	311	252
GHG Emission Benefits (MT/yr)	2.56	2.09	1.63	3.16	2.60	2.03	3.78	3.14	2.45	3.16	2.65	2.06
NOX (tons/yr)	2.27E-04	1.37E-04	4.67E-05	4.32E-04	2.56E-04	7.95E-05	6.49E-04	3.82E-04	1.14E-04	6.20E-04	3.64E-04	1.07E-04
PM (tons/yr)	3.61E-05	1.69E-05	6.64E-07	7.13E-05	3.31E-05	7.81E-07	1.09E-04	5.03E-05	9.04E-07	1.05E-04	4.84E-05	7.37E-07
VOC (tons/yr)	3.74E-04	2.58E-04	1.47E-04	6.51E-04	4.39E-04	2.33E-04	9.45E-04	6.31E-04	3.24E-04	8.88E-04	5.89E-04	2.97E-04
Monetized Societal Benefits per Vehicle												
Petroleum Displacement	$113.46	$90.82	$70.22	$150.91	$121.92	$94.98	$190.61	$154.87	$121.22	$165.17	$134.70	$105.75
GHG Emission	$28.19	$25.06	$26.14	$34.71	$31.21	$32.48	$41.61	$37.72	$39.20	$34.81	$31.75	$32.95
NOx	$1.06	$0.70	$0.28	$2.02	$1.30	$0.48	$3.03	$1.94	$0.70	$2.90	$1.85	$0.65
PM	$52.35	$27.92	$1.31	$103.44	$54.70	$1.54	$157.59	$83.08	$1.79	$151.62	$79.81	$1.46
VOC	$0.42	$0.31	$0.21	$0.73	$0.54	$0.33	$1.06	$0.77	$0.46	$0.99	$0.72	$0.42

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Table 55. PEV Light Truck Annualized Cost Analysis

Light Truck	Conventional			PHEV10			PHEV20			PHEV40			BEV		
() Denotes Cost Savings	2013	2020	2030	2013	2020	2030	2013	2020	2030	2013	2020	2030	2013	2020	2030
Vehicle															
Incremental Price ($)	-	-	-	$7,509	$3,442	$1,027	$15,017	$6,884	$2,055	$20,142	$8,873	$3,280	$24,035	$8,251	$1,995
Federal Rebate ($/car)	-	-	-	$2,500	$1,250	$-	$4,000	$2,000	$-	$7,500	$3,750	$-	$7,500	$1,875	$-
State Rebate ($/car)	-	-	-	$1,500	$500	$-	$1,500	$500	$-	$1,500	$500	$-	$2,500	$1,500	$-
Total Capital ($)	-	-	-	$3,509	$1,692	$1,027	$9,517	$4,384	$2,055	$11,142	$4,623	$3,280	$14,035	$4,876	$1,995
Annual Costs ($/yr)	-	-	-	$454	$219	$133	$1,233	$568	$266	$1,443	$599	$425	$1,818	$632	$258
Infrastructure															
LEV1 Percent	-	-	-	100%	100%	100%	100%	100%	100%	70%	70%	70%	10%	10%	10%
LEV2 Percent	-	-	-	0%	0%	0%	0%	0%	0%	30%	30%	30%	90%	90%	90%
LEV 1 ($/charger)	-	-	-	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200	$200
LEV 2 ($/charger)	-	-	-	$1,757	$1,326	$1,326	$1,757	$1,326	$1,326	$1,757	$1,326	$1,326	$1,757	$1,326	$1,326
Total Capital ($)	-	-	-	$200	$200	$150	$200	$200	$150	$667	$538	$451	$1,601	$1,213	$1,053
Annual Costs ($/yr)	-	-	-	$16	$16	$12	$16	$16	$12	$54	$43	$36	$128	$97	$84
Operating Costs															
Annual Gas VMT (mi/year)	14,965	14,965	14,965	11,315	11,315	11,315	7,665	7,665	7,665	3,796	3,796	3,796	0	0	0
Annual eVMT (mi/yr)	-	-	-	3,650	3,650	3,650	7,300	7,300	7,300	11,169	11,169	11,169	10,768	10,768	10,768
Total Gasoline Consumption (GGE/yr)	687	593	471	336	309	232	228	209	157	113	104	78	0	0	0
Total Electricity Usage (kWh/yr)	-	-	-	1,326	1,242	1,039	2,652	2,483	2,077	4,058	3,800	3,178	3,912	3,663	3,064
TOU Grid Price ($/kWh)	-	-	-	$0.11	$0.18	$0.26	$0.11	$0.18	$0.26	$0.11	$0.18	$0.26	$0.11	$0.18	$0.26
Domestic Grid Price ($/kWh)	-	-	-	$0.18	$0.28	$0.40	$0.18	$0.28	$0.40	$0.18	$0.28	$0.40	$0.18	$0.28	$0.40
Gasoline Price ($/GGE)	$3.89	$4.34	$5.10	$3.89	$4.34	$5.10	$3.89	$4.34	$5.10	$3.89	$4.34	$5.10	$3.89	$4.34	$5.10
TOU Electricity Cost ($/yr)	-	-	-	$152	$222	$268	$304	$444	$536	$466	$680	$820	$449	$656	$791
Domestic Electricity Cost ($/yr)	-	-	-	$239	$345	$413	$477	$689	$826	$730	$1,054	$1,263	$704	$1,016	$1,218
Gasoline Cost	$2,672	$2,575	$2,400	$1,309	$1,339	$1,181	$887	$907	$800	$439	$449	$396	$-	$-	$-
Fuel Cost Avoided	$2,672	$2,575	$2,400	$2,672	$2,575	$2,400	$2,672	$2,575	$2,400	$2,672	$2,575	$2,400	$1,922	$1,853	$1,727
Incremental Fuel Cost TOU Rate	$-	$-	$-	$(1,211)	$(1,013)	$(951)	$(1,481)	$(1,223)	$(1,064)	$(1,767)	$(1,445)	$(1,184)	$(1,473)	$(1,197)	$(936)
Incremental Fuel Cost Dom. Rate	$-	$-	$-	$(1,124)	$(891)	$(806)	$(1,308)	$(979)	$(774)	$(1,502)	$(1,071)	$(740)	$(1,218)	$(836)	$(509)
Incremental Maint. Cost ($/lifetime)	-	-	-	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(1,806)	$(3,863)	$(3,863)	$(3,863)
Incremental Maint. Cost ($/yr)	-	-	-	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(386)	$(386)	$(386)
Total Cost															
Annual Incremental Capital Costs	-	-	-	$470	$235	$145	$1,249	$584	$278	$1,496	$642	$461	$1,946	$729	$343
Annual Incremental Fuel TOU Rate Cost	-	-	-	$(1,211)	$(1,013)	$(951)	$(1,481)	$(1,223)	$(1,064)	$(1,767)	$(1,445)	$(1,184)	$(1,473)	$(1,197)	$(936)
Annual Incremental Fuel Dom. Rate Cost	-	-	-	$(1,124)	$(891)	$(806)	$(1,308)	$(979)	$(774)	$(1,502)	$(1,071)	$(740)	$(1,218)	$(836)	$(509)
Annual Incremental Maintenance Cost	-	-	-	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(181)	$(386)	$(386)	$(386)
Total Annual Costs TOU Rate	-	-	-	$(921)	$(959)	$(987)	$(413)	$(820)	$(967)	$(451)	$(984)	$(904)	$86	$(854)	$(980)
Total Annual Costs Domestic Rate	-	-	-	$(834)	$(836)	$(842)	$(240)	$(575)	$(677)	$(186)	$(610)	$(460)	$342	$(494)	$(552)

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Table 56. PEV Light Truck Annualized Societal and Monetized Societal Benefits

Light Trucks	PHEV10			PHEV20			PHEV40			BEV		
	2013	2020	2030	2013	2020	2030	2013	2020	2030	2013	2020	2030
Annual Societal Benefits per Vehicle												
Petroleum Displacement (GGE/yr)	350	285	239	459	384	314	574	490	393	494	427	339
GHG Emission Benefits (MT/yr)	3.51	2.88	2.42	4.25	3.64	2.96	5.04	4.44	3.53	4.18	3.77	2.94
NOX (tons/yr)	2.24E-04	1.37E-04	5.08E-05	4.18E-04	2.51E-04	8.07E-05	6.23E-04	3.72E-04	1.12E-04	5.93E-04	3.52E-04	1.03E-04
PM (tons/yr)	3.48E-05	1.62E-05	4.27E-07	6.85E-05	3.15E-05	2.04E-08	1.04E-04	4.77E-05	-4.10E-07	1.00E-04	4.57E-05	-5.99E-07
VOC (tons/yr)	4.23E-04	2.98E-04	1.86E-04	7.11E-04	4.93E-04	2.80E-04	1.02E-03	6.99E-04	3.79E-04	9.46E-04	6.49E-04	3.43E-04
Monetized Societal Benefits per Vehicle												
Petroleum Displacement	$154.58	$123.50	$100.50	$202.46	$166.68	$131.91	$253.21	$212.45	$165.21	$218.03	$185.18	$142.38
GHG Emission	$38.60	$34.54	$38.68	$46.76	$43.66	$47.29	$55.41	$53.32	$56.41	$45.97	$45.19	$47.03
NOx	$1.05	$0.70	$0.31	$1.95	$1.28	$0.49	$2.91	$1.89	$0.68	$2.77	$1.79	$0.63
PM	$50.53	$26.76	$0.84	$99.28	$51.98	$0.04	$150.96	$78.71	$(0.81)	$145.11	$75.50	$(1.19)
VOC	$0.47	$0.36	$0.26	$0.79	$0.60	$0.40	$1.14	$0.85	$0.54	$1.06	$0.79	$0.49

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Forklifts. Table 57 below shows the main data sources and assumptions for the forklift cost analysis. All analyses and results in the following tables are per forklift. The 8,000 lb forklift is assumed to operate on gasoline and the 19,800 lb forklift to operate on diesel. Table 59 uses the values in Table 57 to develop the annualized cost and private benefits. Table 60 shows the annual societal benefits per forklift and the monetization of these benefits. The cost analysis and societal benefits are for a new forklift purchased in 2013 and are compared to a new ICE forklift 2013. See Appendix A for the details on the calculation of societal benefits for forklifts.

Table 57. Forklift Data Sources and Assumptions

Variable	Value	Source
Vehicle, Battery and Charger Costs	Values in Table 59	Direct quotes from dealers – Hawthorne and SCMH
Operating Life	Conventional Fuel Lift – 7 yrs / 21,000 hrs 8,000lb Electric – 8 yrs / 24,000 hrs 19,800ln Electric – 8 yrs / 24,000 hrs	Conventional: OFFROAD model; Electric: ratio of Electric/Conventional from Hyster[113]
Charger Life	14 yrs	Previous CalETC Study
Fraction of Regular and Fast Charge	Regular Charge: 72.5% Fast Charge: 27.5%	Previous CalETC Study
Annual Usage	3,150 hrs/yr (525 6-hr shifts/yr)	Previous CalETC Study
Battery Sizes	8,000 lb – 43.6 kWh 19,800 lb – 124 kWh	Survey of existing electric forklifts including Kalmar, Nissan, and CAT
Electricity Usage	80% battery depletion per 6-hr shift	ICF Assumption
Electricity Grid Cost	Regular Charge - $0.18/kWh Fast Charge - $0.32/kWh	Previous CalETC Report with update for current rate schedules: See Table 58
Discount Factor	5%	ICF Assumption
Gasoline and Diesel Prices	2013 Gasoline - $3.89/gal (used as surrogate for propane) 2013 Diesel - $3.91/gal	CEC IEPR 2013
Gasoline and Diesel Fuel Consumption	Gasoline – 0.70/gal Diesel – 1.10/gal	OFFROAD Model
Maintenance Costs	Electricity – 22 hrs/yr Conventional – 40 hrs/yr $26/hr for Labor	Previous CalETC Study

[113] "Timely Replacement of Lift Trucks," Hyster Company, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=9&cad=rja&ved=0CIIBEBYwCA&url=http%3A%2F%2Fwww.hyster.com%2FWorkArea%2FDownloadAsset.aspx%3Fid%3D8589935299&ei=qDbsUqW-BdO1kQecuoDQAg&usg=AFQjCNGiyt9PkuQeuuMU03LatU2bIQqAIA&sig2=7nT4Qh_ufsaK4VgPZqfk8A&bvm=bv.60444564,d.eW0

Table 58. Forklift Electricity Rate Assumptions

	SCE	PG&E	LADWP/Public	SDGE
Tariff Schedule	TOU-8	E-19 Mandatory	A-3	AL-TOU
Share of Electricity	35%	35%	20%	10%
Summer Share	33%	50%	33%	42%
Winter Share	67%	50%	67%	58%
Charging Power Demand	11kW: Regular 34.88kW: Fast	11kW: Regular 34.88kW: Fast	11kW: Regular 34.88kW: Fast	11kW: Regular 34.88kW: Fast
Percent Subject to Time Demand Charges	25%	25%	25%	25%
Percent Subject to Facility Demand Charges	100%	100%	100%	100%

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Table 59. Forklift Annualized Cost Analysis

	Conventional 8,000 lb	Electric 8,000 lb	Conventional 19,800 lb	Electric 19,800 lb
() Denotes Cost Savings	Gasoline/LPG	Electric	Diesel	Electric
Forklift				
Forklift High Cost ($/truck)	$23,500	$38,000	$165,000	$170,000
Forklift Low Cost ($/truck)	$31,500	$34,000	$165,000	$170,000
Battery High Cost ($/battery)		$13,000		$14,280
Battery Low Cost ($/battery)		$9,850		$12,750
Forklift Operating Life	7	8.9	7	8.4
Battery Operating Life		8.9		8.4
Batteries per forklift		1.0		2
Total Capital - High	$23,500	$51,000	$165,000	$198,560
Total Capital - Low	$31,500	$43,850	$165,000	$195,500
Annual Costs -High	$4,061	$7,234	$28,515	$29,526
Annual Costs -Low	$5,444	$6,219	$28,515	$29,071
Charger				
Regular Charger Cost - High		$4,650		$5,000
Regular Charger Cost - Low		$3,500		$3,500
Fast Charger Cost - High		$15,000		$15,000
Fast Charger Cost - Low		$10,000		$10,000
Regular Charger (%)		72.5%		72.5%
Fast Charger (%)		27.5%		27.5%
Charger Life		14		14
Total Capital - High		$7,496		$11,375
Total Capital - Low		$3,913		$7,825
Annual Costs - High		$757		$1,149
Annual Costs - Low		$395		$791
Operating Costs				
Annual Usage (hr/year)	3,150	3,150	3,150	3,150
Total Electricity Usage (kWh/yr)		18,312		52,080
Regular Grid Cost ($/kWh)		$0.18		$0.12
Fast Grid Cost ($/kWh)		$0.32		$0.17
Electricity Cost ($)		$4,046		$7,082.67
Gasoline/Diesel Fuel Cost ($)	$9,193		$13,593	
Annual Maint. Cost ($)	$2,452	$1,546	$2,452	$1,546
Total Cost				
Annual Incremental Capital Costs - High		$4.587		$3,355
Annual Incremental Capital Costs - Low		$1,736		$2,523
Annual Incremental Operating Cost ($)		$(6,053)		$(7,416)
Total Annual Costs - High		$(1.466)		$(4,061)
Total Annual Costs - Low		$(4,317)		$(4893)

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Table 60. Forklift Annualized Societal and Monetized Societal Benefits

	8,000 lb Electric	19,800 lb Electric
Annual Societal Benefits		
Petroleum Displacement (GGE/yr)	2,205	4,043
GHG Emission Benefits (MT/yr)	18.33	29.93
NOX (tons/yr)	0.016	0.021
PM (tons/yr)	3.18E-04	0.001
VOC (tons/yr)	0.009	0.004
Monetized Societal Benefits		
Petroleum Displacement	$972.83	$1,783.66
GHG Emission	$201.59	$329.22
NOx	$73.38	$97.18
PM	$461.55	$1,116.31
VOC	$10.27	$4.30

Truck Stop Electrification. Table 61 below shows the main data sources and assumptions for the TSE cost analysis. All analyses and results in the following tables are per truck stop (20 spaces).Table 63 uses the values in Table 61 to develop the annualized cost and private benefits. Table 64 shows the annual societal benefits per truck stop and the monetization of these benefits. See Appendix A for the details on the calculation of societal benefits for TSE.

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Table 61. TSE Data Sources and Assumptions

Variable	Value	Source
Vehicle Side Cost	328 - 600	Carrier Transicold and DiamondPower APU
Operating Life	7 yrs	Previous CalETC Study
Spaces Per Truck Stop	20	Previous CalETC Study
Capacity Factor	0.6	Previous CalETC Study (SCE/ IdleAir)
Idle Hours to Plug-In per Day	8	ICF Assumption
Market Share	Plug-In APU – 75% IdleAir – 25%	Previous CalETC Study
Facility Infrastructure Costs ($/space)	Plug-in APU: $2,600 - $6,000 IdleAir - $5,000 - $10,000	Plug-in APU – Previous CalETC study (Shorepower); IdleAir – Ethan Garber of IdleAir
Facility Operating Life	20 yrs	Previous CalETC Study
Power Requirement	1.39 kW	Previous CalETC Study
Electricity Grid Cost	Plug-In APU - $0.16/kWh IdleAir - $0.15/kWh	Previous CalETC Report with update for current rate schedules: See Table 62
Discount Factor	5%	ICF Assumption
Diesel Prices	2013 Diesel - $3.91/gal	CEC IEPR 2013
Diesel Fuel Consumption	Diesel – 0.21/gal	Anti-Idling ISOR
Labor Costs	IdleAir - $105,000/yr	Previous CalETC Study (NYSERDA)

Table 62. TSE Electricity Rate Assumptions

	SCE	PG&E	LADWP/Public	SDGE
Tariff Schedule	GS-2	A-6	A-2 (B)	AL-TOU
Share of Electricity	35%	35%	20%	10%
Summer Share	50%	75%	50%	42%
Winter Share	50%	25%	50%	58%
Power Demand (kW)	Plug-In APU – 27.7 IdleAir – 83.2			
Percent Subject to Time Demand Charges	0%	0%	0%	0%
Percent Subject to Facility Demand Charges	100%	100%	100%	100%

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Table 63. TSE Annualized Cost Analysis

	Plug-In APU/ Shorepower	IdleAir
Vehicle		
Incremental High Cost ($/truck)	$600	$-
Incremental Low Cost ($/truck)	$328	$-
Spaces per Truck Stop	20	60
Capacity Factor	0.6	0.6
Idle Hours to Plug-In (hr/day/truck)	8	8
Stop Based Trucks	36	108
TSE Technology Life (yrs)	7.0	7
Total Capital per Truck Stop - High	$21,600	$-
Total Capital per Truck Stop - Low	$11,808	$-
Annual Costs per Truck Stop - High	$1,244	$-
Annual Costs per Truck Stop -Low	$680	$-
Facility		
Infrastructure Cost - High ($/space)	$6,000	$10,000
Infrastructure Cost - Low ($/space)	$2,600	$5,000
Facility Project Life (yrs)	20	20
Total Capital - High	$120,000	$600,000
Total Capital - Low	$52,000	$300,000
Annual Costs - High	$9,629	$48,146
Annual Costs - Low	$4,173	$24,073
Operating Costs		
Annual Usage (hr/year/space)	5,256	5,256
Total Electricity Usage (kWh/yr/space)	7,290	7,290
Regular Grid Cost ($/kWh)	$0.16	$0.15
Electricity Cost ($/stop)	$23,762	$66,857
APU Diesel Fuel Consumption	0.21	0.21
Diesel Fuel Cost ($/gallon)	$3.91	$3.91
Diesel Cost Savings ($/stop/yr)	$85,492	$256,476
Annual Labor Cost ($)	$-	$105,000
Total Cost		
Annual Incremental Capital Costs - High	$10,873	$48,146
Annual Incremental Capital Costs - Low	$4,853	$24,073
Annual Incremental Operating Cost ($)	$(61,730)	$(84,619)
Total Annual Costs per Stop - High	$(50,856)	$(36,474)
Total Annual Costs per Stop- Low	$(56,877)	$(60,546)

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Table 64. TSE Annualized Societal and Monetized Societal Benefits

	Plug-In APU/ Shorepower	IdleAir
Annual Societal Benefits (Per Truck Stop)		
Petroleum Displacement (GGE/yr)	25,427	76,282
GHG Emission Benefits (MT/yr)	233	700
NOX (tons/yr)	1.658	4.975
PM (tons/yr)	0.014	0.043
VOC (tons/yr)	0.084	0.251
Monetized Societal Benefits (Per Truck Stop)		
Petroleum Displacement	$11,218	$33,655
GHG Emission	$2,566	$7,698
NOx	$7,754	$23,262
PM	$20,917	$62,751
VOC	$94	$281

Transport Refrigeration Units. Table 65 below shows the main data sources and assumptions for the TRU cost analysis. All analyses and results in the following tables are per facility (19 spaces). All TRUs are assumed to operate on diesel if not plugged in. Table 67 uses the values in Table 65 to develop the annualized cost and private benefits. Table 68 shows the annual societal benefits per facility and the monetization of these benefits. The cost analysis and societal benefits are for new e-standby TRUs purchased in 2013 and are compared to new non e-standby TRUs purchased in 2013 that comply with LEV III. See Appendix A for the details on the calculation of societal benefits for TRUs.

Table 65. TRU Data Sources and Assumptions

Variable	Value	Source
Vehicle Side Cost	Semi - $3,700 - $5,000 Bobtail - $550 - $650	Dealers for Thermoking and Carrier Transicold
Operating Life	16 yrs	Previous CalETC Study
Spaces Per Facility	19	ARB 2005 ISOR
Capacity Factor	0.6	Previous CalETC Study
Annual Operating Hours in California	Semi In-State: 1,325 hrs/yr Semi Out of State: 210 hrs/yr Bobtail: 1,360 hrs/yr Bobtail <11hp: 1,360 hrs/yr	ARB 2011 TRU ISOR
Fraction of Time at the Facility for e-standby	30%	ARB2011 TRU ISOR and Conversations with CARB Staff
Facility Infrastructure Costs ($/space)	Semi - $4,300 Bobtail - $1,500	Previous CalETC Study (EPRI)
Facility Operating Life	20 yrs	Previous CalETC Study
Power Requirement	Semi - 8 kW Bobtail – 6 kW Bobtail <11hp – 2 kW	Previous CalETC Study
Electricity Grid Cost	Semi - $0.25/kWh Bobtail - $0.27/kWh Bobtail <11hp - $0.24/kWh	Previous CalETC Report with update for current rate schedules: See Table 66
Discount Factor	5%	ICF Assumption
Diesel Prices	2013 - $3.91/gal	CEC IEPR 2013
Diesel Fuel Consumption	Semi - 0.85 gal/hr Bobtail – 062 gal/hr Bobtail <11hp – 0.29 gal/hr	OFFROAD model and EPRI

Table 66. TRU Electricity Rate Assumptions

	SCE	PG&E	LADWP/Public	SDGE
Tariff Schedule	TOU G-3	E-19 Mandatory	A-3	AL-TOU
Share of Electricity	35%	35%	30%	0%
Summer Share	33%	50%	33%	42%
Winter Share	67%	50%	67%	58%
Power Demand (kW)	Semi – 152 kW Bobtail – 152 kW Bobtail <11 HP – 43.7 kW			
Percent Subject to Time Demand Charges	20%	20%	20%	20%
Percent Subject to Facility Demand Charges	20%	20%	20%	20%

Table 67. TRU Annualized Cost Analysis

	Semi In-State	Semi Out of State	Bobtail	Bobtail <11 HP
Horsepower Category	25-50	25-50	11-25	<11
Truck				
Incremental High Cost ($/truck)	$5,000	$5,000	$650	$650
Incremental Low Cost ($/truck)	$3,700	$3,700	$550	$550
Hook-ups per Facility	19.0	19	19	19
Capacity Factor	0.6	0.6	0.6	0.6
Annual Operating Hours in CA (hr/truck)	1,325	210	1,360	1,360
Fraction of Time at Facility to Plug-In	0.3	0.3	0.3	0.3
Facility Based Trucks	251	1585	245	245
TRU Technology Life (yrs)	16	16	16	16
Total Capital per Truck Stop - High	$1,256,151	$7,925,714	$159,097	$159,097.06
Total Capital per Truck Stop - Low	$929,552	$5,865,029	$134,621	$134,621
Annual Costs per Truck Stop - High	$115,905	$731,305	$14,680	$14,680
Annual Costs per Truck Stop -Low	$85,770	$541,166	$12,421	$12,421
Facility				
Infrastructure Cost - ($/hook-up)	$4,300	$4,300	$1,500	$1,500
Facility Project Life (yrs)	20	20	20	20
Total Capital	$81,700	$81,700	$28,500	$28,500
Annual Costs	$7,538	$7,538	$2,630	$2,630
Operating Costs				
Baseline Fuel Consumption (gal/hr)	0.85	0.85	0.62	0.29
Annual Usage (hr/year/hook-up)	5,256	5,256	5,256	5,256
Electricity Load (kW)	8	8	6	2
Total Electricity Usage (kWh/yr/hook-up)	42,048	42,048	31,536	11,826
Regular Grid Cost ($/kWh)	$0.25	$0.25	$0.27	$0.24
Electricity Cost ($/facility)	$196,427	$196,427	$164,240	$52,957
Diesel Cost Savings ($/facility/yr)	$331,898	$331,898	$242,090	$112,142
Total Cost				
Annual Incremental Capital Costs - High	$123,443	$738,843	$17,310	$17,310
Annual Incremental Capital Costs - Low	$93,308	$548,704	$15,051	$15,051
Annual Incremental Operating Cost ($)	$(135,471)	$(135,471)	$(77,851)	$(59,185)
Total Annual Costs - High	$(12,028)	$603,372	$(60,541)	$(41,876)
Total Annual Costs - Low	$(42,163)	$413,233	$(62,799)	$(44,134)

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Table 68. TRU Annualized Societal and Monetized Societal Benefits

	Semi In-State	Semi Out of State	Bobtail	Bobtail <11 HP
Annual Societal Benefits (Per Facility)				
Petroleum Displacement (GGE/yr)	98,715	98,715	72,004	33,354
GHG Emission Benefits (MT/yr)	818	818	590	293
NOX (tons/yr)	7.402	7.402	8.375	3.211
PM (tons/yr)	0.022	0.022	0.052	0.020
VOC (tons/yr)	0.221	0.221	0.175	0.089
Monetized Societal Benefits (Per Facility)				
Petroleum Displacement	$43,552	$43,552	$31,767	$14,715
GHG Emission	$8,996	$8,996	$6,494	$3,227
NOx	$34,609	$34,609	$39,157	$15,014
PM	$31,979	$31,979	$75,490	$29,041
VOC	$247	$247	$195	$100