Los Angeles County
Metropolitan Transportation Authority

CLEAN TRUCK TECHNOLOGY COMPARATIVE REPORT 8

Recommendations

METRO GOODS MOVEMENT PLANNING



Metro

MAY 2022

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Nomenclature

AB	Assembly Bill
ACF	Advanced Clean Fleets
ACT	Advanced Clean Trucks
AQMD	Air Quality Management District
BEV	Battery-Electric Vehicle
CAIRP	California Registered International Registration Plan
CARB	California Air Resources Board
CEC	California Energy Commission
DCFC	DC Fast Charging
EMFAC	EMission FACtor
EPA	Environmental Protection Agency
FCEV	Fuel Cell Electric Vehicle
GHG	Greenhouse Gas
HD I&M	Heavy-Duty Inspection and Maintenance
HD Omnibus	Heavy-Duty Engine and Vehicle Omnibus Regulation
HVIP	Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project
ICE	Internal Combustion Engine
LCFS	Low Carbon Fuel Standard
NOx	Nitrogen Oxides
NREL	National Renewable Energy Laboratory
NZE	Near-Zero Emission
TCO	Total Cost of Ownership
TRL	Technology Readiness Level
ZE	Zero-Emission
ZEV	Zero-Emission Vehicle

1 Background and Overview

Metro commissioned the Clean Truck Technology Comparative Report to facilitate informed discussion and decision-making on actionable steps to advance the LA Metro's on-going Countywide Clean Truck Initiative (CCTI). The work conducted for developing the Report is taking place during the same period that the CCTI work is focusing on I-710 Zero Emission Truck Program (710 ZET Program). The 710 ZET Working Group has been meeting monthly to shape strategies and actionable steps to realize the 710 ZE Truck Program, leveraging $50 million that Metro Board approved as seed funding. Findings and recommendations offered throughout the previous technical reports are intended to facilitate informed discussions and decision making through objective and current assessment of ZE and NZE vehicle technologies, infrastructure maturity, and impacts to fleets and owner operators.

In this final technical report, a synthesis of the previous seven reports is compiled to provide recommendations for accelerated deployment of low-NOx natural gas and ZE truck technologies, as well as achieving public health goals for LA County. The adoption of clean truck technologies addresses near-term air quality goals and will mitigate the adverse impacts of air pollution, particularly for low-income and disadvantaged communities, who have endured prolonged negative impacts. The deployment of clean vehicle charging and fueling infrastructure, as well as policies and planning efforts, will provide physical and regulatory structures to chart a path towards achieving long-term climate targets. The discussion developed throughout these reports has been delivered with the intention to illustrate LA County's current trucking landscape (e.g., number of trucks by type and fuel technologies) and propose a truck new technology mix, as well as charging and fueling infrastructure needed for LA County in support of such vehicles to achieve its air quality, climate, and public health goals. Additionally, these technical reports provided an in-depth overview of the regulatory and incentive programs that facilitate adoption of clean truck technologies and identified some of the challenges associated with these programs, especially as they may relate to small businesses and owner-operators to access ZE trucks. As part of these technical reports, the project team also assessed the end-users' perspective toward ZE technologies, which include both positive and negative views about the technology. The 710 ZET Working Group offered general consensus that a lack of sufficient infrastructure to support all the ZE trucks would be a much bigger barrier for a large scale ZE truck deployment that the current state of ZE truck technologies.

This report opens with a summary of key takeaways from the previous seven reports. Then, the report identifies key barriers toward adoption of NZE and ZE technologies, providing recommendations for the types of actions that LA Metro, as well as other local and states agencies and utilities, can take to overcome those barriers.

2 Summary of Previous Key Takeaways

Report 1: Baseline Conditions

The first report provides an overview of Class 8 truck operations and their environmental impact in LA County under business-as-usual conditions. This "lay of the land" was developed to determine the types of trucks operating in LA County and a representative emissions inventory based on characteristic activity. The report emphasized that the South Coast Air Basin's most effective strategy to overcome ozone air quality issues would be to dramatically reduce NOx emissions due to a complex relationship between NOx emission and resulting ozone concentrations. The results indicated that the projected baseline Class 8 truck population through the long-term would hinder progress towards achieving health protective air quality standards, especially if their impact is not adequately mitigated in disadvantaged communities. The report also covered various duty cycles (use cases) among Class 8 trucks and discussed desirable clean technology types that would meet the operational demand for such duty cycles. Clean truck technologies would yield the necessary air pollutant and GHG reductions, so an assessment of vehicle technology readiness and transition schedule was considered in subsequent reports. Report 1 also demonstrated the contribution of out of state trucks travelling

through LA County and their contributions to local air quality issues. This illustrated that achieving health protective emissions reductions in LA County will require not only transitioning local truck fleets to ZE, but also out of state truck fleets, which are often difficult to regulate (or difficult to enforce the existing regulations on them).

Report 2: Vehicle Technology Readiness

The second report summarized current and projected readiness, commercial availability, and costs for all four vehicle technologies (diesel, natural gas, battery-electric, fuel cell electric) across immediate-, short-, medium-, and long-term timeframes. A review of pertinent literature, as well as market outlooks were key in consolidating knowledge on cost portfolios, energy requirements, and successful pilot projects. The report concurred with other literature and analyses that the ZE Class 8 truck market has demonstrated considerable growth in model availability and decreases in capital costs, particularly from reductions in battery pack prices. The report also highlighted that while today the ZE technology is mainly available for short- and regional-haul vocations, there are various industry announcements on production of longer range zero emission technology over the next 5 – 7 years that will enable zero emission technology adoption within interstate and long-range operations. This transition is anticipated based on the likely adoption of the ZE technology vehicles operating on predictable and shorter routes with overnight charging access first. In support of this transition, CARB's Advanced Clean Truck rule is designed to address the supply-side of the ZE vehicle ecosystem and sets targets for vehicle manufacturers to produce certain shares of their total vehicle production for ZE technology vehicles. As a near-zero emission technology, when used with renewable natural gas, natural gas-powered trucks can fully eliminate diesel PM, offering immediate public health benefits to communities who are exposed to high concentrations of diesel PM. The current status of hydrogen fuel cell (HFC) as applied to drayage and heavy-duty delivery sectors is still at demonstration and pilot stages. However, there is much anticipation for HFC Class 8 trucks for long-haul application because of the energy capability of HFC.

This report also documented current cost comparisons and assessed that when existing incentives and grants are fully utilized by vehicle owners, that the projected TCO and operational capabilities of BEV and FCEV technologies are compelling enough to enable accelerated adoption.

Report 3: Technology Mix for Meeting Public Health and Climate Goals

The third report provides conducted fleet modeling and emissions reductions assessments that assume a full implementation and compliance of current and proposed state policies, such as the HD Omnibus, ACT, HD I&M, and ACF regulations, and resulting truck technology mix. In this assessment, the project team considered the effects of the final technology mix showed that upon successful implementation of policies such as the HD I&M and ACF regulations, resultant emission reduction targets in the medium- through long-term are achieved. Although the existing and proposed regulations considered in this report will support the accelerated adoption of clean technologies, successful adoption of these technologies relies on the deployment of needed charging and fueling infrastructure.

Report 4: Fueling and Charging Infrastructure

The fourth report summarized charging and fueling infrastructure needs for Class 8 trucks, focusing on estimating the number, type, and cost of development. Current infrastructure in place, as well as projected infrastructure and associated costs, were investigated in depth for the four previously specified vehicle technologies. The technology mix identified in Report 3 was used as the basis for estimating charging and fueling infrastructure, with different fuel pathways explored to measure the viability of renewably sourced fuels in the immediate- and short-terms. Regarding electric truck charging infrastructure, analysis in Report 4 suggests that there may be a need for the following across LA County by 2040: 25,936 Private charger ports (also referred to as plugs), 11,272 Public charger plugs for overnight charging, and 8,080 Public charger plugs for fast charging (also known as opportunity charging). The estimated capital cost for electric vehicle supply equipment (EVSE, also referred to as

the charger) hardware and installation by 2040 is $430 million for the private EVSE, $328 million for the public (overnight) EVSE, and $1.261 billion for the public (opportunity/fast) EVSE, for an estimated grand total of $2.02 billion. Regarding hydrogen fueling stations, it is estimated that, depending on the daily throughput of the stations, between 52 (if assuming station throughput of 5,000 kg/day) and 262 (if assuming station throughput of 1,000 kg/day) stations may be needed to meet demand by 2040. The total estimated capital cost for developing these stations ranges between $520 million (if assuming station throughput of 5,000 kg/day) and 1.31 billion (if assuming station throughput of 1,000 kg/day) by 2040. Some additional natural gas fueling infrastructure may also be required to meet the demand from an increased number of natural gas trucks. If it is assumed that existing natural gas stations in LA County are already at maximum capacity, and therefore new stations need to be constructed to meet additional fueling demand, then it is estimated that approximately as many as 61 (40 private, 21 public) additional stations may be needed by 2040. The capital costs of developing these stations is estimated to cost between $47 million and $71 million. Importantly, these estimates do not include the cost of land acquisition. As described later in this report, land acquisition has been identified as a challenge to accelerating the development of charging and fueling infrastructure.

Report 5: Air Quality, Climate, and Public Health Impacts

The fifth report quantified the air quality, climate, and public health impacts of each truck technology over four timeframes. The emissions inventory generated by EMFAC2021 and the CA-GREET3.0 were used to assess air pollutant emissions and GHGs from vehicles or production of fuels; electric carbon intensity was assessed using the 2019 RESOLVE model and is guided by CARB's 2020 Mobile Sources Strategy to determine the carbon footprint of electric trucks. The report concluded that with the declining carbon intensity of electricity and hydrogen in California, significant air quality and climate benefits can be achieved through adoption of ZE technologies over the long-term. The avoided health outcomes, valuated at approximately 5 billion dollars[1], will significantly improve public health especially in low income and disadvantaged communities neighboring ports and major freight facilities given higher concentration of air toxic cancer risks and poverty and asthma correlation.

Report 6: Incentives and Regulations

The sixth report described relevant policy and planning efforts as they relate to clean truck adoption. Various incentive and grant programs within California have supported an accelerated transition to clean truck and ZE infrastructure; adopted and recently proposed regulations have also promoted clean truck adoption. This report identified some of the gaps or constraints among clean truck technology policies, wherein which some gaps may be filled by proposed incentives or rules. Broadly speaking, large and small truck fleet owners are interested in accelerating clean truck adoption, but funding structures favor large fleet owners with higher accessibility to resources. Additionally, the report highlights the need for rapid development of public charging and fueling infrastructure to overcome the existing barriers faced by small owner-operators who, unlike large fleets, may not have access to depot charging.

Report 7: End User Perspectives

The seventh report compiled the perspectives of truck owners and fleet operators from existing literature as they relate to several key considerations related to ZEVs and ZEV infrastructure, including vehicle performance, charging and fueling infrastructure, costs, regulations, and incentive programs. Both positive and negative feedback from truck owners and drivers toward ZE technologies are documented. Although most publicly reported experiences are positive, some fleets have expressed concerns or issues with vehicle performance, costs, and availability of infrastructure. Anecdotal

[1] This is the monetized health benefits due to exposure to PM2.5 (primary and secondary) associated with emissions reductions resulting from the technology mix proposed under Report 3. We used the U.S. EPA Benefit Per Ton (BPT) estimates for exposure to PM2.5 as of January 2022. Link: https://www.epa.gov/benmap/estimating-benefit-ton-reducing-directly-emitted-pm25-pm25-precursors-and-ozone-precursors

findings through an informal interview with an industrial real estate executive highlighted challenges in realizing needed charging infrastructure due to current business models used by logistics and warehousing industry. Typical business models involve multiple decision-makers to invest in on-site charging infrastructure for ZE heavy-duty trucks, including real estate developers, their tenants, and cities.

3 Gaps & Barriers

This section of the report discusses the major barriers to adoption of ZE and NZE Class 8 trucks. Certain factors that would delay clean truck adoption, such as technology price disparities and availability, as well as a significant gap in charging and fueling infrastructure have been identified in Reports 2 and 4. Report 6 also provided an in-depth discussion on the existing incentive programs that serve as a catalyst for adoption of clean technology vehicles and deployment of needed infrastructure. However, the project team also highlighted several key gaps and shortcomings within the existing programs that inhibit equitable adoption of the technology and access to ZE infrastructure. The following section summarizes some of these key barriers and shortcomings.

Lack of Availability and High Cost of Zero Emission Technology

As discussed in Report 2, conventional ICE truck technologies have been the norm in the commercial transportation industry – diesel and natural gas truck technologies are mature and have widespread fueling infrastructure. By comparison, ZE truck technologies are still evolving through different commercialization stages, primarily in the production of models to serve various trucking vocations. ZE charging and fueling infrastructure also needs further development to address the concerns voiced by fleet owners and operators, per the project team's findings in Report 7.

ZE truck technologies, including battery-electric and hydrogen fuel cell electric, are rapidly evolving. This is especially true for Class 8 BEVs, where in certain applications the technology has passed the development stage and is now commercially available for operation. Within the medium- and heavy-duty ZEV space, transit buses are farthest along in the market, followed by drayage (i.e., short- and regional-haul trucks), refuse and delivery trucks. Multiple vehicle models from several OEMs have been reported available as early as 2019. The demonstrated success and appeal of BEVs may drive manufacturers to increase BEV availability, especially Class 8 trucks which have been slower to develop than lighter vehicles and those with shorter range requirements. On the other hand, FCEVs are largely still in development stages, ranging between TRL 6 through 9. In particular, the only heavy-duty FCEVs with TRL 9 and in use are hydrogen fuel cell electric transit buses – California transit fleets, such as Orange County Transit Authority (OCTA) and Sunline Transit have already deployed HFC buses onto routes serving disadvantaged communities[2]. Other heavy-duty vehicle vocations, such as drayage or long-haul delivery, have yet to see commercially available FCEV models. However, the expected options within the short-term have compelling range capabilities, reportedly as high as 900 miles of range using hydrogen. In the case of widespread access to hydrogen fueling stations,, truck fleet owners may benefit from longer range, faster fueling, and greater cargo capacity of FCEVs as compared to BEVs. Indeed, Class 8 HFC trucks are expected to better meet the technical needs of long-haul operations while battery electric trucks are primed to serve short- and regional-haul needs.

Despite the current and expected near-term availability and benefits identified across ZE Class 8 truck options, vehicle acquisition remains a challenge. Principally, high capital costs for battery-electric trucks, fuel cell electric trucks, and associated infrastructure are commonly cited as a primary barrier to increased deployment. A report produced by ICF for the California Electric Transportation Coalition (CalETC) detailed tentative TCO assumptions used in Report 2, including initial purchase price. As of 2019, the average battery-electric truck is $312,000, which is $177,000 more than its average diesel

[2] https://ww2.arb.ca.gov/our-work/programs/innovative-clean-transit/ict-rollout-plans

truck counterpart and $147,000 more than its average natural gas counterpart. Also as of 2019, the average fuel cell electric truck 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. A promising consideration highlighted in Reports 2 and 4 are the projected decreases in battery pack prices and hydrogen fuel cell stacks, which would bring the difference in initial purchase prices for diesel, natural gas, battery-electric, and hydrogen fuel cell Class 8 trucks to within tens of thousands of dollars by 2030. With a reduction in price for battery packs, however, it is anticipated that the amount of incentives offered towards battery electric trucks would also decrease. 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.

Lack of Access to Fueling and Charging Infrastructure

As discussed in Report 4, dynamic truck operations will require a suite of charging and fueling options, ranging from variable charger power output to escalated hydrogen fuel production and storage. BEV technologies have benefitted from some established charging connector standardization, which may enable cross-compatibility across different OEM models. At least two electric vehicle supply equipment (EVSE) types have been made commercially available with BEV technologies – Level 2 and DCFC electric chargers. For FCEVs, hydrogen refueling stations consist of on-site (liquid or gaseous) hydrogen storage tanks and high-pressure dispensers that inject a tank's worth of fuel within minutes. However, hydrogen fueling stations are still relatively expensive developments, and hydrogen production itself would need to be significantly ramped up. Notwithstanding strides made in ZE charging and fueling technology, there are significant deployment gaps that will require more targeted consideration.

First, the technology mix in Report 3 indicated that 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 subsequent energy demand assessment showed that electricity consumption for Class 8 BEVs in LA County is expected to increase from approximately 1 MWh per day in 2020 to 10,000 MWh per day by 2040; for Class 8 FCEVs in LA County, hydrogen demand is expected to increase to 125,000 kg per day by 2030 and nearly 250,000 kg per day across all Class 8 FCEVs in LA County by 2040. For comparison, the current average natural gas consumption in LA County is 50,000 kg/day and is expected to grow to roughly 100,000 kg/day by 2030.

Based on the projected natural gas truck fleet projection from Report 3, it is estimated that up to 61 additional natural gas stations may need to be deployed to meet peak natural gas demand by 2035, with 40 being private stations and 21 being public.[3] Although natural gas refueling station capital costs vary by capacity and dispense rate, the estimated cumulative cost of public natural gas infrastructure ranges between $25 million and $37 million in the 2035 scenario year. Within the same timeframe, the projected increases in the Class 8 BEV and FCEV populations would need rapid parallel development of infrastructure to meet their respective energy demands. Based on the analysis in Report 4, it is estimated that the total number of charging ports required to meet demand from all Class 8 trucks (Single Unit, Drayage, CAIRP Intrastate, CAIRP Interstate, Out of State) will grow to 25,936 private ports, 11,272 public ports for overnight charging, and 8,080 public ports for opportunity/fast charging by the 2040 scenario year. The estimated capital cost for electric vehicle supply equipment (EVSE, also referred to as the charger) hardware and installation by 2040 is $430 million for the private EVSE, $328

[3] This estimate assumes that existing natural gas stations are at maximum capacity, requiring the construction of new stations. It also assumes that the number and type (public vs private) of stations will increase proportionally with the increased number of natural trucks. In actuality, it may be the case that at least some of the existing public stations can support additional demand, and so this estimate should be seen as a conservatively high estimate.

million for the public (overnight) EVSE, and $1.261 billion for the public (opportunity/fast) EVSE, for an estimated grand total of $2.02 billion. As for hydrogen fueling stations, it is estimated that, depending on the daily throughput of the stations, between 52 (if assuming station throughput of 5,000 kg/day) and 262 (if assuming station throughput of 1,000 kg/day) stations may be needed to meet demand by 2040. The total estimated capital cost for developing these stations ranges between $520 million (if assuming station throughput of 5,000 kg/day) and 1.31 billion (if assuming station throughput of 1,000 kg/day) by 2040.

Aside from the cost, building public charging and fueling infrastructure would entail many elements including land acquisition, site readiness/make-ready, electric utility distribution grid equipment upgrades, and equipment installation and operation. One of the significant issues which could bottleneck charger and fueling infrastructure deployment revolve around permitting processes and land acquisition. Based on the estimates provided in Report 4, the charging infrastructure alone would require extensive, long-term land acquisition and infrastructure/utility planning. Considering that, unlike gas stations, charging stations would require parking spots for trucks, the amount of land needed to support the extensive number of EV charging ports to power Class 8 BEV trucks could pose a significant barrier for deployment of the chargers. Additionally, zoning and parking rules at local levels may need to be addressed to reserve parking space and enable the deployment of this infrastructure. These are issues that will require significant collaboration across various levels of government with inputs from communities and the private sector..

The current gap in BEV charging, natural gas and hydrogen fueling infrastructure, as well as seemingly prohibitive capital costs and land use challenges pose significant barriers in transitioning Class 8 truck fleets to clean technologies.

Lack of Targeted Incentives for Small Fleets & Owner-Operators

As described in Report 6, currently there is a suite of different incentive programs within California that provide funding toward purchase of ZE trucks, replacement of older diesel vehicles with cleaner technology and buildout of ZE infrastructure. For example, in the 2022-23 budget, Governor Newsom introduced a $6.1 billion ZEV package (still pending legislative approval) to accelerate the state's transition to ZEVs. This is in addition to the $3.9 billion multi-year investment that was allocated in 2021. A significant fraction of this package is earmarked for heavy-duty vehicles and their supporting infrastructure. Of the pending $6.1 billion, $935 million is allocated for the purchase of 1,000 ZE short-haul drayage trucks and 1,700 ZE transit buses. Another $1.5 billion is provided for the purchase of electric buses for school transportation programs. Additionally, the package provides $1.1 billion to assist with purchase of ZE trucks, buses, and off-road equipment plus related fueling infrastructure, with $400 million to enable port electrification. Table 1 below provides specific details on the allocated budget toward zero emission vehicles including medium and heavy-duty trucks (shown as "Big ZEVs").

Table 1. California ZEV Package Investment

(Dollars in Millions)

Investment Category	Program	2021 ZEV Package Multi-Year Investment	2022 ZEV Package Multi-Year Investment	ZEV Package Totals
Passenger Vehicles	Clean Vehicle Rebate Project	$525	$0	$525
	Clean Cars 4 All & Other Equity Projects	$400	$256	$656
	ZEV Fueling Infrastructure Grants	$300	$600	$900
	Equitable At-home Charging	$0	$300	$300
Big ZEVs	Drayage Trucks & Infrastructure	$470	$475	$945
	Drayage Trucks & Infrastructure Pilot Project	$65	$0	$65
	Transit Buses & Infrastructure	$290	$460	$750
	School Buses & Infrastructure	$450	$1,500	$1,950
	Clean Trucks, Buses and Off-Road Equipment	$700	$1,100	$1,800
	Ports	$0	$400	$400
	Near-Zero Heavy Duty Trucks	$45	$0	$45
Other	ZEV Consumer Awareness	$5	$0	$5
	ZEV Manufacturing Grants	$250	$0	$250
	Community-Based Plans, Projects and Support / Sustainable Community Strategies	$0	$419	$419
	Emerging Opportunities	$0	$200	$200
	Transportation Package ZEV	$407	$383	$790
	Totals	**$3,907**	**$6,093**	**$10,000**

Despite significant investment by the State, almost $5.2 billion over four budget years for medium and heavy-duty trucks, the funding needed to fully transition the state's medium and heavy-duty trucks to ZE and buildout of the necessary charging and fueling infrastructure to support them is much more significant. As illustrated in Report 4, in LA County alone, it is estimated that there may be a need for $2.5 - $3.3 billion in capital investment to build electric charging and hydrogen fueling infrastructure.

Aside from the size of the funding needed to facilitate the transition being a challenge, current funding programs are mainly geared towards larger fleets who a) have the resources to apply for different grants with various complexities in their application process, and b) can cover the incremental cost of ZE vs. diesel after the incentives are applied. For example, assuming today a diesel truck costs approximately $150,000, and a battery electric Class 8 trucks costs approximately $350,000, there is a $200,000 cost difference of which the HVIP program can only cover up to $120,000. Furthermore, sales tax and vehicle registration fees are calculated based on the purchase price of a vehicle, not the out-of-pocket amount after the HVIP is applied. This means that a purchaser of a battery electric Class 8 truck would pay a lot more in sales tax and fees. Larger fleets have the financial ability to cover the rest of the incremental cost either using their available cash, or through various financing mechanisms available to them, and then recoup the cost through operational saving (i.e., lower fuel cost). However, such options may not be necessarily available to a small fleet owner-operators, and despite availability of incentive funds, those smaller fleets, which represent approximately 30% of California's trucks[4], may not be able to transition to zero emission technologies without programs designed specifically to address their capital constraints. Additionally, incentive programs such as Carl Moyer that requires scrappage do not seem to be attractive to small fleets when considering the transition to ZE technology. Adding on top of these challenges is 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 LCFS program to reinvest into EV purchases or EV infrastructure

[4] Per CARB Fleet Database data, 30% of Class 8 trucks registered in California belong to a fleet with 3 trucks or less.

deployment, an owner-operator that does not own or lease a private depot would not have access to such revenues.

Additionally, as discussed in Report 6, there are several shortcomings with the existing incentive programs including the tax implications related to Carl Moyer program as well as programs that follow Moyer guidelines. As described, grants received through these programs are currently subject to federal and state income tax which reduces the efficacy of these program and can result in higher out-of-pocket costs for purchasing ZE trucks.

4 Recommendations

Simplify existing structures of incentive and grant programs: As state agencies, such as CARB and CEC, examine options to offer greater funding opportunities to fleet owner-operators, the project team's findings suggest that these programs need to be designed to be much more user friendly, particularly to enhance accessibility of these funds to small owner-operators. In Report 7, a study[5] found that while most fleets had used incentives in the past, the overall experience was highly inconvenient as the programs were so complex administratively. If given a choice of just one government program to incentivize electric trucks, 38% of respondents said they would prefer no government incentive program and those same respondents never chose an electric truck in their choice scenarios, more than 50% of the study's respondents expressed that low-interest loan or lease options and purchase price rebates would be preferrable pathways for ZE truck acquisition, and 13% would prefer charging equipment rebates. These findings suggest that owner-operators seek simpler and easier incentive programs, as well as multiple options for vehicle or infrastructure payment plans. As new state policy looms closer in implementation, as with the ACF regulation, drayage truck owners will be among the first wave of Class 8 trucks to have to find a way to cover the cost of ZE trucks. Designing incentive and grant programs to be simpler and more user friendly prior to this kind of policy implementation would be an important element to supporting ZE truck transition.

Provide technical assistance to small fleets: Similar to the owner-operator grant assistance program offered by Southern California Edison (which is only limited to SCE customers), LA Metro should consider developing a program that would offer technical assistance (in the form of grant application assistance as well as post-grant activities such as, contract execution and reporting) to smaller truck fleets as they apply for various state grants and incentives. Most of these smaller fleets and owner-operators do not have the essential resources to apply to these grants. Evaluation of end user perspectives from Report 7 reinforced that costs associated with ZEVs and infrastructure installation are primary barriers to fleet transition. One opportunity area for LA Metro, presented in SCE's Charge Ready Transport program, is to identify specific small truck fleet owners who are interested in procuring public/private BEV 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.

Create public-access overnight charging lots for small fleets: One of the main concerns raised in the fleet perspective, and the 710 ZE Truck Working Group is the challenge associated with smaller fleets and small businesses securing overnight charging sites. These small fleets often do not have dedicated depots and will most likely rely on public charging/fueling infrastructures once they transition to ZE technologies. As illustrated in Report 1, currently almost 1/3 of Class 8 truck registered in California belong to fleets of 1 – 3 vehicles, which will likely need to rely overnight public charging infrastructure to meet their daily demands. This is a sizable need to be addressed. LA Metro should find mechanisms to provide public overnight charging lots for smaller fleets without depots. This

[5] Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement Study, 2020

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. 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.

Coordinate with Ports, public agencies, and transportation & warehousing industry sector to develop a Countywide Infrastructure Development Implementation Plan: Apart from the truck fleets themselves, Ports, transportation and warehouse industry sectors will have the best working knowledge of truck operations and routing in the region. Given the recent legislative push toward deploying ZEVs and ZEV infrastructure, particularly South Coast AQMD's Warehouse Indirect Source Rule (ISR), these facilities have significant motivation to deploy ZEV infrastructure that will enable the deployment and operation of Class 8 ZE trucks. Given the focus on electrifying drayage trucks and the significant share of small drayage owner-operators in LA County, innovative ZE infrastructure strategies are needed, such as point-to-point infrastructure availability and the availability of semi-public overnight electric truck charging yards. Other legislative efforts, such as SB 671's Clean Freight Corridor Efficiency Assessment, seek to similarly expand state-level funding programs for infrastructure and technology. LA Metro may consider collaborating with these entities to develop ZEV infrastructure development strategies, which can include infrastructure siting analysis, determination of asset ownership, business models, financing, and funding.

Streamline permitting, site development requirements, and land acquisition requirements to support EV charging infrastructure and hydrogen fueling station deployment: One of the significant issues which could bottleneck charger and fueling infrastructure deployment revolve around permitting processes and land acquisition. CARB's 2019/2020 EV Charging Infrastructure Nonresidential Building Standards assesses near-term BEV infrastructure and practical space requirements, citing nonresidential buildings as low-cost opportunities to install charging infrastructure[6]. The 2019 nonresidential building standards required that new buildings with 10 or more parking spaces reserve 6% of parking space to accommodate Level 2 chargers; CARB performed a gap analysis to demonstrate that California's ZEV infrastructure was not keeping up with BEV deployment and suggested that the mandatory BEV capable parking spaces be increased from 6% to 10% of new total spaces to fill charging infrastructure gaps prior to the 2025 deadline. CARB also found that setting this requirement on new construction avoids between $7,000 through $8,000 in retrofit costs per parking space. The results from this report focus on light-duty BEVs but are important considerations as medium- and heavy-duty BEV projects are slated in goods movement corridors. 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 required under ACF to be among the first sectors of Class 8 trucks to undergo the transition to EVs, 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 land owners, 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. Hydrogen fueling stations for heavy-duty FCEVs could potentially face similar deployment issues. One example to consider is POLA's "Shore to Store" (S2S) project. In

[6] https://ww2.arb.ca.gov/sites/default/files/2020-09/CARB_Technical_Analysis_EV_Charging_Nonresidential_CALGreen_2019_2020_Intervening_Code.pdf

2018, POLA announced that a public and private sector partnership[7] awarded $82.5 million in funding to deploy ten Class 8 hydrogen fuel cell electric drayage trucks and two new large-capacity hydrogen fueling stations in Wilmington and Ontario[8]. As of 2021, the S2S project's new stations have helped form an integrated five-station heavy-duty hydrogen fueling network in LA County. However, CARB cites that despite significant partnership contributions, the unfamiliarity with hydrogen production and fueling to Wilmington and Ontario caused delays through permitting processes[9]. These lessons learned from hydrogen fueling station demonstrations serve to emphasize that co-development of heavy-duty FCEV fleets and fueling infrastructure can be brought up to pace and would benefit significantly from a reevaluation of permitting processes for ZE truck projects in disadvantaged communities.

Leverage Public-Private Partnership (P3) 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. LA Metro could leverage the existing P3 procurement as well as vehicle and infrastructure as-a-service models (e.g., WattEV in Port of Long Beach[10]) 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.

Education and Outreach: In terms of BEV and FCEV technology awareness, additional education and outreach at local level are much needed for wider acceptance and greater deployment.. A study documented anxieties or concerns about ZE trucks among fleet owners and operators11. The survey results indicated that 66% of participants are somewhat knowledgeable about ZE trucks, 24% are very knowledgeable, and 10% are not knowledgeable at all. Although most participants know about ZE truck technologies, purchase price and range are top concerns amongst all respondents, followed closely by charger siting and operating costs. The project team's technology readiness assessment, as well as its infrastructure projections, could be leveraged to develop educational materials; the research conducted across Reports 2 and 4 show that truck owner-operators will be able to expect purchase price drops in battery packs, hydrogen fuel, and total (capital cost, commissioning, installation) charging and fueling infrastructure costs over time. For other fleet owners and truck drivers less knowledgeable on ZE truck technologies, funding for alternative technician programs (i.e., Volvo heavy-duty electric truck maintenance course at Rio Hondo College and San Bernardino Valley College) could prove useful to maintenance staff as they begin to adopt clean truck technologies.

Residents and businesses would also benefit from additional information around welcoming ZE technology and infrastructure, particularly those that support Class 8 vehicles, in their communities. For example, where existing energy infrastructure is not sufficient to meet the needs, infrastructure upgrades, including installation of new substations maybe needed. As mentioned earlier, hydrogen stations ranging between 52 through 262 would be needed to support fuel cell electric trucks in the future. Potential impacts from such new infrastructure and resulting new traffic patterns as vehicles will be accessing these facilities will need to be informed and vetted.

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[7] Partners include CARB, Kenworth Truck Company, Toyota Motor North America, Shell Oil Products USA, Port of Hueneme, South Coast AQMD and National Renewable Energy Laboratory

[8] https://www.portoflosangeles.org/references/2021-news-releases/news_060721_zanzeff

[9] https://ww2.arb.ca.gov/lcti-port-los-angeles-shore-store-project

[10] https://www.wattev.com/post/wattev-to-electrify-ttsi-heavy-duty-truck-fleet

[11] Developing Markets for Zero Emission Vehicles in Short Haul Goods Movement Study, 2020