ATTACHMENT D

Clean Truck Technology Comparative Report

Final Report

September 2022

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List of Acronyms

AC	Alternating Current
ACF	Advanced Clean Fleets
ACT	Advanced Clean Trucks
AQMD	Air Quality Management District
BET	Battery Electric Truck
BPT	Benefit per Ton
CalETC	California Electric Transportation Coalition
CARB	California Air Resources Board
CEC	California Energy Commission
CNG	Compressed Natural Gas
DC	Direct Current
DCFC	Direct Current Fast Chargers
DGE	Diesel Gallon Equivalent
DPM	Diesel Particulate Matter
EDF	Environmental Defense Fund
EMFAC	Emission Factor
EPA	Environmental Protection Agency
ER	Emergency Room
EV	Electric Vehicle
EVSE	Electric Vehicle Supply Equipment
FCET	Fuel Cell Electric Truck
g/bhp-hr	Grams per Brake Horsepower-Hour
GHG	Greenhouse Gases
GNA	Gladstein, Neandross, & Associates
GVWR	Gross Vehicle Weight Rating
HVIP	California Hybrid and Zero Emission Truck and Bus voucher Incentive Project
IPT	Incidence per Ton
Kg	Kilogram
kW	Kilowatt
LADWP	Los Angeles Department of Water and Power
LCFS	Low Carbon Fuel Standard
LFG	Landfill Gas
MD/HD	Medium-Duty / Heavy-Duty
MOU	Memorandum of Understanding
MWh	Megawatt-hour
NAAQS	National Ambient Air Quality Standards
NH4	Ammonium
NOx	Nitrogen Oxides

P3	Public-Private Partnership
RNG	Renewable Natural Gas
SCE	Southern California Edison
SOx	Sulfur Oxides
TCO	Total Cost of Ownership
VIP	Carl Moyer Voucher Incentive Program
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compounds
VW	Volkswagen
ZETI	Zero Emission Technology Inventory

1 Executive Summary

Despite significant improvement in air quality and public health over the past decades, there are still many communities in California, especially low-income and disadvantaged communities near major freight facilities, which are suffering from high levels of air pollution. Of all the sources of air pollution, mobile sources, especially diesel trucks and equipment are one of the major contributors to adverse air quality and public health in California. Considering that Los Angeles County (LA County) is home to the largest container port complex in the nation, emissions from Class 8 trucks, especially those serving the Ports of Los Angeles and Long Beach (San Pedro Bay Ports), rail yards, and logistics facilities have been one of the major public health concerns within communities surrounding the ports. In response to these concerns, local and state agencies in California have recently adopted multiple regulations and policies to curb the emissions from diesel trucks and transition the California heavy duty fleet to zero emission (ZE) technologies. While these regulations and policies will require the vehicle manufacturers to sell and fleets operating in California to purchase zero emissions vehicles, successful adoption of these programs will also heavily rely on the availability and accessibility of charging and fueling infrastructure. This report is intended to uncover some of the challenges with accelerated adoption of heavy-duty zero emission truck technologies and provide a set of recommendations that various stakeholders can consider in the near term.

Today there are more than 55,000 Class 8 trucks operating within LA County emitting approximately 25 tons of nitrogen oxides (NOx) – a precursor to ozone – and approximately 385 lbs. of diesel particulate matter (DPM) every day, per analysis of California Air Resources Board's (CARB) Emission Factor (EMFAC2021) data.[1] When considering that these trucks travel through communities and near schools and residential areas, it becomes even more important to design effective programs and strategies that can accelerate the emissions reductions from these vehicles and reduce the air pollution burden, especially within low income and disadvantaged communities in the County. To effectively guide policy and program design, the project team initiated this study by conducting a comprehensive evaluation of the commercial availability, readiness, and total cost of ownership (TCO) of various clean truck technologies such as battery electric, hydrogen fuel cell, low NOx natural gas, and low NOx diesel. This assessment provides a clear picture on the market status of each of these four technologies and an outlook for technology commercialization. Specifically with respect to battery electric technology, our assessment demonstrated that while today there are several zero emission models available that could serve in drayage and delivery business, it will take until the mid- to late-2020s for the technology to be vastly deployed in regional-hauls, and until 2030 for the long-haul operations. Similarly with hydrogen fuel cell electric trucks (FCET), while today there is a limited availability, it is expected that by 2030, there will be models available that could be placed in long-haul intrastate and interstate operations.

The project team projected the mix of Class 8 truck technologies that LA County could anticipate between 2022 through 2040 considering the impact of the State's Advanced Clean Trucks (ACT) and proposed Advanced Clean Fleets (ACF) regulations. Through this assessment, it is estimated

[1] California Air Resources Board. (n.d.). EMFAC2021. In *EMFAC*. Retrieved from https://arb.ca.gov/emfac/

that by 2040, LA County could expect approximately 48,500 battery electric and 10,700 hydrogen fuel cell electric Class 8 trucks operating on its roadways, which make up approximately 56 percent and 12 percent of the total projected 2040 truck population, respectively. Our analysis also showed that as a result of this massive zero emission technology adoption, by calendar year 2040, NOx emissions from Class 8 trucks in LA County would be as low as 2.5 tons per day, nearly 10 times lower than business-as-usual emissions in the same year. With respect to DPM, the projected technology mix is expected to result in an 85% reduction from the 2030 baseline. Our analysis, based on the U.S. Environmental Protection Agency's (EPA) Benefit per Ton estimates[2], demonstrated that these reductions could result in cumulative health benefits in the form of 511 – 524 reduced mortality, 285 fewer respiratory related emergency room (ER) visits, 57 fewer respiratory related hospital admissions, and almost 75,000 fewer work loss days in LA County. All combined, these health outcomes are estimated to bring in more than $5 billion in cumulative health benefits between 2024 through 2040.

Aside from the emissions reductions and the health benefits, the project team also estimated that by 2040 these zero emission trucks will likely consume more than 10,000 megawatt-hour (MWh) of electricity and approximately 260,000 kilograms (kg) of hydrogen per day. To support such demand, we estimate that there may be a need for more than 45,000 level 2 and direct current fast charger (DCFC) ports of which approximately 26,000 may be located at fleets' private truck depots (i.e., private charging ports), 11,000 may be deployed as public charging ports for overnight charging, and more than 8,000 public charging ports may be available for opportunity fast charging. There may also be a need for roughly 50 up to 260 hydrogen fueling stations to support FCETs, depending on the stations' assumed daily fueling throughput (this study considered scenarios of 1,000 to 5,000 kg/day). Importantly, these estimates are only for one scenario and set of assumptions; results may vary based on several factors such as charger capacities, station throughputs, truck-to-charger ratios, etc. Altogether, building such a network of zero emission infrastructure in LA County is estimated to cost anywhere between $2.9 to $3.7 billion. Note that this only reflects the direct costs of equipment and installation; it excludes the cost associated with land acquisition, electric utility distribution grid equipment upgrades, upgrades to site-level make-ready infrastructure, design, engineering, and permitting. It is expected that total costs will exceed this range due to these additional capital expenditures.

Already, California offers a suite of incentive programs that provide funding towards the purchase of zero emission trucks and buildout of zero emission infrastructure. While these funding programs have been instrumental in reducing the incremental cost of zero emissions trucks, the overall cost of transition is much greater than the funding made available through the state budget. That is why complementary programs and policy actions by local agencies and utilities, such as LA Metro, and South Coast Air Quality Management District (AQMD), the San Pedro Bay Ports, Southern California Edison, and Los Angeles Department of Water and Power (LADWP) will be necessary to ensure the County can achieve its public health goals through an equitable transition

[2] U.S. Environmental Protection Agency. (2022, January 13). Estimating the Benefit per Ton of Reducing Directly-Emitted PM2.5, PM2.5 Precursors and Ozone Precursors from 21 Sectors. In Benefits Mapping and Analysis Program (BenMAP). Retrieved from https://www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors

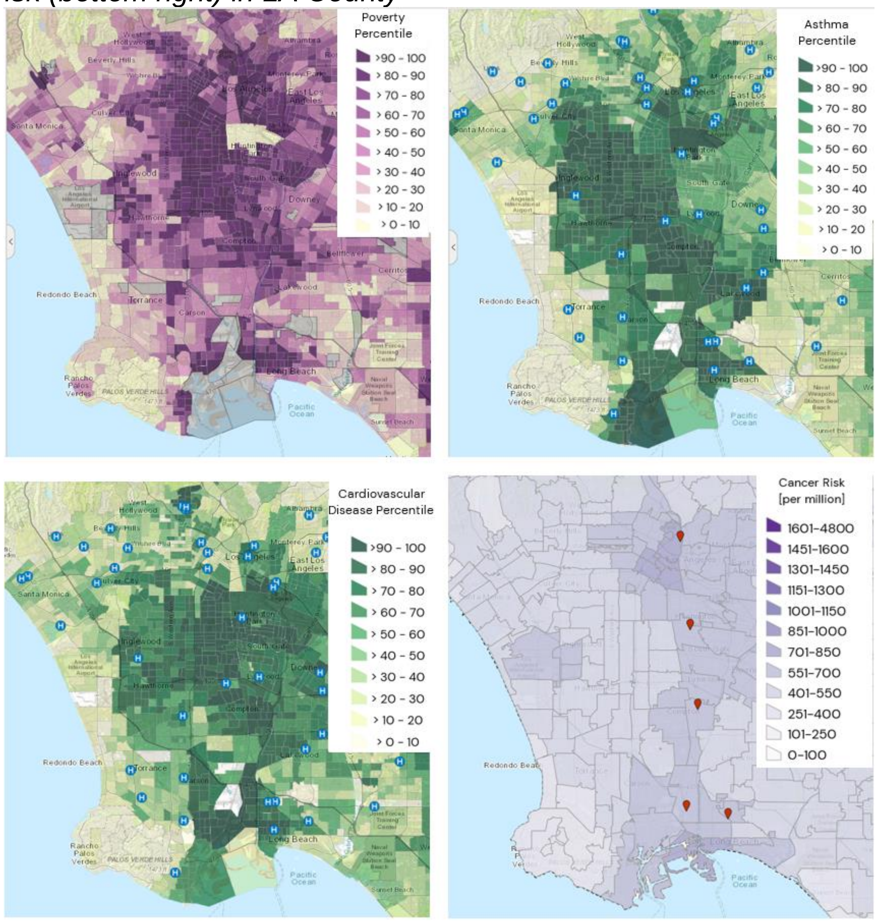
to zero emission trucks. In coordination with these stakeholders, the project team developed a set of recommendations that various stakeholders could consider as they join forces to accelerate adoption of clean technology in the County. These include:

- **Create public-access overnight charging lots for small fleets:** Currently, almost one third of Class 8 trucks registered in California belong to fleets of 1 – 3 vehicles, which are less likely to have private depots to host charging infrastructure and will likely need to rely on overnight public charging infrastructure to meet their daily demands. Engaged stakeholders and end users should find mechanisms to provide public overnight charging lots for smaller fleets without depots. This approach would more directly address local, short-term needs for smaller fleets within LA County. For the long-term, LA Metro may consider coordinating with other major freight centers outside of LA County to determine how they can support the eventual deployment of long-haul ZE trucks through strategically located and sized charging and fueling infrastructure.
- **Streamline permitting, site development requirements, and land acquisition requirements to support EV charging infrastructure and hydrogen fueling station deployment:** Building this infrastructure will entail many elements including land acquisition, site readiness, equipment installation and operation. Because these processes involve multiple entities including landowners, fleet owners and operators, cities, and utilities, improving existing processes to streamline and eliminate inefficiency would be paramount to realizing the needed infrastructure implementation in a timely manner.
- **Simplify structures of existing incentive and grant programs:** Existing literature on end user perspectives of zero emission trucks suggests that fleets find some programs difficult to navigate, and that there are tax implications associated with receiving incentive funding. More specifically, fleets have expressed concerns regarding the cost impact of income taxes imposed on incentives received, along with vehicle registration fees for those vehicles. As state agencies, such as CARB and CEC, examine options to offer greater funding opportunities to fleets, the design of these programs may have room to become more user friendly, particularly to enhance accessibility and attractiveness of these funds to small fleets.
- **Provide technical assistance to small fleets:** Our evaluation of existing literature on end user perspectives of zero emission trucks reinforced that costs associated with these vehicles and infrastructure installation are some of the largest barriers to fleet transition. Further, small businesses and small fleets, in particular, have fewer resources and technical knowledge to fully benefit from incentives and grant programs. To address these barriers, one opportunity is to identify small truck fleet owners who are interested in procuring zero emission vehicles and offer technical assistance so they can pursue state grants and incentives.
- **Leveraging Public-Private Partnership (P3) Models:** P3s have been proven to be effective tools for rapid delivery of infrastructure projects and increasing the opportunities for innovation. Engaged stakeholders and end users could leverage the existing P3 model, as well as vehicle and infrastructure as-a-service models, to facilitate and speed up deployment of public fueling and charging infrastructure across major freight corridors.

2 Introduction

Los Angeles County, the most populous county in the United States with more than 10 million inhabitants, is one of very few regions in the country that is suffering from high levels of photochemical smog, which is a type of air pollution containing ground level ozone and other chemicals. Exposure to ground level ozone can cause negative health effects, including coughing, difficulty breathing, and an increased frequency of asthma attacks. The county is one of the only two areas in the country that extremely exceeds national ambient air quality standards (NAAQS) for ozone. Failure to meet these standards by the U.S. EPA's designated deadline would not only have negative public health impacts but could also trigger various federal sanctions, such as highway sanctions, which will impose adverse economic impacts on the region. Aside from the federal air quality requirements, there are also many communities within LA County that are disproportionately impacted by air pollution from transportation and industrial activities within the region. For example, Figure 1 shows a side-by-side comparison of asthma, cardiovascular disease cases (from CalEnviroScreen 4.0), and air toxics cancer risk (from South Coast AQMD's MATES V Multiple Air Toxics Exposure Study) to poverty levels (from CalEnviroScreen 4.0) in LA County. This figure illustrates how regions with higher levels of poverty, especially those surrounding ports and major freight facilities, are the same communities suffering from high levels of asthma, cardiovascular diseases, and are exposed to high levels of air toxics cancer risk.

Figure 1. Poverty (top left), asthma cases (top right), cardiovascular disease (bottom left), and air toxics cancer risk (bottom right) in LA County[3]



Of all sources of air pollution, Class 8 heavy-duty diesel vehicles (above 33,000 lbs. gross vehicle weight rating - GVWR) are one of the major sources driving air quality issues in these communities. These vehicles are significant emitters of NOx (a precursor to ozone), fine particulate matter (i.e., PM2.5), and Diesel PM. Here we briefly describe some of these ambient air pollutants that are caused by emissions from Class 8 heavy-duty diesel vehicles.

Ground level ozone is mainly formed through the reaction of NOx and volatile organic compound (VOC) emissions – pollutants that are known as ozone precursors. According to U.S. EPA, short-term exposure to ground-level ozone can cause a variety of respiratory health effects, including inflammation of the lining of the lungs, reduced lung function, and respiratory symptoms such as cough, wheezing, chest pain, burning in the chest, and shortness of breath. Exposure to ambient concentrations of ozone has been associated with the aggravation of respiratory illnesses such as asthma, emphysema, and bronchitis, leading to increased use of medication, absences from

[3] Based on CalEnviroScreen 4.0 and MATES V Multiple Air Toxics Exposure Study:
California Office of Environmental Health Hazard Assessment. (2021, October 20). CalEnviroScreen 4.0. In California Office of Environmental Health Hazard Assessment. Retrieved from https://oehha.ca.gov/calenviroscreen/report/calenviroscreen-40 ; South Coast Air Quality Management District. (n.d.). MATES V Multiple Air Toxics Exposure Study. In South Coast Air Quality Management District. Retrieved from http://www.aqmd.gov/home/air-quality/air-quality-studies/health-studies/mates-v

school, doctor and emergency department visits, and hospital admissions. Short-term exposure to ozone is associated with premature mortality.

Particulate matter or PM is a generic term that is used to describe a broad class of chemically and physically diverse substances that exist as discrete particles (liquid droplets or solids) over a wide range of sizes. PM could be emitted directly from emissions sources (PM emissions from the vehicle tailpipe) or formed in the atmosphere through reaction of gaseous emissions such as Sulfur Oxide (SOx), NOx, and ammonium (NH4) (also known as secondary PM). In general, particulate matter is grouped by its size into PM10 and PM2.5. PM2.5 refers to particles with a diameter less than 2.5 micrometers (um), whereas PM10 refers to particles of diameter between 2.5 um and 10 um. Studies have demonstrated that short or long-term exposure to both PM2.5 and PM10 could result in adverse health effects such as premature mortality, aggravation of respiratory and cardiovascular disease (e.g., increased hospital admissions and emergency visits), and changes in sub-clinical indicators of respiratory and cardiac function

Diesel PM is a type of PM that is generated through combustion of diesel fuel in an internal combustion engine. In 1998, CARB identified DPM as a toxic air contaminant[4] based on published evidence of a relationship between diesel exhaust exposure and lung cancer and other adverse health effects. These health impacts are of particular concern for communities surrounding goods movement facilities. These health effects include exacerbation of asthma, increased hospitalizations, premature birth, and premature deaths from heart and/or lung diseases.

Figure 2 shows a high-level relationship between major emissions from Class 8 heavy duty diesel trucks (along with those from other sources), ambient air pollutants (e.g. Ozone, ambient PM2.5, and Diesel PM), and their associated public health impacts.

[4] According to section 39655 of the California Health and Safety Code, a toxic air contaminant (TAC) is "an air pollutant which may cause or contribute to an increase in mortality or an increase in serious illness, or which may pose a present or potential hazard to human health.". A complete list of TACs can be found at: https://oehha.ca.gov/air/general-info/toxic-air-contaminant-list-staff-reportsexecutive-summaries

Figure 2. Simplified relationship between emissions (e.g., NOx, SOx, VOC, directly emitted PM2.5), ambient air quality (e.g., Ozone, and ambient PM), and public health impacts

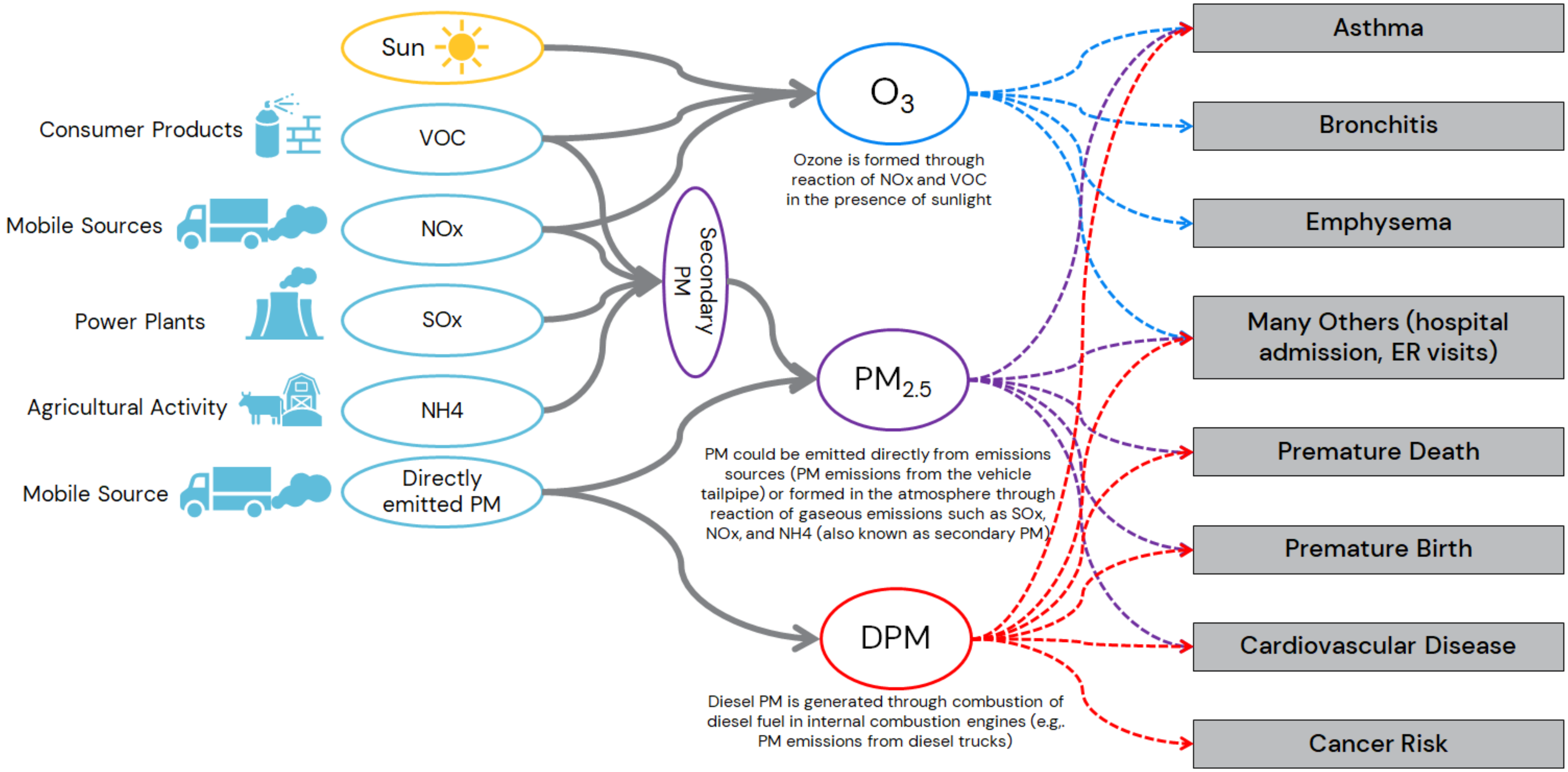
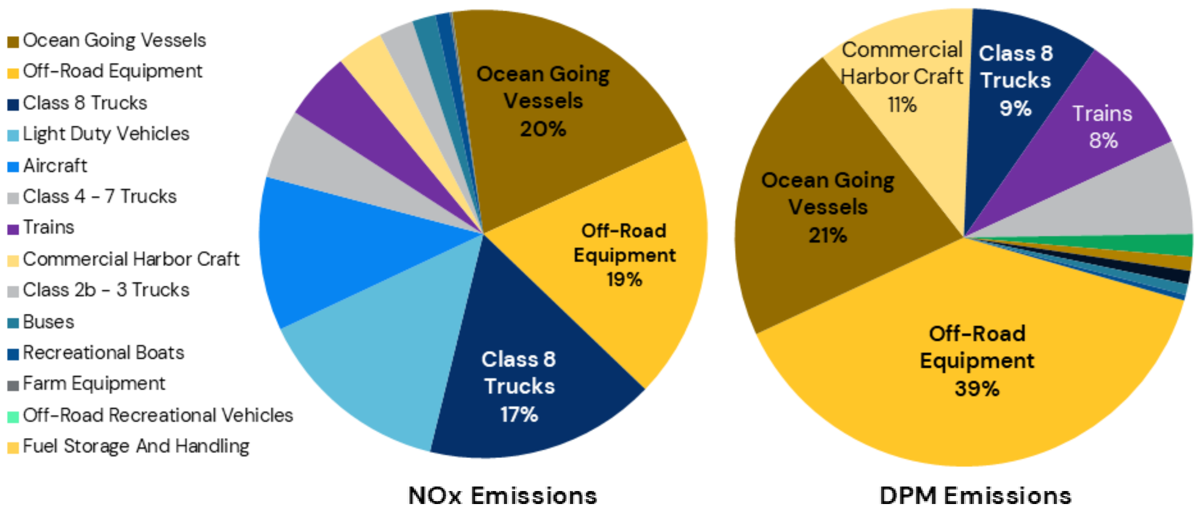


Figure 3 below shows the contribution of these vehicles to NOx and DPM emissions within LA County in 2022. While only 10 percent of DPM and one-fifth of NOx emissions in California are associated with operation of these vehicles, emissions from these vehicles are occurring in close proximity to schools and residential areas as these trucks travel through local communities. Such proximity makes these vehicles a significant contributor to air pollution exposure in these communities. These vehicles are also a significant source of greenhouse gas (GHG) emissions contributing to global climate change.

Figure 3. NOx and DPM emissions by mobile source categories – LA County, 2022[5]



In response to these issues, the State of California has established numerous goals and adopted various policies to accelerate the adoption of zero and near-zero emission vehicles across these sectors. For example, in September 2020, Governor Gavin Newsom signed Executive Order No. N-79-20, setting ambitious targets for the state to reach 100 percent zero emission medium- and heavy-duty (MD/HD) vehicles in the state by 2045 for all operations where feasible, and 100 percent zero emission drayage trucks by 2035. To achieve these ambitious targets, CARB has adopted multiple regulations such as the ACT regulation to accelerate the adoption of zero emissions technologies in the heavy-duty sector. CARB is also pursuing a new regulation called the Advanced Clean Fleet regulation which, starting in 2024, will require fleets operating in California to transition to zero emission technology with the goal of transitioning all drayage trucks to zero emission by 2035 and the rest of heavy-duty vehicles to zero emission by 2045. CARB is planning to adopt this new regulation in late 2022. Additionally, State agencies such as CARB and California Energy Commission (CEC), as well as public and investor-owned utilities, are currently offering a suite of different incentive programs within California that provide funding toward purchase of zero emissions trucks, replacement of older diesel vehicles with cleaner technology, and buildout of zero emissions infrastructure.

Achieving these ambitious goals will require an “all-hands on deck” approach. While state agencies are establishing regulatory requirements and incentive programs to accelerate the

[5] California Air Resources Board. (n.d.). CEPAM2019v1.03 - Standard Emission Tool. In California Air Resources Board. Retrieved from https://ww2.arb.ca.gov/applications/cepam2019v103-standard-emission-tool

transition, contributions from local agencies such as LA Metro will be crucial to prepare the region for the upcoming wave of clean fuel technologies, including battery electric trucks (BET) and hydrogen FCETs. In response to this need, LA Metro commissioned ICF to develop a Clean Truck Technology Comparative Report which could serve as guidance to inform decision-making among policymakers and Metro staff as it relates to near-,mid-, and long-term actions that the agency should take to support the transition to clean heavy-duty truck technologies. Through this report, the project team delivers an objective assessment of various zero and near-zero emission technologies over various time periods and provide insights on the level of technology transformation needed for LA Country to meet its public health and climate goals, as well as the scale of fueling and charging infrastructure needed to support this transition.

To further elaborate on the complexity of transitioning Class 8 heavy duty trucks to zero and near-zero emission technology, it is critical to understand the current inventory and operation of these vehicles within the County. Here in this section, we will provide some statistics on the population and mix of these trucks in LA County. Unlike light duty vehicles, Class 8 heavy duty trucks come in many different body styles, body types, and vocations which is why transitions to zero emission technology is often more challenging due to their unique operational and logistical constraints. In this project, we divided Class 8 trucks into 5 major categories:

Out of State – Out of State trucks refer to trucks that are not registered to the state of California but travel within California roadways. These trucks are also referred to as “interstate” or “long-haul” trucks, and often with sleeper cabs.

California Registered Interstate – These are similar to out of state trucks but are registered in California instead. These are commonly tractor-trailer combination trucks that can move heavy loads and goods across states.

California Registered Intrastate – California Registered Intrastate trucks refer to tractor-trailer combination trucks that move heavy loads, livestock, and refrigerated trailers, only operate within California boundaries, and are often day cabs.

Drayage – Trucks that pick up and deliver shipping containers from Ports or intermodal railyards to other facilities. In this report, drayage trucks are defined as California registered Class 8 trucks that visit the ports two times a week on average.

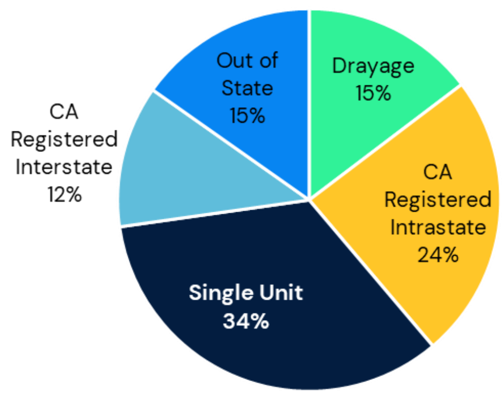
Single Unit – Single Unit trucks are often single-body trucks (i.e., trucks that do not have detachable trailers) that are more purpose oriented (e.g., concrete mixers, dump trucks, refuse trucks, some of the delivery trucks).

According to CARB’s EMission FACtor (EMFAC2021) model[6], currently there are more than 55,000 Class 8 trucks operating within LA County.

[6] California Air Resources Board. (n.d.). Welcome to EMFAC. In California Air Resources Board. Retrieved from https://arb.ca.gov/emfac/

Figure 4 shows the mix of these trucks by the categories defined earlier. Of the 55,000 Class 8 trucks, more than 8,000[7] are frequently visiting the San Pedro Bay Ports (more than two times per week). These trucks are often travelling locally between the ports, railyards, and warehouses and are one of the major air pollution concerns to communities near those facilities. This is why for many years, communities surrounding the ports and I-710 have been seeking state and local agencies to accelerate transition of these trucks to zero emission. In addition to drayage trucks, there are about 15,000 interstate trucks operating within the County (8,500 registered outside of CA and 6,500 registered within California). These trucks are often traveling across state borders, which makes their transition to zero emissions challenging, not only due to their energy intensive operation but also their need to access regional and national zero emissions infrastructure networks. There are also more than 32,000 CA registered trucks operating in LA County of which almost 60 percent are single unit trucks and 40 percent are tractor trailers. These trucks operate in a variety of duty cycles from long-range intrastate travel to local operations. For example, the single unit truck category encompasses a multitude of truck types that are comparable by body type (e.g., delivery trucks, cement mixers, dump trucks, and other trucks where the whole vehicle is considered as one piece unlike tractor-trailers), but drastically different in terms of operation.

Figure 4 - Class 8 Trucks by Vehicle Category for LA County 2022



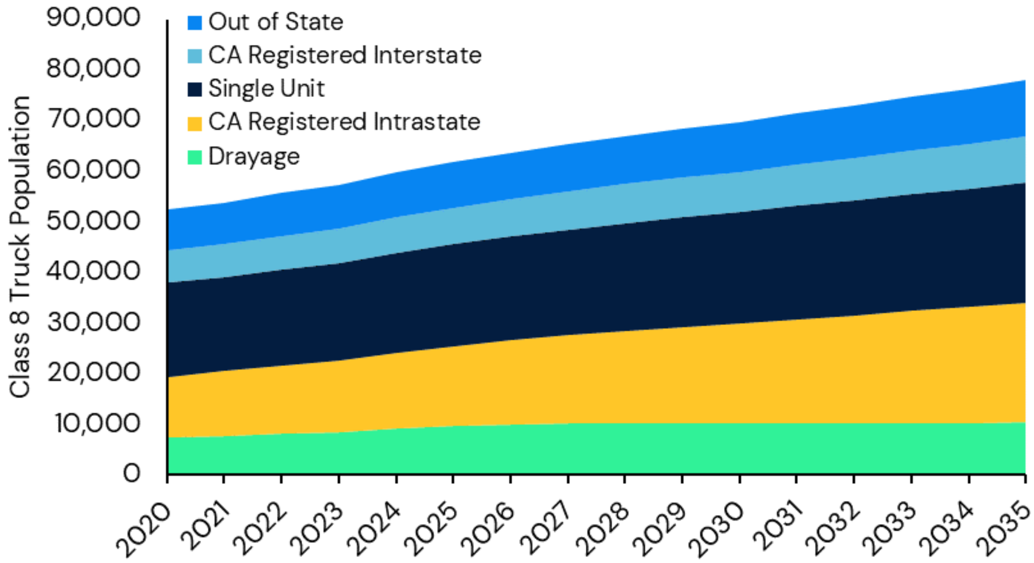
Vehicle Category	Population
Out of State	8,473
Drayage	8,163
CA Registered Intrastate	13,430
CA Registered Interstate	6,680
Single Unit	18,880
Total	55,626

The EMFAC2021 model can also forecast the population of Class 8 trucks. As shown in Figure 5, the total Class 8 truck population in LA County is expected to go from 55,000 in 2022 to almost 78,000 trucks in 2035, an increase of 40 percent by 2035. Within the next decade, the number of California registered Interstate and Intrastate trucks are expected to increase significantly by 35 percent and 76 percent, respectively. Unlike the other truck categories, the population of drayage trucks is expected to plateau post 2035, due to cargo capacity limitations associated with the Ports. In a business-as-usual scenario, most of these trucks are assumed to be powered by diesel, although a small fraction will be powered by zero

[7] This number is lower than the commonly reported 18,000 trucks that serve these two ports. It needs to be noted that not all those trucks are frequently visiting the ports, and not all of them are operating within LA County at any given point in time (while they visit the ports, 100 percent of their operation is not in LA County). That is why the number reported in Figure 4 is lower than the drayage truck numbers reported by the Ports.

emissions technologies due to the zero emission truck production mandate (i.e., ACT regulation). More on the existing and projected truck technology mix is provided in Section 4, including how other regulations (e.g., CARB's ACF Rule) are expected to impact the mix of truck technologies over time.

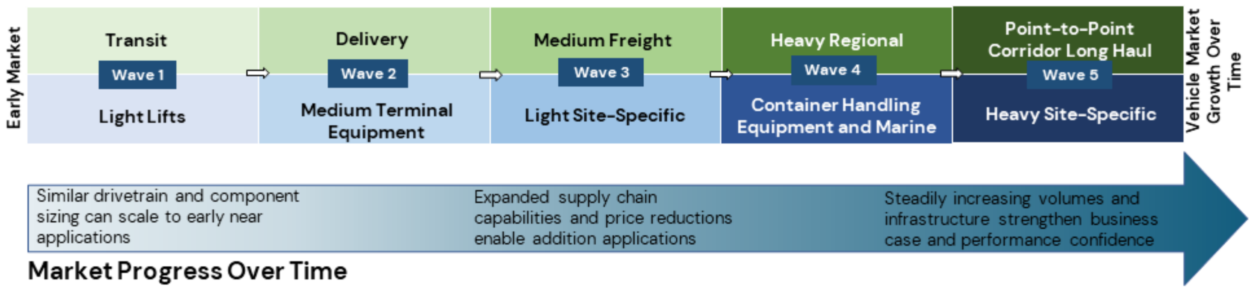
Figure 5 - Projected Class 8 Truck Population by Vocation in LA County



3 Market Readiness and Costs

Class 8 truck technologies that will be discussed in this report include conventional diesel and natural gas fueled heavy-duty trucks, as well as hydrogen FCETs and BET. This section will discuss the technology readiness for each of the alternative truck technologies. In summary, diesel and natural gas trucks are in the mature stage of commercial readiness, with improvements to emissions control systems and fuel efficiency expected over the next 5 to 10 years. For zero emission technologies it is expected that these technologies will commercialize systematically, with vehicles operating on predictable and shorter routes succeeding first, particularly those with access to overnight charging depots. Following these use cases, technology is expected to develop to serve longer and more complicated applications over time. CARB calls this projection of commercialization the Beachhead Strategy, and it is shown graphically in Figure 6 below.

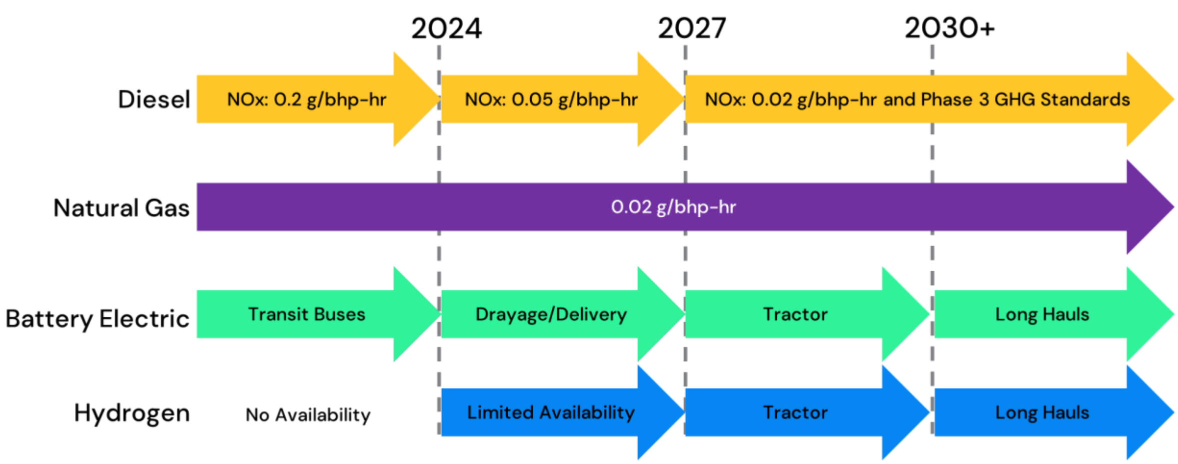
Figure 6 - CARB Zero Emission Beachhead Strategy (from CALSTART)[8]



Despite zero emission technology being in early stages of commercialization, over the last three years there have been several announcements by major truck manufacturers on the development and production of zero emission MD/HD vehicles (i.e., battery electric and fuel cell trucks). According to the Global Commercial Vehicle Drive to Zero Initiative's Zero Emission Technology Inventory (ZETI), there are approximately 20 heavy-duty BET models and 8 heavy-duty hydrogen FCET models either available or planned to be available by the mid-2020s, as of March 2022.[9] These models are offered with different battery capacities and electric ranges making them suitable for various trucking vocations.

The remainder of this section will describe where the technology stands today, and how it is envisioned to evolve over the next 10 – 15 years considering upcoming regulatory actions and industry announcements. A summary of this is illustrated in Figure 7.

Figure 7 - Progression of Technology Development over the next 10 years[10]



[8] CALSTART. (n.d.). The Beachhead Strategy. In *Global Commercial Vehicle Drive to Zero*. Retrieved from https://globaldrivetozero.org/about/program/
[9] CALSTART. Zero Emission Technology Inventory. Retrieved March 14, 2022, from https://globaldrivetozero.org/tools/zero emission-technology-inventory/.
[10] Diesel and Natural gas emission rates indicate NOx emission reductions due to engine improvements.

Diesel

Source: Kenworth

For diesel trucks, the introduction of new engine and aftertreatment systems, combined with the use of renewable diesel, has led to significant reductions in both criteria and GHG emissions. Today, all new diesel engines sold across the U.S. are meeting a national NOx emission standard of 0.2 grams per brake horsepower hour (g/bhp-hr) and PM standard of 0.01 g/bhp-hr.[11] Compared to 1998 standards (4 g/bhp-hr for NOx and 0.1 g/bhp-hr) these standards are 20 times cleaner for NOx and 10 times cleaner for PM. In August 2020, CARB adopted its proposed amendments to the exhaust emissions standards and test procedures for 2024 and subsequent model year heavy-duty engines and vehicles (also known as the Heavy Duty Omnibus regulation) that requires all California-certified heavy-duty engines of model year 2024-2026 to meet 0.05 g/bhp-hr NOx standard, with more stringent standards (0.02 g/bhp-hr) for the subsequent model years. With these standards on the book in California we expect to see cleaner diesel technology (i.e., 0.02 g/bhp-hr) to be commercially available nationwide in the next 3 – 5 years. In addition, the market for renewable diesel is growing in the U.S. and especially in California, as a result of the federal Renewable Fuel Standard as well as California's Low Carbon Fuel Standard (LCFS) Program. It is expected that production capacity could increase significantly through 2024, based on project announcements that either are currently under construction or could be in development soon.[12]

Natural Gas

Source: Hiller Truck

Natural gas-powered trucks are another type of commercially available technology that, when compared to diesel trucks, can reduce criteria pollutants such as NOx and PM, GHG emissions, and most importantly fully eliminate diesel PM, one of the key sources of public health issues in communities near major freight facilities. In 2016, the first 0.02 g/bhp-hr certified natural gas engine was introduced by Cummins Westport Inc. As of February 2022, there are several low NOx-certified engine models and sizes that are available for sale in California.[13] Please note that this list includes engines for both medium-duty and heavy-duty vehicles. In addition to low NOx engines, the use of renewable natural gas (RNG) is also an approach to reduce the environmental impacts of natural gas trucks. Lifecycle GHG emission reductions can be significantly improved when

[11] The U.S. EPA has also proposed a new rule that would set more stringent standards to reduce NOx and GHG emissions, beginning in vehicles with model year 2027. See: https://www.epa.gov/regulations-emissions-vehicles-and-engines/proposed-rule-and-related-materials-control-air-1

[12] U.S. Energy Information Administration. (2021, July 29). U.S. renewable diesel capacity could increase due to announced and developing projects. In Today in Energy. Retrieved from https://www.eia.gov/todayinenergy/detail.php?id=48916

[13] California Air Resources Board. (n.d.). Optional Reduced NOx Standards for Heavy-duty Vehicles. In California Air Resources Board. Retrieved from https://ww2.arb.ca.gov/our-work/programs/optional-reduced-nox-standards

natural gas trucks are powered by RNG. Domestic production of RNG began around 2005 with the majority of projects being landfill gas (LFG). As of 2021, agricultural RNG and LFG projects each made up approximately 50% of domestic RNG projects, with other potential feedstocks on the horizon such as diverted green waste. However, when it comes the use of RNG, there are many sectors that will be competing for this fuel. Not only can RNG be used in decarbonizing the transportation sector, but it is also envisioned to facilitate reduction of emissions in hard to electrify sectors such as heavy industry and buildings.

Hydrogen Fuel Cell Electric

Source: Toyota

Hydrogen fuel cell vehicles are largely still in technology development stages with demonstrations and pilots still ongoing. Hydrogen fuel cell transit buses are fully commercially available, but HD hydrogen trucks are still being developed and automaker-announced models generally have later timeframes for release compared to BETs. Due to their on-board hydrogen storage, hydrogen FCETs have a longer range, require fewer stops on long routes, can be fueled much faster, and have less risk of lost cargo capacity compared to BETs. Through the Global Commercial Vehicle Drive to Zero Program, CALSTART has developed a list of heavy-duty FCETs that are currently available or expected to be available within the next few years. Currently there are eight hydrogen heavy-duty truck models announced to be manufactured over the next 2 - 3 years. Hydrogen powered trucks from Hyundai, Hyzon, Kenworth, Nikola and Navistar International Corporation are expected to be released through 2024, according to reported availability dates per CALSTART's Zero Emission Technology Inventory.[14] The expected electric range for these vehicles spans between approximately 250 miles for the Hyundai Xcient to 900 miles for Nikola Two FCEV. Importantly, there is currently limited availability of hydrogen fueling infrastructure in LA County which is capable of serving Class 8 trucks. Significant hydrogen fueling infrastructure, and electric vehicle (EV) charging infrastructure for that matter, will need to be developed to accommodate future increases in the number of these trucks on the road. This topic is addressed in greater detail within Section 5.

Battery Electric


Source: Tesla

The readiness of Class 8 EVs varies depending on the vehicle's duty cycle, range requirements, and general application. As referenced in Figure 7, transit buses are farther along in the market followed by short-haul drayage, refuse and delivery trucks. However, Class 8, BET technology is still under development. While truck models are relatively more available for some drayage and short-haul applications, manufacturers are still working to produce

[14] CALSTART. Zero Emission Technology Inventory. Retrieved March 14, 2022, from https://globaldrivetozero.org/tools/zero emission-technology-inventory/.

models with longer range capabilities. Class 8 trucks with shorter and more predictable routes are suitable candidates for early deployment EVs. These duty cycles do not need EVs with significantly high ranges (with the exception of routes with several turns and shifts), and the return to base and local operations of these vehicles make charging infrastructure deployment less complicated compared to longer range and more energy intensive applications. With that said, all heavy-duty vehicles are in the early market entry stage of commercialization. A January 2022 report by CALSTART indicates that there had been 47 heavy-duty zero emission truck deployments across the United States as of December 2021, not including pending truck orders.[15] Of the 20 electric models reported by the Drive to Zero Initiative, ranges vary from as low as 56 miles with BYD 8R refuse trucks to as high as a projected 500 miles for the Tesla Semi (Long-Range Edition). While the reported availability years for some of these trucks are noted as 2021 or 2022, production of these vehicles may have been delayed due to supply chain issues caused by the pandemic or for other issues faced by the manufacturers. Though most manufacturer targets commit to fossil-free vehicles without prescribing to a specific technology, it is likely that manufacturers will provide more BET offerings than hydrogen FCETs due to the size of the current and expected near-term BET market (25 vehicle offerings) in comparison to the hydrogen truck market (8 vehicle offerings), as well as the expected pathway for commercialization (favoring short-haul routes first) and BETs business case advantage over FCETs for shorter routes.

Another important consideration is the cost of zero emission Class 8 trucks and how the costs compare to conventional diesel and natural gas trucks. One useful framework for assessing the cost to own and operate a vehicle is total cost of ownership, which considers the capital cost to purchase the vehicle (including taxes) and the infrastructure, as well as operating costs, including fuel and maintenance. Specifically, the TCO helps to understand the economics of a vehicle over its lifecycle, and offers a framework to compare different truck technologies with each other (e.g., BETs compared to diesel trucks). Three TCO studies were reviewed for this project, including those conducted as part of CARB's ACT[16] and ACF[17] rulemakings, as well as one ICF conducted as part of a study for the California Electric Transportation Coalition (CalETC).[18] As shown in Figure 8, this literature review suggests that multiple studies project battery electric Class 8 trucks used on short-haul routes to have lower average lifetime TCO than other fuels.[19] Importantly, this figure is showing average results; whether one truck technology is more or less costly than the other will depend on several factors, including the purchase price of the truck, the cost of infrastructure, the

[15] Al-Alawi, B. M., MacDonnell, O., McLane, R., & Walkowicz, K. (2022, January). Zeroing In On Zero Emission Trucks. In CALSTART. Retrieved from https://calstart.org/wp-content/uploads/2022/02/ZIO-ZETs-Report_Updated-Final-II.pdf

[16] CARB. (2019, February 22). Appendix H Draft Advanced Clean Trucks Total Cost of Ownership Discussion Document. Retrieved from https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/apph.pdf

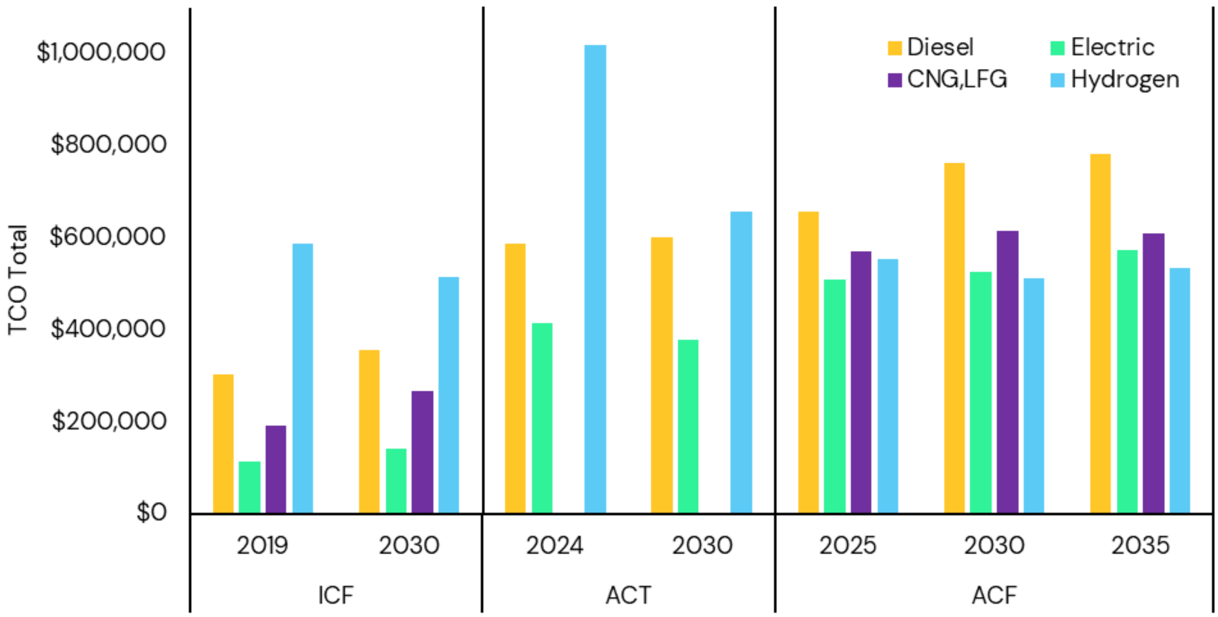
[17] CARB. (2019, February 22). Appendix H Draft Advanced Clean Trucks Total Cost of Ownership Discussion Document. Retrieved from https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2019/act2019/apph.pdf

[18] ICF. (2019, December). Comparison of Medium- and Heavy-Duty Technologies in California. Retrieved from https://caletc.aodesignsolutions.com/assets/files/ICF-Truck-Report_Final_December-2019.pdf

[19] Some studies reviewed include incentives within their respective cost analyses. See the technical report which is associated with this final report and titled *Vehicle Technology Readiness, Market Acceptance, Commercial Availability, and Estimated Costs* for more details.

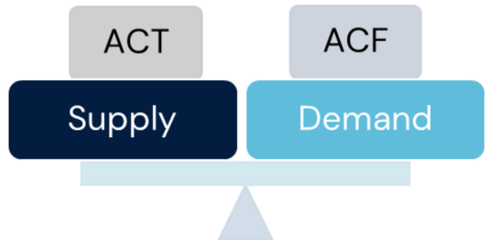
truck's operations, fuel costs, maintenance costs, and whether or not incentives are factored into the calculations. It is important to note, however, that TCO studies make a number of assumptions which influence the final results. Total cost of ownership is highly dependent on several factors, such as the type of truck purchased, truck purchase prices, daily mileage, truck fuel economy, fuel prices, maintenance costs, the inclusion of incentive funding, and general operational characteristics for the truck. Results may vary depending on these assumptions and across different studies.

Figure 8. Reviewed TCO Analysis Results – Class 8 Trucks Used on Short-Haul Routes[20]



[20] To see more detail on each study' s assumptions and results, please refer to the technical report associated with this final report that is titled *Vehicle Technology Readiness, Market Acceptance, Commercial Availability, and Estimated Costs*.

4 Vision for Class 8 Truck Technology



To accelerate adoption of zero emission trucks in California, the state has recently adopted several regulations which require both the supplier of the trucks (i.e., manufacturers) to sell zero emission trucks in California and Californian consumers (i.e., fleets) to purchase those trucks. Therefore, these regulations are intended to both increase the supply of zero emission trucks and induce consumer demand.

On the supply side, the ACT regulation is a manufacturers ZEV sales requirement which applies to vehicles with a GVWR greater than 8,500 lbs. (Classes 2b through 8) and manufacturers with greater than 500 annual California sales[21]. The regulation requires manufacturers to produce and deliver zero emission trucks in California. By 2035, the regulations will require 55 percent of Class 2b-3, 75 percent of Class 4-8 vocational (i.e., any class 4- 8 trucks excluding class 7-8 tractors), and 40 percent of Class 7-8 tractors sold in California to be zero emission. CARB adopted the ACT regulation in June 2020 with the first sales requirement kicking in 2024. Upon the adoption of the ACT regulation in California, 15 states and the District of Columbia announced a joint memorandum of understanding (MOU), committing to work collaboratively to advance and accelerate the market, with the goal of reaching 100 percent of all new MD/HD vehicle sales to be zero emission vehicles by 2050, and with an interim target of 30 percent zero emission vehicle sales by 2030.

In the meantime, CARB is working on a complementary regulation to create consumer demand for zero emission trucks in California. The ACF regulation, planned for board consideration in fall 2022, seeks transition of fleets to zero emission vehicles and will focus on setting two major ZE truck requirements. The first is a ZE vehicle purchase schedules for public fleets. The second is 100% ZE requirements for drayage and high priority/federal fleets[22]. Beginning 2024, a large fraction of heavy-duty vehicles operating in California would be subject to the following requirements:

a) **State and Local Government Fleets:** From 2024 through 2026, at least 50% of new public vehicle additions must be ZE vehicles, and the 100% of new purchases should be ZE starting in 2027.

b) **Drayage Fleets:** Beginning in calendar year 2024, new drayage trucks added to Port registries must be ZE, and all drayage trucks must be ZE by 2035. The ACF regulation notes that legacy drayage trucks (i.e., diesel and natural gas drayage trucks) may enter the Port registry prior to 2024 and operate to the extent of their useful life, but not past 2035.

c) **High Priority and Federal Fleets:** California heavy-duty truck fleets are high-priority if: 1) the fleet has 50 or more vehicles, or 2) the fleet earns $50 million in gross annual revenue – otherwise, the fleet is not subject to this regulation. Similar to drayage trucks, starting 2024,

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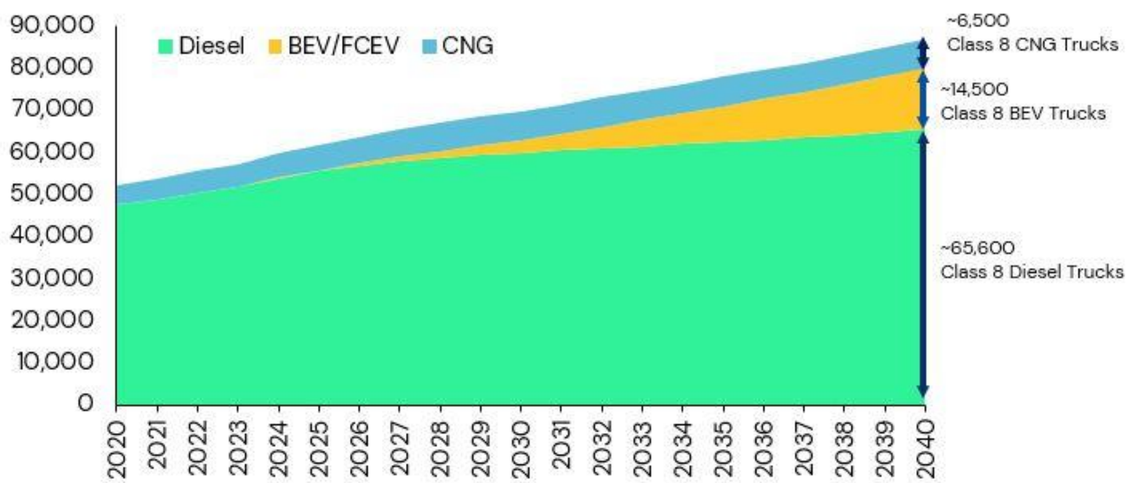
[21] Manufacturers with less than 500 annual California sales are exempt, but may opt-in to earn credits for selling ZEVs.
[22] South Coast Air Quality Management District. (2022). *Draft Air Quality Management Plan.* http://www.aqmd.gov/docs/default-source/clean-air-plans/air-quality-management-plans/2022-air-quality-management-plan/draft2022aqmp.pdf?sfvrsn=12

high priority fleets can only add ZEVs to their fleets and legacy ICE vehicles have until the end of their useful life to transition to ZE. The proposed ACF regulation also provides another compliance option wherein which fleets are not restricted from procuring ICE vehicles after 2024, but are required to hit pre-established ZEV milestones each year.

According to CARB's estimates, by 2050, almost two-thirds of the trucks operating in California are supposed to be zero emission. It is expected that the ACT and ACF regulation are going to drastically change the mix of Class 8 truck technologies in LA County. To project that mix, the project team utilized the EMFAC2021 model to establish a fleet and emissions inventory under baseline conditions between calendar years 2020 through 2035. Under this baseline scenario, the EMFAC2021 model already reflects the impact of adopted regulations, including ACT sales requirements, HD Low-NOx Omnibus standards, and the Truck and Bus Rule. The projected Class 8 truck population by fuel type is shown in Figure 9. Under the baseline scenario, an overwhelming majority of Class 8 trucks are projected to use diesel fuel. Under this scenario, by 2035, 80% of all Class 8 trucks would be diesel powered, whereas only 10% of all Class 8 trucks would be zero emission as a result of ACT and other already adopted regulations.

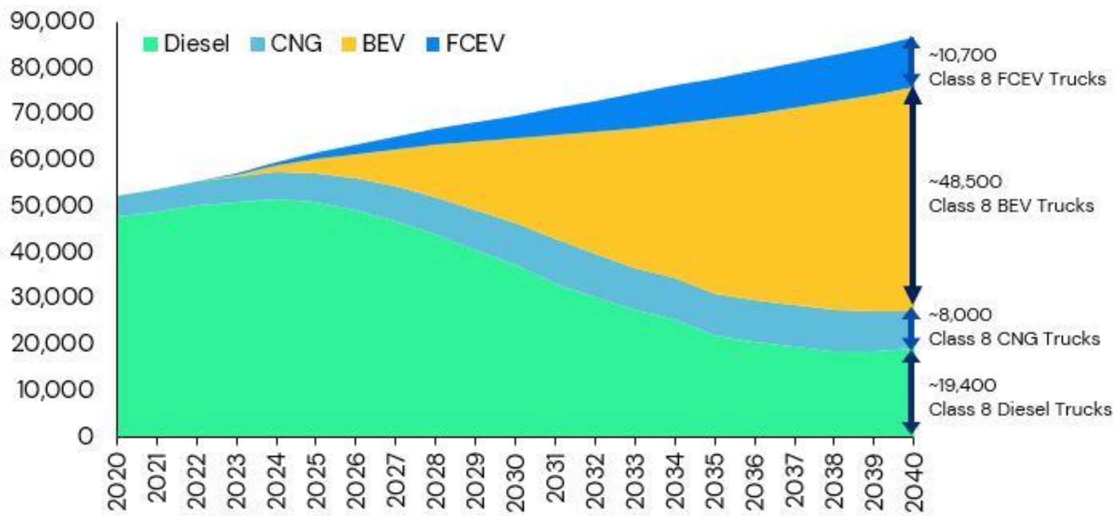
Figure 9. Projected Class 8 Truck Population by Fuel in LA County – Business as Usual



To reflect the impact of the ACF regulation, the project team modeled a separate scenario and applied the ACF's proposed regulatory requirements to LA County's baseline fleet and emissions inventory to determine the resultant Class 8 truck technology mix between 2020 through 2040 (the ACF Scenario)[23]. The overall LA County Class 8 truck population by fuel type based on an ACF scenario is shown in Figure 10. As a result of ACF, the project team anticipates that in 2035, the Class 8 diesel truck population would decrease by 70% when compared to the baseline scenario, while the number of zero emission technologies would increase by a factor of five.

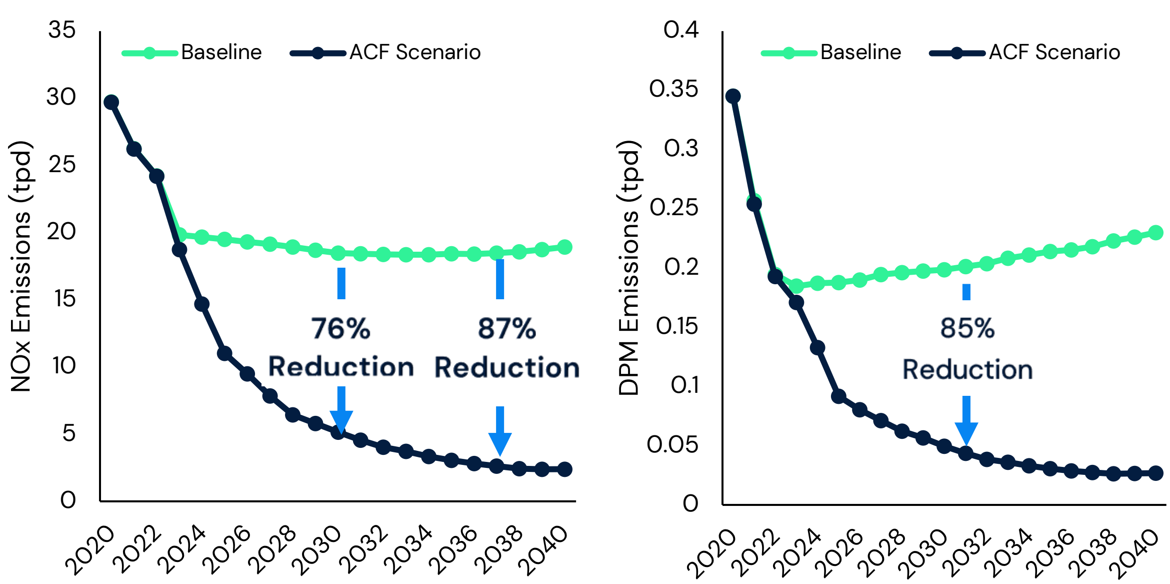
[23] More details on the methodology to reflect ACF regulation is provided in the technical report which is associated with this final report and titled *Projected Changes to Technology Mix from Existing and Proposed Regulations, and Resulting Benefits to Air Quality and Public Health.*

Figure 10. Projected Class 8 Truck Population by Fuel under ACF Scenario in LA County



The project team also modeled the emission reductions projected to occur due to the change in LA County's Class 8 truck technology mix under both scenarios (Baseline and the ACF Scenario). The assessment considers NOx and DPM emission reductions expected from the HD I&M and proposed ACF regulations, and emission reductions are assumed to be proportional to decreases in the diesel truck population. LA County's projected NOx and DPM emissions by scenario are shown in Figure 11.

Figure 11. Projected NOx and DPM Emissions by Scenario in LA County



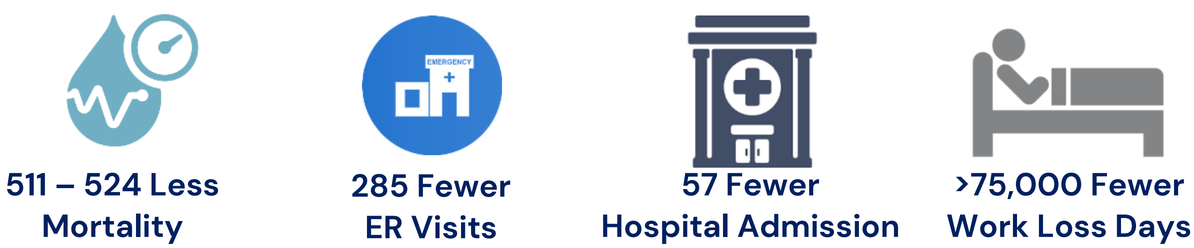
As shown, the projected technology mix for Class 8 trucks in the ACF Scenario is estimated to result in NOx reductions of 76% from the 2031 baseline and 87% reductions from the 2037 baseline, which are key attainment dates for federal ambient air quality standards for ozone in the South Coast Air Basin. By calendar year 2040, NOx emissions from Class 8 trucks in LA County would be as low as 2.5 tons per day, nearly 10 times smaller than baseline emissions in the same year. With respect to DPM emissions, the proposed technology mix is estimated to result in 29% reductions from the 2024 baseline and 85% reductions from the 2030 baseline.[24]

To further elaborate on the public health implications of the proposed technology mix, the project team used the incidence-per-ton (IPT) methodology developed by U.S. EPA[25]. Under this methodology, changes in emissions are assumed to be proportional to changes in health outcomes. Considering that health outcomes of exposure to PM2.5 are much more significant than ozone, in this study, the project team focused our assessment on health benefits of reducing directly emitted PM2.5, and PM2.5 precursors (i.e., NOx). This is also similar to the methodology that CARB uses when quantifying the health benefit of regulations. For the purpose of this report, we quantified values associated with four health outcomes, including:

- Mortality
- ER Visits for Respiratory Issues
- Hospital Admissions for Respiratory Issues
- Work Loss Days.

As illustrated in Figure 12, between 2024 and 2040, the projected technology mix in the ACF Scenario, combined with the reduction in emissions resulting from the HD I/M regulation, is estimated to result in approximately 511 – 524 less mortality, 285 fewer respiratory related ER visits, 57 fewer respiratory related hospital admissions, and almost 75,000 fewer work loss days in LA County. Please note that for mortality rates, U.S. EPA IPT factors provide a low and a high range.

Figure 12. Cumulative (2024-2040) health benefits associated with emissions reductions from Class 8 trucks in LA County



In addition to quantifying the health benefits, the project team also quantified the economic value of avoided health impacts using the U.S. EPA's benefit per ton (BPT) values, which represent the monetized value of avoided health outcomes associated with reduced exposure to PM2.5. These values are reported in 2016 dollars. Using these assumptions, the project team estimated that

[24] LA Metro's 2020 Sustainability Strategic Plan set a target to reduce total PM emissions 62 percent from the 2018 baseline by 2030. See: https://www.transit.dot.gov/sites/fta.dot.gov/files/2022-03/LA-Metro-Sustainability-Strategic-Plan-2020.pdf

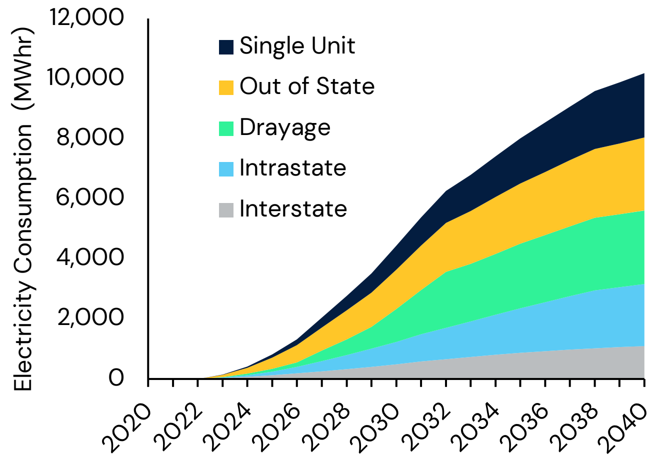
[25] U.S. Environmental Protection Agency. (2022, January 13). Estimating the Benefit per Ton of Reducing Directly-Emitted PM2.5, PM2.5 Precursors and Ozone Precursors from 21 Sectors. In Benefits Mapping and Analysis Program (BenMAP). Retrieved from https://www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors

the technology mix presented could result in avoided health costs of approximately $5 billion in LA County.

5 Charging and Fueling Infrastructure

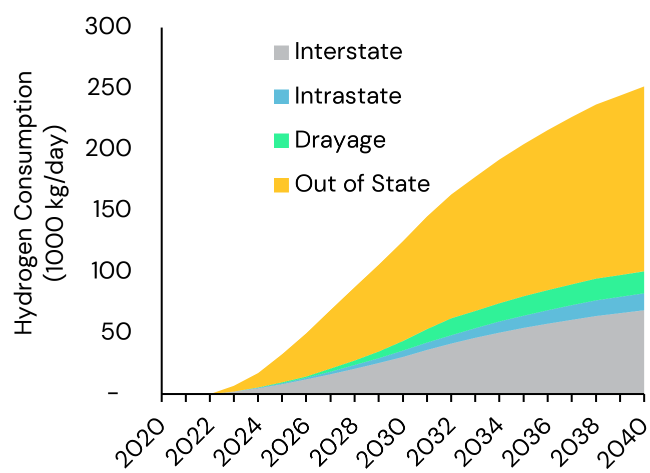
The projected vehicle technology mix, as discussed earlier in Section 4, was used to estimate the shift in charging and fueling demand through 2040, reflecting the displacement of diesel trucks largely by battery and hydrogen powered vehicles. Under the ACF scenario the project team estimated that electricity consumption for Class 8 BETs will increase to ~10,000 MWh per day by 2040. The share of electricity consumption across the five vehicle categories is projected to be relatively similar, with interstate vehicles having the lowest consumption and drayage trucks having the highest consumption. Figure 13 shows the estimated electricity consumption from Class 8 BETs over the timeframe of this analysis.

Figure 13 - Estimated Class 8 Electricity Consumption in LA County



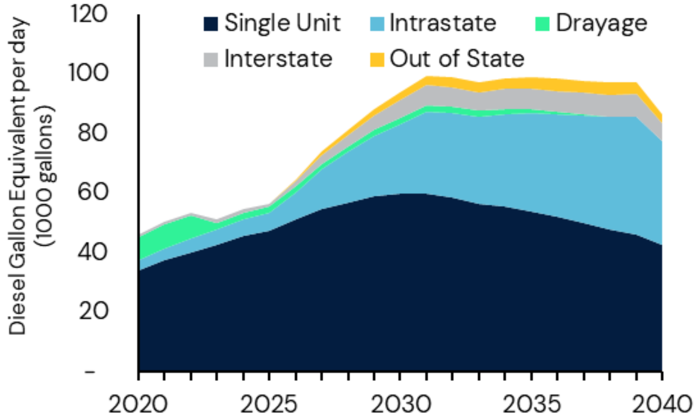
In addition to electricity consumption, the project team also estimated that with the increased adoption of the Class 8 FCETs, there will be a need for up 260,000 kg per day of hydrogen supply in LA County solely for Class 8 trucks. When comparing projected hydrogen consumption across the five vehicle categories, Out of State trucks are expected to consume the majority of hydrogen, followed by interstate trucks. This is no surprise when considering the unique challenges that BETs face with interstate operations, leading hydrogen powered trucks to have a better business case for long-haul operations. Figure 14 shows the estimated hydrogen consumption from Class 8 FCETs over the timeframe of this analysis.

Figure 14 - Estimated Class 8 Hydrogen Consumption in LA County



Similar to electricity and hydrogen, the project team also estimated the increased demand of natural gas (CNG and RNG) resulting from the adoption of low NOx natural gas vehicles in fleets that that are currently untouched by the ACF regulation. According to our analysis, natural gas consumption from Class 8 trucks is also estimated to increase (*Figure 15*) from 50,000 diesel gallons equivalent (DGE) to almost 100,000 gallons in 2030. Single unit and California-registered intrastate trucks are expected to comprise the majority of future natural gas consumption, while California-registered interstate and Out of State trucks are expected to remain at low levels, and natural gas drayage trucks completely phasing out by 2035 due to the ACF requirements.

Figure 15 - Estimated Class 8 NGV Natural Gas Consumption in LA County



The next step of this analysis used the charging and fueling demand above to estimate the number and type of charging and fueling stations required to meet demand. For Class 8 electric trucks it is assumed that each vehicle category, with the exception of Out of State trucks, will exhibit the same fleet distribution as is provided by CARB's fleet database, that is, the number of fleets which contain certain quantities of trucks (e.g., X fleets contain 10-20 trucks). For charging access, this analysis assumes three types of charging access options for electric trucks: Private, Public (Opportunity/Fast), and Public (Overnight). Charging stations deployed within private depots are assumed to charge trucks overnight for 10 hours. Public (Opportunity/Fast) is defined as publicly accessible charging stations meant to provide fast charging. A charging dwell time of 1 hour is assumed for these chargers. Lastly, public (overnight) is defined as charging stations provided at parking lots or truck stops which allows certain fleets (e.g., owner-operators who do not have access to depot charging) to charge their vehicles overnight for a period of 10 hours.

The project team also made some assumptions regarding the number of trucks that a single charger port (also referred to as a plug) can serve. It is assumed that private charging will have a 1:1 truck-to-port ratio, though it is acknowledged that fleets may be able to increase this ratio and not require a dedicated port for each truck. For public overnight charging, a 2:1 ratio is assumed, and for public fast charging a 6:1 ratio is assumed, based on information from the 2021 report prepared for the Port of Long Beach entitled Fueling the Future Fleet: Assessment of Public Truck Charging and Fueling Near the Port of Long Beach.[26]

Fifty percent of trucks in California-registered fleets which have 4-10 vehicles and all trucks in fleets with fewer than 4 vehicles are assumed to require public overnight charging; it is assumed that these trucks may be owned by fleets that either do not have a depot to house charging infrastructure or that they have limited facilities and space to develop private charging infrastructure. All Out of State trucks are also assumed to require public overnight charging at

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[26] Port of Long Beach. (2021, September). Fueling the Future Fleet: Assessment of Public Truck Charging and Fueling Near the Port of Long Beach. https://polb.com/environment/our-zero emissions-future/#program-details

some time; while these trucks may not dwell in LA County overnight in all cases, we assume that the public overnight charging infrastructure will be available to them when needed. All other California-registered trucks are assumed to rely only on private charging infrastructure. Additionally, it is assumed that all Class 8 electric trucks may have a need for public fast charging at some point during their lifetimes. While all trucks may not use public fast charging regularly, we assume that it will be available to all. Of course, this public infrastructure may not be completely public due to security and logistical concerns; arrangements and agreements may need to be established between infrastructure providers and fleets before access is granted. Nevertheless, for the purpose of estimating infrastructure demand, we assume that all trucks may require access to public or semi-public fast charging at some time.

To understand the charger power output levels necessary for accommodating charging demand, we first identified the battery pack sizes of Class 8 electric trucks on the market today and those planned for launch in the near future. Using the average daily vehicle miles traveled (VMT) estimated from EMFAC2021, BET battery pack data from ICF's EV Model Library[27], and the dwell time assumptions described earlier, we estimated the electric vehicle supply equipment (EVSE, also known as the charger) output power level that may be needed for each charging station access type. A full charge is assumed to be from a 20 percent to 80 percent battery state of charge.

Table 1 shows the estimated EVSE output power level for each vehicle category depending on whether a vehicle charges at a public charger, private charger, or a public overnight charging facility.

Table 1 - Estimated EVSE Power Levels (kilowatts, kW) by Vehicle Category and Charger Access Type

Vehicle Categories	Public (Opportunity/Fast)	Private	Public (Overnight)
Out of State	660	-	70
CA Intrastate	250	25	25
CA Interstate	660	70	70
CA Drayage	300	30	30
Single Unit	140	13.8	13.8

Using the estimated power levels illustrated in Table 1, the cumulative number of charging ports by power level was estimated for every 5-year increment as shown in Table 2. In this case, the word cumulative indicates that the number of ports is cumulative by scenario year. For example, 3,832 plugs of chargers that are less than 19.2 kW are estimated to be needed between 2035 and 2040 (12,824 minus 8,992).

[27] ICF maintains an up-to-date inventory of current and future electric vehicles, including cost, range, and battery size.

Table 2 – Cumulative (by Scenario Year) Number of Charging Ports Estimated to be Needed for Class 8 Trucks in Los Angeles County, by Power Level and Year

Scenario Year	<19.2 kW	20-30 kW	70-150 kW	250-360 kW	600+ kW	Cumulative Total
2025	638	1,065	799	222	188	2,912
2030	4,735	6,660	3,409	1,388	680	16,873
2035	8,992	16,148	5,829	3,366	1,091	35,426
2040	12,824	19,487	7,569	4,062	1,345	45,286

As is the case for BET charging infrastructure, the scale and type of hydrogen fueling infrastructure required will vary depending on several variables and assumptions. Importantly, as is the case with other fuel types discussed previously, some share of trucks in LA County are expected to rely on hydrogen fueling stations that are private access, some will rely on stations that are public access, and others may use both types of stations. The analysis below does not make any assumptions regarding the share of private- versus public-access stations, and instead shows total infrastructure estimates.

Table 3 shows the estimated demand for hydrogen fuel on any given day based on the technology scenario described in the previous section (note that these numbers are the same as one shown in *Figure 14*).

Table 3 - Estimated Hydrogen Demand on Any Given Day (kg/day)

Year	Truck Category				
	CA Interstate	CA Intrastate	CA Drayage	Out of State	Totals
2020	0	0	15	0	15
2025	9,446	1,543	642	21,033	32,664
2030	35,766	10,149	6,924	74,371	127,210
2035	63,684	20,247	13,535	113,439	210,906
2040	80,557	28,131	15,386	137,788	261,862

To estimate the number of hydrogen fueling stations, the project team assumed a range of fueling station capacity, and conducted a bounding analysis to estimate the range of fueling stations that may need to be deployed to meet the hydrogen demand from Class 8 FCETs. Specific to this analysis, our project team assumed fueling station capacities ranging from 1,000 to 5,000 kg per day. With that assumption in mind, Table 4 shows the estimated number of hydrogen fueling stations required to meet the demand at various station size scenarios. Naturally, as station throughput increases, the estimated number of required stations decreases. According to the project team estimates, as low as 52 and high as 262 hydrogen fueling stations may be needed to meet the demand from Class 8 trucks in 2040.

Table 4 - Estimated Number of Hydrogen Fueling Stations Depending on Station Throughput

Throughput Capacity in kg/day	Estimated Number of Stations by Year and Scenario				
	2020	2025	2030	2035	2040
1,000	0	33	127	211	262
2,000	0	16	64	105	131
3,,000	0	11	42	70	87
4000	0	8	32	53	65
5,000	0	7	25	42	52

As stated previously, some share of hydrogen FCETs are likely to rely on private fueling infrastructure instead of public fueling stations. While the exact number of trucks expected to prefer private infrastructure is unknown,

Table 5 below shows an example of how the number of required public fueling stations would decrease as a result. In this example, we assume that 35% of California-Registered Interstate, Intrastate, and Drayage trucks use public stations, along with 100% of Out of State trucks.

Table 5 - Example of a Partial Need for Public Infrastructure - Estimated Number of Public Hydrogen Fueling Stations Required (100% of Out of State Trucks and 35% of all other California-Registered Trucks Assumed to Require Public Infrastructure)

Throughput Capacity in kg/day	Estimated Number of Stations by Year and Scenario				
	2020	2025	2030	2035	2040
1,000	0	25	93	148	181
2,000	0	13	46	74	91
3,000	0	8	31	49	60
4,000	0	6	23	37	45
5,000	0	5	19	30	36

While the focus of this analysis is primarily on zero emission Class 8 trucks; the project team also assessed the increased demand of natural gas as a result of deployment of low NOx natural gas trucks. According to our analysis, between 19 and 77 natural gas stations may be needed across LA County to meet the projected demand for natural gas refueling, depending on the throughput of the station. As there are currently 82 CNG and LNG stations in LA County, it is expected that these will likely serve a significant portion of demand, however approximately 65% of those stations are private so some public natural gas fueling infrastructure development may be necessary in the future.

Utilizing the estimated number of charging and fueling stations for each technology, the project team estimated the cost for infrastructure deployment between 2025 and 2040 for every 5-year increment. These timeframes were selected to guide the investments needed in the immediate (i.e., 2025), short-term (i.e., 2030), medium-term (i.e., 2035), and long-term (i.e., 2040) timeframes.

The primary costs associated with building charging stations include hardware, installation, permitting, and engineering review and drawings. Further capital costs may include costs associated with land acquisition, electric utility distribution grid equipment upgrades, and upgrades to site-level make-ready infrastructure. It should be noted that installation cost reductions can be realized when installing more than one charging stations per site; however, this assumption was not included in this cost analysis for simplicity. The analysis herein only includes the estimated costs of charging equipment and installation; it does not include the costs associated with land acquisitions, engineering and design, permitting, utility-side electric grid infrastructure upgrades, or site-level make-ready infrastructure upgrades. Importantly, capital costs for charging infrastructure development are likely to be highly variable from one project to the next. The analysis herein is meant to provide a rough estimate of costs using average unit cost data that is publicly available.

Charging station deployment cost estimates were calculated using the cumulative number of charger ports by power level presented earlier in Table 2. It is assumed that 19.2 kW charging stations will incur average Level 2 hardware and installation costs; 20kW to 30 kW stations are assumed to incur low-cost DCFC hardware and installation costs; 70 kW to 150 kW stations and 250 kW 360 kW stations will experience medium- and high-costs, respectively. DCFC with power output exceeding 360 kW do not appear to be commercially available yet. However, cost estimates have been made; costs for DCFC with output power levels exceeding 360 were assumed to be $375,000 for hardware and $175,000 for installation, per a March 2021 report prepared by Gladstein, Neandross, & Associates (GNA) for the Environmental Defense Fund (EDF).[28] Actual costs may vary as this technology is made commercially available in the future. Charging stations costs shown in Table 6 are cumulative, showing the total cost by scenario to expand the charging network for Class 8 electric trucks. In this case, the word cumulative indicates that the estimated charging infrastructure costs are cumulative by scenario year. For example, $33 million of infrastructure investment is estimated to be required between 2035 and 2040 for chargers that are less than 19.2 kW in output power ($90 million minus $63 million).

Table 6 – Cumulative (by Scenario Year) Charging Infrastructure Costs (million $)

Scenario Year	<19.2 kW	20-30 kW	70-150 kW	250-360 kW	600+ kW	Total
2025	$4	$18	$57	$40	$103	$222
2030	$33	$110	$242	$251	$374	$1,010
2035	$63	$266	$414	$609	$600	$1,953
2040	$90	$322	$537	$735	$740	$2,424

The estimated total charging infrastructure investment need for both private and public infrastructure is estimated to be $222 million in 2025, $1,01 billion in 2030, $1.953 billion in 2035, and $2.424 billion in 2040, cumulatively. Table 7 shows a breakdown of estimated costs in 2040 by charger output power level and by charger access type. These estimates suggest that approximately 62% of the total investment need is for public-access opportunity/fast chargers, 21% for private chargers, and 16% for public-access overnight chargers.

Table 7 Estimated BET Charging Infrastructure Costs in 2040 (million $)

Charger Output Power Level	Public (Opportunity/Fast)	Private	Public (Overnight)	Totals
<19.2 kW	$-	$67	$23	**$90**
20-30 kW	$-	$241	$81	**$322**
70-150 kW	$190	$122	$225	**$537**
250-360 kW	$735	$-	$-	**$735**
600+ kW	$740	$-	$-	**$740**
Totals	**$1,665**	**$430**	**$329**	**$2,424**

The cost of hydrogen fueling stations, as mentioned above, does not make any assumptions for how many stations are private versus those that are publicly accessible. Instead, it only reports the estimated cost associated with the number of stations based on projected demand for hydrogen across truck categories. *Table 8* shows the estimated capital cost to build the stations. These estimates show potential cost reductions through economies of scale; as the daily throughput of the stations increases, the total estimated cost to build the stations decreases. Importantly, stations of various sizes and capacities will be needed throughout Los Angeles

[28] Gladstein, Neandross, & Associates. (2021, March). California Heavy-Duty Fleet Electrification Summary Report. In Environmental Defense Fund. Retrieved from https://blogs.edf.org/energyexchange/files/2021/03/EDF-GNA-Final-March-2021.pdf

County. As illustrated, by 2040, there is estimated to be a need for as low as $520 million and as high as $1.3 billion in investment to deploy private and public hydrogen fueling stations.

Table 8 - Estimated Hydrogen Station Capital Costs Under Various Scenarios

Throughput Capacity in kg	Capital Cost Scenario	Estimated Hydrogen Station Capital Costs (in Millions)				
		2020	2025	2030	2035	2040
1,000	**Low**	$0	$165	$635	$1,055	$1,310
2,000	**Low**	$0	$80	$320	$525	$655
3,000	**Medium**	$0	$83	$315	$525	$653
4,000	**High**	$0	$80	$320	$530	$650
5,000	**High**	$0	$70	$250	$420	$520

$2.9 – 3.7 Billion
Needed Investment for Zero Emission Infrastructure

Altogether, our analysis indicates an estimated need for capital investment on the order of $2.9 - $3.7 billion by 2040 to deploy the needed zero emission infrastructure in LA County. The next section will describe the current incentive and grant programs available at the state and local level that could be leveraged to accelerate the adoption of both the vehicles and the needed charging and fueling infrastructure.

6 Incentives & Grants

While policy actions such as ACT and ACF are key in accelerating the adoption of zero emission trucks in California, the full transition of California's Class 8 trucks to zero emission technology will not be possible without financial incentives. As described, current regulations, such as ACF, are primarily targeting public, drayage, federal, and high priority fleets, while smaller fleets that do not fall into any of these categories may be left unregulated. Additionally, California's regulations are only focusing on vehicle adoption, whereas the previous section made clear to the significant need to prepare and build charging and fueling infrastructure needed to support these vehicles. This is where incentive programs could play a significant role in facilitating this transition. Notably, California has already established several incentive programs that have been instrumental in facilitating the adoption of low-NOx and zero emission vehicles. Many of these incentives have been developed and administered by local and state agencies, such as CARB, CEC, and South Coast AQMD. This section describes a number of these programs. A list of the incentive programs that apply to Class 8 trucks and zero emissions infrastructure in LA County is provided in Table 9.

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

HVIP is a point-of-sale incentive program that provides a voucher up to $120,000 for zero emission Class 8 trucks or trucks with low-NOx diesel engines. At the time of writing this report, the program has supported the purchase of 1,700 natural gas and 1,500 battery-electric trucks since 2010, and over half of all voucher requests have come from disadvantaged communities seeking DPM reductions. Although HVIP has provided much needed resources for adopting clean technologies, it is one of California's most oversubscribed programs, a key issue especially for smaller fleets that do not have the resources to quickly apply for these grants and use them to transition their trucks to clean technologies. Additionally, HVIP cannot be stacked with other State-funded incentives, such as Carl Moyer.

Carl Moyer Program, Carl Moyer Voucher Incentive Program (VIP)

The Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program) provides incentives for cleaner-than-required on-road and off-road diesel engines and equipment. The program has focused on deploying the most advanced low-NOx and zero emission technologies and generates surplus emission reductions through their vehicle scrappage requirement. To date, about $210 million has been allocated to on-road projects, which has resulted in replacement of 7,800 diesel engines across CA, eliminating more than 25,000 tons of NOx and volatile organic compounds (VOC) and 680 tons of DPM. Since the Carl Moyer program considers cost-effectiveness to calculate the amount of funding that can be allocated to projects, and conventional combustion trucks become cleaner over time, the lower emissions benefits have led to lower grant awards. Additionally, the scrappage requirement instills some aversion in fleet owners, especially small fleets, who lack resources to apply for funding and would prefer to sell old trucks rather than scrap them.

Additionally, the Carl Moyer VIP offers a streamlined funding option directed exclusively to smaller fleets with 10 vehicles or less to purchase cleaner vehicle replacements. Similar to the Carl Moyer

Program, zero emission projects in the VIP are eligible for a cost-effectiveness limit of up to $500,000 per weighted ton and projects meeting the 0.02 g/bhp-hr or cleaner emission standard are eligible for a cost-effectiveness limit of up to $200,000 per weighted ton.

Volkswagen Environmental Mitigation Trust for California

The Volkswagen (VW) Mitigation Trust provides capped funding opportunities to mitigate NOx emissions from heavy-duty trucks and support zero emission truck transitions at the Ports. The VW Trust offers up to $85,000 in funding for Class 8 low-NOx trucks and up to $200,000 for Class 8 zero emission trucks, including drayage trucks, waste haulers, dump trucks, and concrete mixers. Public and private fleets are subject to different eligibility criteria for replacement of current trucks for low-NOx and zero emission vehicles. Additionally, the VW Trust requires scrappage of the existing vehicle, and does not permit stacking other state-level funds.

Truck Loan Assistance Program

The Truck Loan Assistance Program offers financing opportunities to qualified small-business truckers who fall below conventional lending criteria and are unable to qualify for traditional financing for cleaner trucks. The loans are accessible to smaller fleet owners – trucking fleets with 10 or fewer heavy-duty vehicles and with less than $10 million in annual revenue – to provide them with funding for low-NOx and zero emission technologies in compliance with the Truck and Bus rule. Loans from this program can be used to finance either one or multiple technologies, and loans can be combined with other incentive programs. According to CARB's Draft 2022-2023 Funding Plan, as of May 13, 2022, about $203 million in Truck Loan Assistance Program funding had been expended to provide about $2.5 billion in financing to small business truckers for the purchase of over 39,500 cleaner trucks, exhaust retrofits, and trailers.

Clean Transportation Program

The CEC's fuel and transportation portfolio includes public and private infrastructure development funding, planning grants, and workforce training to prepare workers for the clean transportation economy. As of December 2021, the CEC has invested more than $1 billion in clean transportation projects, including charging and fueling infrastructure, advanced vehicle technologies, and workforce training. As part of the draft funding allocations for FY 2022‑23, CEC has allocated more than $160 million to support MD/HD ZEV infrastructure to address the need for rapid transition to ZE technologies across the state. Of this, $30 million will be allocated to MD/HD ZE vehicles and infrastructure (Level 2 and DCFC), $85 million is earmarked for drayage, $30 million for transit, and $15 million for school buses. Also in FY 2021-22, CEC allocated $390 million for MD/HD vehicles, of which $105 million was earmarked for drayage and infrastructure pilots, $28.5 million for transit, and $19 million for school buses.

Southern California Edison (SCE) Commercial EV Programs

SCE administers grant assistance and low-to no-cost electrical system upgrades to its customers. SCE's Transportation Electrification Advisory Services provides small- to mid-sized fleets (50 vehicles or fewer) with hands-on support in identifying and submitting applications for funding zero emission fleet transitions. To continue to support fleets as they prepare for incoming zero emission vehicles, SCE's Charge Ready Transport Program provides make-ready charging infrastructure to support the installation of EV charging equipment for MD/HD vehicles. The Charge Ready Transport Program has an approved budget of $342.6 million and a goal to enroll and support a minimum of 870 sites with 8,490 EVs procured or converted to electric. As of December 31, 2021, the Program was working with 139 sites, which includes applications under review as well as committed sites, that can potentially support over 4,200 MD/HD EVs.

LADWP Commercial EV Charging Station Rebate Program

LADWP is also offering its non-residential customers rebates for installation of EV charging infrastructure. This program, which is called the Commercial Electric Vehicle Charging Station Rebate Program, incentivizes the installation of EV charging station equipment, including Level 2 charging stations to charge light-duty EVs, DCFCs to charge light-duty EVs, and alternating current (AC) or direct current (DC) charging stations to charge MD/HD EVs. The program is open to all LADWP commercial customers operating a site (premises) with an active LADWP electric meter on a non-residential rate schedule. LADWP customers who receive these rebates must agree to keep charging stations in service for a minimum of five years. For MD/HD, the program currently pays up to $125,000 per charging station with a maximum of $500,000 per site.

Low Carbon Fuel Standard (LCFS)

The California LCFS is a regulatory program intended to reduce the carbon intensity of transportation fuels used in California via a credit trading system. As such, the program offers fleets the opportunity to earn revenue that can be put toward the operating costs of non-residential EV charging and hydrogen fueling stations. This is because EV chargers and hydrogen fueling stations deliver a low-carbon fuel to vehicles, and therefore, owners of chargers and hydrogen stations are eligible to earn LCFS credits based on the amount of fuel (electricity) dispensed. These credits may then be sold to fuel producers (who, under the program, must reduce the carbon intensity of their fuels or offset carbon by purchasing credits), yielding revenue that fleets can use to lower the costs of operating their electric and hydrogen trucks.

Table 9. Summary of Incentive Programs for Class 8 Trucks

Program	Incentive Structure	Eligibility	Funding Amount for Class 8 trucks
HVIP	Point-of-sale	Zero Emission or 0.01 g/bhp-hr engines	$120,000 (Base)
Carl Moyer	Cost-effectiveness limit	Clean combustion and Zero emissions Requires scrappage	Up to $160,000 for 0.02 engines Up to $410,000 for ZE trucks
Carl Moyer VIP	First come first served	Fleets of 10 or fewer vehicles that have been operating at least 75% (mileage-based) in California during the previous 24 months	Up to $160,000 for 0.02 engines Up to $410,000 for ZE trucks
Community Air Protection (CAP) Incentives	Same as Moyer with no state caps for zero emission trucks	Follows Moyer guideline	Up to $160,000 for 0.02 engines Determine based on C/E for ZE trucks
VW Mitigation Trust	First come first served	Class 8 Freight Trucks (including drayage trucks, waste haulers, dump trucks, and concrete mixers) – Public and private	Up to $85,000 for 0.02 engines Up to $200,000 for zero emission trucks
Truck Loan Assistance	Financing Assistance	Trucking fleets with 10 or fewer heavy-duty vehicles that are also designated as small business	Varies
ZE Drayage Truck & Infrastructure	Competitive solicitation	freight facilities qualify for the project including warehouses, distribution centers, sea/rail ports, intermodal, border points of energy, and other freight facilities	Funded both vehicles as well as charging infrastructure. A minimum of 50% of match funding is required (i.e., only pays up to 50% of the project cost). Maximum of $500,000 per truck.
Clean Transportation Program	Competitive solicitation Block Grants First come first served	Public and private fleets of MD/HD vehicles as well as public charging and hydrogen fueling station developers	Between 50 – 75 percent of the project cost

Program	Incentive Structure	Eligibility	Funding Amount for Class 8 trucks
LADWP Commercial EV Charging Station Rebate Program	Rebates for charging station installation	LADWP commercial customers operating a site (premises) with an active LADWP electric meter on a non-residential rate schedule	Up to $125,000 per charger with a maximum of $500,000 per site.
Southern California Edison Grant Assistance	Grant Assistance	Small and mid-size fleets (<50 vehicles)	Provide grant assistance to small and mid-size fleets
Southern California Edison Charge Ready Transport	Make-Ready Rebates	Fleets of MD/HD vehicles who procure or convert at least two zero emission vehicles; SCE customer	Provide low-to no-cost electrical system upgrades and charging equipment rebates for customers procuring school or transit buses or for non-Fortune 1000 customers deploying infrastructure at sites located in disadvantaged communities. Customer-side of the meter make ready rebates will be the lesser of (a) 80 percent of the Participant's actual installation cost or (b) 80 percent of the average utility direct cost for installing the customer side make-ready infrastructure for the relevant sector.
LCFS	Credit based program	Non-residential EV charging and H2 fueling stations	Number of credits earned x Credit price

7 Barriers and Recommendations

This report has illustrated that full transition to zero emission Class 8 trucks in LA County is not trivial. Despite regulatory actions at the state level, combined with billions of dollars of incentive funding earmarked for zero emission heavy duty vehicles and infrastructure, there still exists significant barriers to full transition of more than 55,000 Class 8 trucks operating in LA County to zero emissions. As illustrated using the assumptions and scenario conditions outlined in this report, by 2040, the total number of charging ports required to meet demand from all Class 8 BETs is estimated to grow to more than 45,000 charging ports, of which approximately 26,000 may be located at private truck depots, 11,000 may be public ports for overnight charging, and more than 8,000 may be public ports for opportunity fast charging. According to the project team's estimates, deployment of such charging infrastructure could cost more than $2.4 billion. A total of 52 (if assuming 5,000 kg/day/station) to 262 (if assuming 1,000 kg/day/station) hydrogen fueling stations (public and private) are estimated to be required by 2040 to meet Class 8 FCET demand. These hydrogen stations are estimated to have a capital cost between $520 million and $1.31 billion by 2040. Note that this only includes the cost of equipment and equipment installation; it does not account for the cost of land acquisition, design and engineering, permitting, or grid and site-level make-ready infrastructure upgrades. Aside from charging and fueling infrastructure, the lack of currently available zero emission truck models and their significantly higher upfront cost as compared to their counterpart diesel and natural gas trucks is another significant barrier inhibiting the accelerated adoption of these vehicles, especially by smaller fleets. Here in this section, we will highlight some of these barriers and provide recommendations on the actions that various agencies and stakeholders can take to help overcome them.

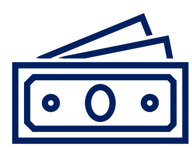
Availability and High Cost of Zero Emission Technology

Despite the current and expected near-term availability and benefits identified across zero emission Class 8 truck options, vehicle acquisition remains a challenge. High upfront costs for battery-electric trucks, FCET, and associated infrastructure are commonly cited as a primary barrier to increased deployment. A report produced by ICF for the CalETC found that as of 2019, the average battery-electric truck is $312,000, which is $177,000 more than its average diesel truck counterpart and $147,000 more than its average natural gas counterpart. Additionally, the average FCET is reported to be $440,000, which is $305,000 more than its average diesel truck counterpart and $275,000 more than its natural gas truck counterpart. Another significant barrier to adoption of clean truck technologies is the relatively recent onset of supply chain disruptions, delivery timelines, and inflationary pressures because of the COVID-19 pandemic and other geopolitical disruptions.

As described in Section 6, California offers a suite of incentive programs that provide funding towards the purchase of zero emission trucks, replacement of older diesel vehicles with cleaner technology and buildout of zero emission infrastructure. These funding programs have been instrumental in reducing the incremental cost of zero emissions trucks. However, despite significant investment by the State (almost $5.2 billion over four budget years for MD/HD trucks), the funding needed to fully transition the state's MD/HD trucks to zero emission and buildout of the necessary charging and fueling infrastructure to support them is much greater. Gaps in funding aside, larger fleets have a greater advantage in applying and procuring grants than smaller fleets. Small fleets represent approximately 30% of California's trucks, and yet they may have more challenges in transitioning to zero emission technologies using the current incentive portfolio. For example, incentives received from Carl Moyer are subject to federal and state income tax, reducing purchasing power. As another example, HVIP offers a point-of-sale incentive to lower the cost of MD/HD vehicles, but sales tax is assessed based on the pre-voucher price of each vehicle. For zero emission trucks with considerably higher retail prices than diesel or natural gas trucks, these sales taxes also add to the cost burden experienced by the vehicle owners. Adding on top of these challenges is the accessibility and cost of charging and fueling infrastructure. While a large fleet might have the ability to install chargers within their depot and utilize the revenue from the LCFS program to reinvest into EV purchases or EV infrastructure deployment, an owner-operator that does not own or lease a private depot would not have access to such revenues, due to their lack of private facilities at which to install the infrastructure.

Recommendations

Leverage Public-Private Partnership Models: P3s involve a private partner who will finance initial capital costs of ZEV procurement or charging/fueling infrastructure, with private debt and equity, and receive returns on initial investment overtime once charging stations or vehicles are available for use. P3s have been proven to be effective tools for rapid delivery of infrastructure projects and increasing the opportunities for innovation. There is a broad range of P3 delivery models with varying levels of public agency participation and risk transfer. Engaged stakeholders and end users could leverage the existing P3 procurement as well as vehicle and infrastructure as-a-service models (e.g., WattEV in POLB) to facilitate and speed up deployment of public fueling and charging infrastructure across major freight corridors (e.g., I-710) and accelerate the adoption of zero emission trucks within LA County.



Simplify existing structures of incentive and grant programs: As state agencies, such as CARB and CEC, examine options to offer greater funding opportunities to fleets, the project team's findings suggest that these programs have room for improvement by being more user friendly, particularly to enhance accessibility of these funds to small fleets. A study[29] found that while most fleets had used incentives in the past, their overall experience was inconvenient and administratively complex. If given a choice of just one government program to incentivize electric trucks, 38% of respondents said they would prefer no government incentive program. Those same respondents never chose an electric truck in their choice scenarios, and more than 50% of the study's respondents expressed that low-interest loan or lease options and purchase price rebates are preferable. Importantly, the study's authors stated that they had difficulty securing survey participants, and suggested that the respondents may be skeptical of electric trucks. These

[29] Giuliano, G., Dessouky, M., et al. (2020). *Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement*. National Center for Sustainable Transportation: https://rosap.ntl.bts.gov/view/dot/57579

findings suggest that owner-operators seek simpler incentive programs, as well as multiple options for vehicle or infrastructure payment plans.

Provide technical assistance to small fleets: Similar to the owner-operator grant assistance program offered by SCE (which is only limited to SCE customers), a program that offers technical assistance in the form of grant application assistance, as well as post-grant activities such as contract execution and reporting, would be a value proposition to smaller trucking fleets as they apply for various state grants and incentives. Most of these smaller fleets and owner-operators may not have the essential resources to apply to these grants. Evaluation of end user perspectives reinforced that costs associated with ZEVs and infrastructure installation are the largest barriers to fleet transition. One opportunity for engaged stakeholders is to identify specific small truck fleet owners who are interested in procuring public/private BET charger rebates at the city-level (Los Angeles, Long Beach, Carson, Wilmington, etc.), and explore ways to offer technical assistance so that they can also pursue state grants and incentives towards zero emission vehicles. This could potentially lead to a prioritization queue based on proximity or impact to disadvantaged communities, working to increase charger access and ease air pollution burdens more quickly.

Access to Fueling and Charging Infrastructure

There are significant infrastructure deployment gaps that require more targeted consideration. LA County's Class 8 truck population is expected to transition from being fueled almost entirely by diesel, to a mix of conventional and low-NOx diesel, low-NOx natural gas, battery-electric, and hydrogen. The rapid deployment of Class 8 battery-electric trucks is expected to increase the electricity demand associated with these vehicles to 10,000 MWh per day by 2040. For Class 8 FCETs in LA County, hydrogen demand is expected to increase to nearly 250,000 kg per day by 2040. To fulfill the Class 8 truck electricity demand, it is estimated that there may need to be over 45,000 mixed types of electric charging ports added to the existing electric grid by 2040, which could cost more than $2.4 billion. To fulfill the Class 8 truck hydrogen demand, it is estimated that there may need to be between 52 through 262 hydrogen stations added (depending on station throughput), which could cost between $520 million and $1.3 billion. In other words, in just LA County, it is estimated to cost between $2.9 - $3.7 billion to develop charging and fueling infrastructure by 2040, not including costs of land acquisition, grid upgrades, site-level make ready infrastructure development, design and engineering, or permitting. Additionally, site permitting and land acquisition for all the new infrastructure could significantly hold up infrastructure deployment.

7.1.1 Recommendations

Create public-access overnight charging lots for small fleets: One of the main concerns raised in the fleet perspectives research and the 710 ZE Truck Working Group is the challenge associated with smaller fleets and small businesses securing overnight charging sites. These small fleets may not have dedicated depots and will most likely rely on public charging/fueling infrastructures once they transition to ZE technologies. Currently, almost one third of Class 8 trucks registered in California belong to fleets of 1 – 3 vehicles, which will likely need to rely on overnight public charging infrastructure to meet their daily demands. This is a sizable need to be addressed. Identifying mechanisms to provide public overnight charging lots for smaller fleets without depots is a critical element to a successful transition to Class 8 BETs. This approach would more directly address local, short-term needs for smaller fleets within LA County. For the long-term, LA Metro may consider coordinating with other major freight centers outside of LA County to determine how they can support the eventual deployment of regional and long-haul ZE trucks through strategically located and sized charging and fueling infrastructure. Discussions with other entities in the Western U.S. may yield opportunities to indirectly meet state air quality and climate goals, particularly where accelerated ZEV truck adoption would enable these facilities to generate LCFS credits or secure private investor funding.

For the near-term, prioritize key drayage and short-haul corridors for siting charging and fueling infrastructure, such as the I-710. To enable this, streamline permitting, site development requirements, and land acquisition requirements: One of the significant issues which could bottleneck charger and fueling infrastructure deployment revolve around permitting processes and land acquisition. Every day, approximately 25,000 heavy-duty trucks travel near the I-710 freeway, many of which are drayage trucks, especially between the port and SR-91 intersection. Considering that drayage trucks are expected to be among the first sectors of Class 8 trucks to undergo the transition to EVs (as a result of ACF regulation), building charging infrastructure across the I-710 corridor should be a high priority. Building public charging infrastructure would entail many elements including land acquisition, site readiness, equipment installation and operation. Because these processes involve multiple entities including landowners, fleet owners and operators, cities, and utilities, improving existing processes to streamline and eliminate inefficiency would be paramount to realizing the needed infrastructure implementation in a timely manner.