Zero-Emissions Drayage Truck Feasibility Study

November 2019

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1. Introduction

1.1. Background

The Port of Oakland Board of Port Commissioners approved the Seaport Air Quality 2020 and Beyond Plan (2020 and Beyond Plan, Port of Oakland, 2019a) on June 13, 2019 in Resolution 19-41. The 2020 and Beyond Plan establishes zero-emissions operations as the policy direction of the Seaport. The Plan has a Near-Term Action Plan consisting of 37 clean air actions which the Port will undertake in the next five years (2019-2023). It also has Intermediate-Term Goals for the following five years, including a goal of deploying 21 zero-emissions drayage trucks by 2027.

As part of Resolution 19-41, the Board directed Port staff to return within six months with three separate reports:

1. On the capacity of the Seaport's electrical system, tenant needs for electric vehicle charging equipment, and the ability of the Port to provide electric vehicle charging equipment;
2. On the feasibility of replacing all drayage trucks at the Port with zero emissions trucks including the feasibility of related goals and metrics;
3. On the feasibility of replacing all cargo handling equipment (CHE) at the Port with zero-emissions equipment including the feasibility of related goals and metrics

Each of these studies support strategies and goals of the 2020 and Beyond Plan. The electrical capacity study supports Strategy #3: Develop Infrastructure to Support the Pathway to Zero Emissions. The truck and CHE feasibility studies directly support Strategy #2: Promote Pathway to Zero Emissions Equipment and Operations. It is important to understand the relationship of each study individually and collectively to achieving the Board's vision of a zero-emissions Seaport.

At the time that the Board approved the 2020 and Beyond Plan, some community and regulatory agency stakeholders noted that the San Pedro Bay Ports Clean Air Action Plan Update (CAAP 3.0, November 2017) has a stated goal of 100% zero-emissions trucks by 2035. These stakeholders questioned why the Port of Oakland did not include a similar goal in the 2020 and Beyond Plan or otherwise set interim percentage goals on the pathway to zero-emissions. [The Port's response to those comments is provided in the Response to Comments document (Volume II of the 2020 and Beyond Plan) on Topic #8: Goals, page RTC-27.] The CAAP goal was set by the Mayors of Long Beach and Los Angeles as an aspirational goal in a joint declaration on June 12, 2017. The CAAP does not, however demonstrate how this goal will be reached, nor provide for interim goals to transition to zero-emissions.

This report discusses the two types of zero-emissions trucks currently being developed: battery-electric and hydrogen fuel cell. Per Board direction, this report does not discuss near-zero-emissions trucks such as compressed natural gas (CNG), or hybrid electric. For context, about 8,000-9,000 trucks currently serve the Port, all but three of which are diesel. The three non-diesel trucks are demonstration battery-electric trucks at GSC Logistics. The Port itself does not own or operate any drayage trucks.

The two known types of zero-emissions trucks are described briefly below. This information is from Appendix C of the 2020 and Beyond Plan, where more detail is provided.

Battery-Electric Trucks

Battery-electric trucks are essentially the same as new plug-in electric cars on roadways today, but at a much bigger scale. They have an electric motor instead of an internal combustion engine transmitting power to the drive shaft. There is no exhaust, no fuel tank, fuel pump, or fuel lines. BYD is currently the only manufacturer with Class 8 electric trucks in production. Other major manufacturers such as Peterbilt, Freightliner, and Tesla have announced their intent to produce electric trucks and are in various stages of development.

Battery-electric trucks carry a bank of batteries, which need to be recharged at a special charging station once they are depleted. The rate and duration of charging depend on the design of the charging station and the state of the batteries. Charging can take many consecutive hours or overnight, which may pose problems for some duty cycles. One of the issues facing battery-electric trucks is that the batteries are very heavy which means the combined tractor weight plus cargo payload may be higher than the 80,000 lb overall gross weight allowed on California streets and highways. The curb weight of the new BYD electric truck is 26,235 lb[1], compared to about 17,000-18,000 lb for a conventional diesel truck. They have limited range, currently about 100 miles before needing to be recharged.

The Port of Oakland currently has three BYD trucks in demonstration with up to eight more coming, and ten Transpower/Peterbilt electric trucks coming early 2020. The Ports of Los Angeles and Long Beach currently have about ten battery-electric trucks delivered and operating or soon-to-be-operating, plus up to 35 more funded and being produced over the next months and years for testing.

Hydrogen Fuel Cell Trucks

Hydrogen fuel cell trucks are similar to battery-electric trucks, except that the electricity comes from a fuel cell instead of a battery. A fuel cell works by passing fuel (typically hydrogen) and oxidants (air) over electrodes separated by an electrolyte. This produces a chemical reaction that generates a constant stream of electricity without combustion. The reaction within the fuel cell only produces electricity, heat, and water when hydrogen is used as the fuel. Fuel cells have a much higher energy density than batteries, so fuel cell trucks will be lighter than battery-electric trucks. Refueling times are comparable to refueling with diesel. Hydrogen fuel is a volatile and flammable gas, but experience with compressed natural gas fueled engines has provided similar experience to operations of onboard hydrogen tanks.

Two manufacturers are planning to make hydrogen fuel cell trucks for drayage operations: Kenworth, and a new company called Nikola Motor.

- Kenworth has a grant for a pilot project at the Port of Long Beach. The grant covers ten trucks, in two sets of five, with the second group applying lessons learned from demonstration of the first five. The first truck has been built and is undergoing stress-testing in Washington before being delivered. The grant also covers two fueling stations, in Ontario and Wilmington.
- Nikola has made many promising announcements, including pre-orders for hundreds of trucks and plans for building 700 hydrogen fueling stations across the country. However, Nikola trucks are not yet in production.

[1] Curb weight listed on 2019 BYD 8TT Cut Sheet, for Gen 2 trucks.

1.2. Organization of this Report

Section 2 analyzes the feasibility of zero-emissions trucks and presents some of the major challenges for transitioning the drayage truck fleet serving the Port including challenges that are specific to certain types of truck routes. Section 3 provides background information about the main pollutants and issues of concern, along with context for air quality as it relates to drayage trucks serving the Port. Section 4 gives updates on relevant State-wide regulations, legislation, and the current status of diesel drayage truck technology.

Section 5 offers a literature review of six recent reports, studies, and presentations about the transition to zero-emissions trucks. These were produced by the Ports of Los Angeles and Long Beach, CARB, the California Energy Commission, and BAAQMD.

Section 6 presents information about the current truck fleet such as number of licensed motor carriers, fleet size, and engine ages. Additional related information about overweight corridors, the status of the Port's Truck Management Plan, and different methods available for reaching out to truck drivers are also provided in this section.

Section 7 provides an update on the two zero-emissions demonstration projects currently underway at the Port as well as other grant and incentive programs that may become available for future projects.

The report closes with a short conclusion including a summary of interim metrics for the transition to zero-emissions trucks in Section 8.

2. Feasibility

The 2020 and Beyond Plan establishes seven criteria for evaluating whether a suggested clean air action is feasible. The criteria are: exposure reduction, affordability, cost-effectiveness, commercial availability, operational feasibility, acceptability, and need. This section discusses the challenges with commercial availability (technological readiness), affordability (cost), and operational feasibility (by type of duty cycle).

The transition to zero-emissions trucks faces many challenges. The two most obvious hurdles in the short term are that the technology is not commercialized and the cost is prohibitively high. Other obstacles include lack of standards for charging and fueling equipment and lack of charging and fueling stations and driving range, as detailed below.

2.1. Commercial Availability

Technological Readiness

Appendix D of the 2020 and Beyond Plan discusses Technological Readiness Levels (TRL). TRL values range from 1, when scientific research begins, through 9, once the technology has been fully developed and tested under real life operating conditions. Widespread adoption of zero-emissions trucks will not occur until the technology reaches TRL 9, meaning the equipment has been proven reliable under the full range of conditions and parts and maintenance are readily available.

The comprehensive *2018 Feasibility Assessment for Drayage Trucks* report published by the San Pedro Bay Ports in April 2019 (Tetra Tech, 2019) concludes that battery-electric trucks are currently at TRL 6 to 7, with prototypes and technology validation, and may be at TRL 8 by 2021, with actual equipment being tested through demonstration projects. The same report states that fuel cell trucks are currently at TRL 5 to 6, with laboratory- and engineering-scale pilot vehicles undergoing testing, and may be at TRL 7 by 2021 (a more detailed summary of the report is provided in Section 5.1).

Lack of Charging/Fueling Standards

The Port of Long Beach "Electric Vehicle Blueprint" (Port of Long Beach, 2019) identifies the lack of charging and fueling standards as a challenge. The report states that the type of electrical infrastructure (in terms of voltage, amperage, phasing, and 'withstand rating') being installed for demonstration projects "is likely to change to a higher withstand rating and voltage." In addition to the internal electrical components of the charging equipment, there are currently no standards for the connecting devices either. The Electric Vehicle Blueprint reports that the "industry has not yet coalesced around a single connector, although the field of options is narrowing." The same is true for hydrogen fueling equipment, although the Society for Automotive Engineers is working on adapting light duty standards for heavy duty equipment.

It is not clear when these standards will be developed and finalized. In the meantime, any common or public charging or fueling station would need to have separate custom charging units for each truck model that may arrive.

Lack of Charging/Fueling Locations

The current lack of charging and fueling locations in Oakland and broader region is another challenge, especially for long-haul trucks which do not return to the same home base each day.

The Port has established a protocol for installing electric charging stations on tenant leaseholds. The process will be refined over time as more tenants submit requests. Port staff developed an "Electric Vehicle Charging Station Permit Application" in April 2019, available on the Port's website under Building & Development Permits. The process starts with a simple one-page application where the tenant lists the number and type of chargers they are considering, provides a picture of their meter, and identifies where they want the chargers located. The Port does a preliminary assessment of the viability of planned charging stations, including the availability of sufficient power. The Port responds to the tenant with a rough cost estimate for the infrastructure, and the tenant decides whether to move forward with the process.

Electric Charging

Electric charging stations will need to have more acreage than familiar diesel fueling stations because of the amount of time it requires to charge. Typical charging durations are not fully understood, depend on the type of charger being used, and will likely shorten as technology develops. But it is safe to say that trucks will need to be charged for many hours in a row or overnight. A fueling time analysis done by McKinsey & Company and presented in a Forbes article on April 14, 2019, states that "for a truck to go 500 miles, it takes about 25 minutes for a diesel, 42 minutes for hydrogen and potentially more than two and a half hours for a battery truck.[2]" The time for charging would come out of the drivers' hours-of-service driving window, unless the driver can sleep or otherwise time it to use their ten consecutive off-duty hours. Trucker driving limits and rest requirements are mandated by law.

Unless charging times come down significantly, future charging stations will look more like parking lots. Each parking stall will need to be long enough for the truck cab as well as its chassis (for long-haul routes) and will need adequate circulation space. Drivers will need accommodations such as food, restrooms, and security. These charging stations will take up a lot of space which is a significant land use issue, coming at a time when cities are shutting down gas stations and redeveloping them into housing and other uses. It is not clear where there is space for charging stations, or what the cost-benefit analysis would be for opening a charging station. A different vision for the zero-emissions trucking future is that battery-electric trucks are not used for long-haul service until batteries and charging systems evolve such that recharging times are more in line with typical diesel fueling times.

Hydrogen Fueling

Hydrogen fuel is expensive. When it is made by steam reforming of methane gas, it costs about twice as much as conventional diesel on a mileage basis. Moreover, this type of hydrogen is more carbon intensive than petroleum based diesel. When hydrogen is made by electrolysis using renewable electricity, the carbon intensity decreases, but the cost increases up to about six times the cost of diesel[3].

There is currently one hydrogen fueling station in Oakland. It is on Grand Avenue, right above Lake Merritt. The station opened September 20, 2019. It is for passenger cars only; it cannot accommodate large trucks. AC Transit has a public hydrogen station in Emeryville that has one dispenser open to the public.

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[2] https://www.forbes.com/sites/alanohnsman/2019/04/14/can-a-15-billion-bet-on-fuel-cell-big-rigs-be-a-game-changer-for-hydrogen/#424e63afe4ce

[3] 2020 and Beyond Plan, Appendix C, under discussion of Implementing Actions Category 2: Fuels, page C-12.

- A new 84-passenger hydrogen fuel cell ferry is currently being built at Bay Ship & Yacht in Alameda, expected to be complete at the end of 2019. The ferry may be home berthed at Berth 9 where it would be fueled via truck.
- Nikola Motor is promising to install over 700 hydrogen fueling stations in the U.S. by 2028. The map on their website (accessed 9/18/19) shows they have one station planned for San Francisco, one near Lodi, and one near Manteca, but none near Oakland.

2.2. Affordability (Cost)

As discussed in Appendix F of the 2020 and Beyond Plan (see page F-25), drayage truck drivers typically purchase used trucks. It will be a long time before there is a market for used zero-emissions trucks, therefore the relevant up-front cost comparison is between new zero-emissions trucks and used diesel trucks. Zero-emissions truck manufacturers are not releasing pricing information on their websites, but a reasonable assumption for a new battery-electric truck plus charger is $470,000[4]. This is anywhere from five to ten times higher than the cost of a used diesel truck, which is around $30,000 to $80,000. The cost for a hydrogen fuel cell truck is not known but is assumed to be significantly higher than battery-electric[5].

In addition to the truck itself, battery-electric trucks require a charging station. There is no typical cost for a charging station; it depends on many factors, such as whether the site has an existing substation with sufficient capacity already in place, whether the transmission system to the substation needs capacity upgrades, and the distance from the substation to the charging stations. Trenching through paved areas can be very expensive, especially if the soil is contaminated.

The Port has a few examples that illustrate the range of charging station costs.

- The Port is currently building ten charging stations for tenant Shippers Transport Express at a cost of about $1.25M-$2M, or about $125,000 to $200,000 each. The project required a new substation and panel, but did not require additional capacity to the system.
- GSC Logistics bought their first charging station for about $11,000 and paid about $10,000 to install it. They utilized the existing panel which had capacity available for the charging stations.
- GSC Logistics' second and third charging stations cost around $5,000 each and cost about $20,000 total to install[6]. The installation cost was higher because it required trenching.
- According to an April 19, 2019 FreightWaves article, "the type of "fast charging" stations that the [West Coast Clean Freight Corridor] is considering could cost between $15,000 and $90,000 each. Each station could need up to one megawatt of power."[7]

[4] Appendix C of 2020 and Beyond Plan, page C-32.
[5] HVIP vouchers for hydrogen fuel cell trucks are $315,000 within a disadvantaged community, versus $165,000 for a battery-electric truck within a disadvantaged community
[6] Email correspondence on 10/1/19 from Pete Smith (GSC) to Tracy Fidell (Port), with subject line: "GSC LOGISTICS EV expenses"
[7] https://finance.yahoo.com/news/western-state-utilities-look-installing-145709700.html

Table 1: Comparison of Truck Cost and Availability

	Battery-Electric	Hydrogen Fuel Cell	Used Diesel
Rough Cost	$470,000 incl. charging station	Unknown	$30,000 - $80,000
Current Number of Major Manufacturers in Production	1	0	5+*
* 98% of trucks serving the Port were built by one of five major manufacturers: Freightliner, Peterbilt, Volvo, Kenworth, and International.			

Source: Port of Oakland

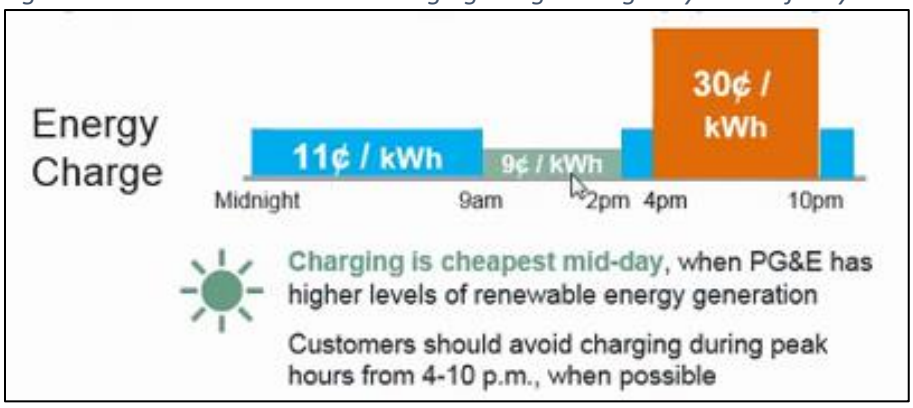
Grants can be used to offset the high up-front cost of purchasing a new zero-emissions truck. However, applying for grants is not a simple process, and many truck drivers do not have staff or resources to dedicate to grant applications. Voucher grants are the simplest type of grants. California's HVIP program offers voucher amounts of $165,000 for a battery-electric truck in a Disadvantaged Community (such as West Oakland) and $315,000 for a hydrogen fuel cell truck. Grant funding is discussed further in Section 7.3.

Fuel Costs

The cost of fuel also factors in to the overall cost equation. Fueling costs need to be on par with the cost of diesel to make zero-emissions trucks affordable.

- Hydrogen currently costs anywhere from two to six times the price of diesel.
- PG&E has established a price structure for charging stations that has a monthly subscription of $184 for 50kW (plus $25 more for each additional 10kW) plus a usage charge that changes by time of day.

Figure 1: PG&E Electric Vehicle Charging Usage Charges by Time-of-Day



Source: PG&E webinar presentation hosted by California Trucking Association Sept. 17, 2019

2.3. Operational Feasibility

The challenges for transitioning to a zero-emissions truck fleet are different for different types of truck duty cycles. For this feasibility analysis, short-haul is loosely defined as routes within the Port itself or within the East Bay areas of Oakland, Hayward, San Leandro, and Emeryville. Medium-haul routes are to Stockton, Tracy, Salinas, Lodi, and Lathrop. Long-haul routes are even further, such as to Reno, Nevada or Arizona or Oregon. This section discusses the types challenges for the different duty cycles.

Short-haul

Short-haul service is the most promising sector to introduce battery-electric trucks. There are no major hills and no need to reach freeway speeds. The most ideal type of service is repositioning empty containers or moving light loads so the battery weight does not put the truck over the standard roadway limit of 80,000 lb overall (see Overweight Corridor discussion in Section 6.2).

Trucks in this type of service most likely work either one or two shifts and return to the same place each night. That means trucks can charge overnight where they are domiciled.

One challenge is that this type of duty cycle is a specialty niche, and truck owners typically want a truck that is not limited to one type of cycle. Another challenge is that the truck owner needs to have access to a charging station wherever they park at the end of their shift.

Medium-haul

This type of service presents a different set of challenges. These trucks need to reach freeway speeds and transit over hills like the Altamont Pass while pulling full loads with the air conditioner or heater running.

For this to be possible, technology needs to advance, especially for battery life and range. Battery range is currently about 150 miles. Truck charging stations or hydrogen fueling stations would need to be available in at least a few locations throughout the region so that drivers do not get stranded and need to be towed. A stranded truck driver could face many financial consequences. In addition to the expense of towing the truck and lost productive work time, perishable goods such as frozen meats could expire, or an export load could miss its sailing cutoff.

Long-haul

For this to become possible, there needs to be a network of charging and fueling stations throughout the state, and even across state lines to Nevada, Arizona, Oregon, and beyond. Companies such as Nikola make the case that hydrogen fuel cells are a more appropriate technology for long-haul trucks over battery-electric, due to fueling times and battery weight.

Utilities along the West Coast have started a West Coast Clean Transit Corridor Initiative to study how to provide sufficient charging stations along Interstate 5 from Mexico to Canada to support electric long-haul trucks. The study will identify potential locations for stations, with associated needs for charging equipment and electrical supply. The study was not available at the time of this report.

Owner-operator model

One of the biggest hurdles is that single-truck owner-operators and small fleet operators do not have the luxury of owning a truck that can only be used for a single-purpose. Drivers may need to fulfill different duty cycles depending on the loads that are available which can vary by season, by contract, or by day. For example, truckers may drive to Salinas and back during certain agricultural seasons and then shift to repositioning empties, or taking imports to a local warehouse, or hauling heavy waste paper recycling from San Leandro. Most of the truck drivers working at the Port need the flexibility to do any of these types of moves with one single truck.

There is a new State law, AB 5, that is injecting a lot of uncertainty into the owner-operator business model. The bill is meant to protect workers in the “gig” economy from being exploited by having them become employees. The International Brotherhood of Teamsters union supports the new law, saying it

protects truck drivers and will allow them to unionize. Other organizations, such as the California Trucking Association and Western State Trucking Association, say that the law threatens the livelihood of truck owners because trucking companies will no longer be able to contract with them without hiring them. It is not clear how this new law will affect owner-operators and the trucks they buy.

3. Context for Air Quality and Health Risk

There are four main pollutants of concern when it comes to trucks and the transportation system in California. The impact of each type is felt on different scale, from global to regional to local. Each is discussed briefly in this discussion along with some context for the Port, the West Oakland neighborhood, and the Bay Area, as applicable. Table 2 summarizes the emissions of highest concern for the Port.

Table 2: Summary of Source and Scale for Emissions of Concern

Pollutant		Truck-Related Source	Issue	Scale
Greenhouse Gases (GHG)		Exhaust	GHG trap heat in the earth's atmosphere which leads to global warming. Global warming causes sea level rise, more intense storms, and changing weather patterns including more drought in some places and more rainfall in others. This leads to problems such as wildfires and floods.	Global
Oxides of nitrogen (NOx)		Exhaust	NOx is a precursor to ozone, NO_2, nitrate secondary particulate matter, acid deposition, and peroxyacetyl nitrate among other components of smog. Smog can cause eye irritation, chest pain, coughing, asthma, and cardiovascular and lung disease.	Regional
Fine Particulate Matter	Particulate matter less than 2.5 microns in diameter (PM2.5)	Road dust, brake wear, tire wear	Fine particulates in the air are a component of smog and lead to heart and lung disease.	Local
	Diesel particulate matter (DPM)	Exhaust	DPM is a toxic air contaminant. People regularly exposed to DPM have a higher risk of cancer.	Local

Source: Port of Oakland

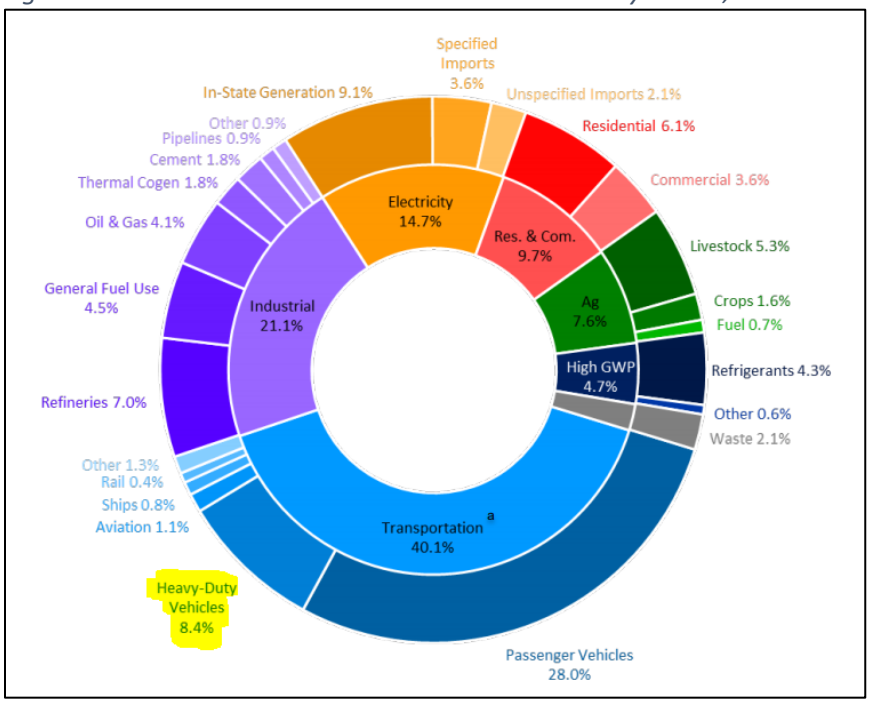
Each of these emissions of concern is discussed further below.

3.1. Greenhouse Gases

California, as a national leader in trying to mitigate the effects of climate change, has set its own greenhouse gas reduction goals through various laws and a suite of Executive Orders issued by the two most recent governors. AB 32, passed by voters in 2006, requires the State to reduce its GHG emissions

to 1990 levels by 2020. The State's Cap-and-Trade program was established in 2013 as a result of AB 32. The State plans to reach its goals by targeting different sectors, including power generation and transportation. Heavy-duty vehicles were responsible for about 8% of statewide GHG emissions in 2017 (CARB, 2019a).

Figure 2: State-wide Greenhouse Gas Contributions by Sector, 2017



Source: CARB (2019a), page 6

A summary of the Executive Orders is provided in Table 3.

Table 3: Summary of Relevant Executive Order

Executive Order	Date	Summary
S-3-05	June 1, 2005	Reduce GHG 80% below 1990 levels by 2050
B-16-12	March 23, 2012	1 million ZEVs on the road by 2020 1.5 million ZEVs by 2025
B-30-15	April 29, 2015	Add interim goal to cut GHG 40% below 1990 levels by 2030
B-32-15	July 17, 2015	Create a Sustainable Freight Action Plan that establishes goals for zero-emissions vehicles in freight[8] Goal: deploy over 100,000 zero-emissions capable freight vehicles and equipment by 2030
B-48-18	January 26, 2018	250,000 electric vehicle charging stations and 200 hydrogen refueling stations by 2025 and 5 million zero-emissions vehicles by 2030

Source: Port of Oakland

[8] The California Department of Transportation, CARB, the CEC and the Governor's Office of Business and Economic Development collaborated on the Sustainable Freight Action Plan, which was published in July 2016. The target for transitioning to zero-emissions equipment is presented on page 10 of that report.

One interesting aspect of battery-electric trucks is that from a greenhouse gas perspective they are only as clean as the grid used to charge them. California has a Renewables Portfolio Standard (RPS) that requires all electrical grids in the State to achieve specific levels of renewable (carbon-free) electricity by year. A simplified summary of the goals is shown in Table 4 below.

Table 4: California Renewables Portfolio Standard

By End of Year	Minimum Percent Renewable
2020	33%
2024	44%
2027	52%
2030	60%
2045	100%

Source: California Energy Commission[9]

3.2. Ozone

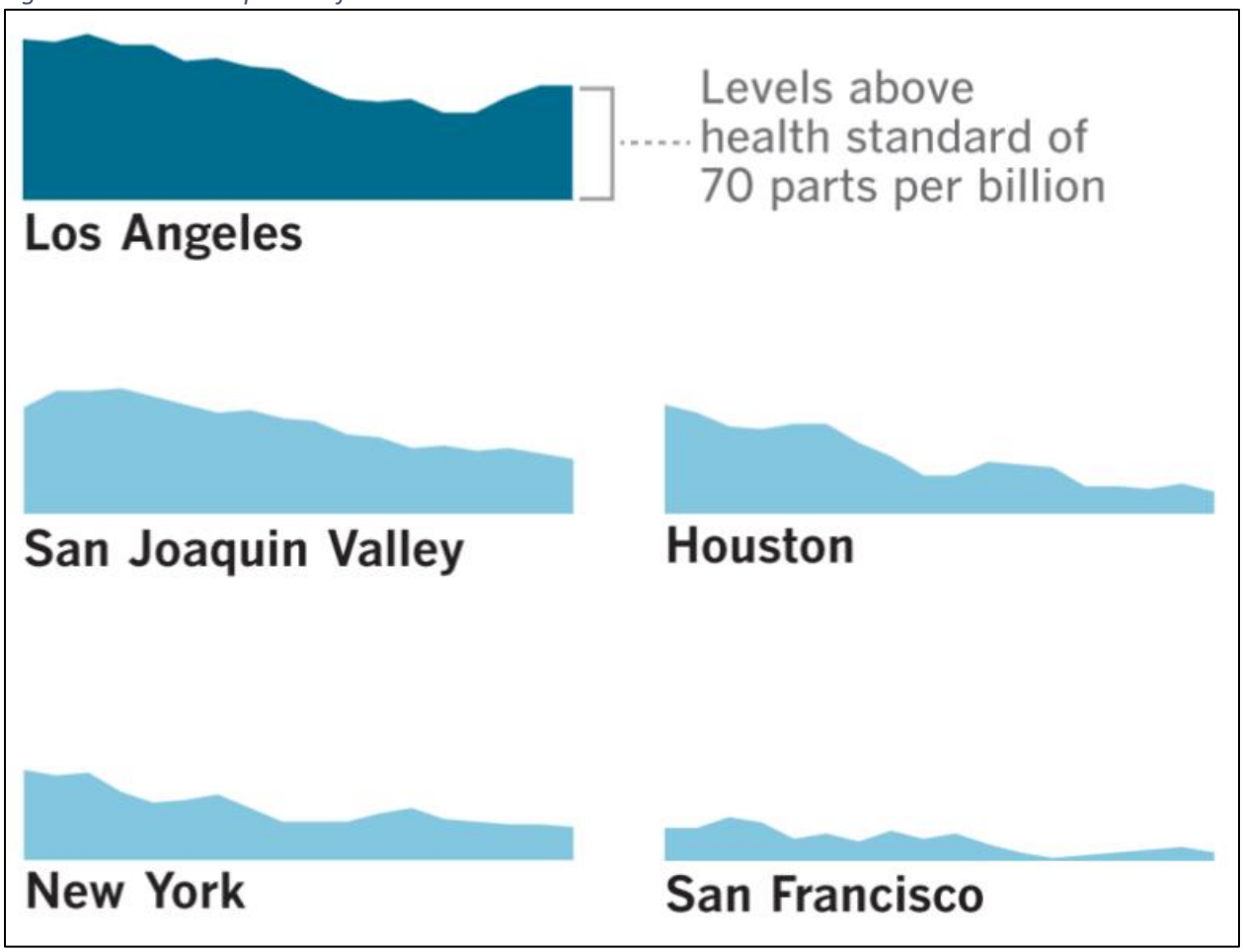
NOx and hydrocarbon molecules react in the presence of sunlight to form ground-level ozone which leads to smog. NOx emissions occur primarily from combustion sources, including diesel engines. Hydrocarbon emissions have many sources, including vegetation, oil and gas production, and solvent use, among others. Smog formation occurs over many hours, thus smog pollution is of a regional nature and affects large areas within an airshed.

For context, the graphic below shows ozone levels in the San Francisco Bay Area compared to other parts of California and the country based on data from air quality monitoring stations since 2001. The measurements are highest daily readings in 3-year averages. The graphic is from a July 1, 2019 article in the LA Times[10]. It shows that ozone in the Los Angeles air basin is currently a much bigger problem than other locations in the state and country.

[9] CEC, "Renewables Portfolio Standard – Verification and Compliance," accessed 10/24/2019, https://www.energy.ca.gov/programs-and-topics/programs/renewables-portfolio-standard/renewables-portfolio-standard-1

[10] July 1, 2019 article in the LA Times titled "*The war on Southern California smog is slipping. Fixing it is a $14-billion problem.*" https://www.latimes.com/local/lanow/la-me-smog-southern-california-20190701-story.html

Figure 3: Ozone Comparison for Various Cities



Source: LA Times article dated July 1, 2019

Given the lower ozone levels in the San Francisco Bay Area, NOx emissions are of less concern in the Bay Area as compared to Los Angeles. In addition, NOx sources that contribute to ozone pollution are widespread and of lower importance within the context of local community air quality planning. For example, there are no NOx reduction goals in the West Oakland Community Plan (WOCAP, 2019). The WOCAP only mentions ozone in the glossary section, and only mentions NOx in the context of describing CARB regulations.

3.3. Fine Particulate Matter

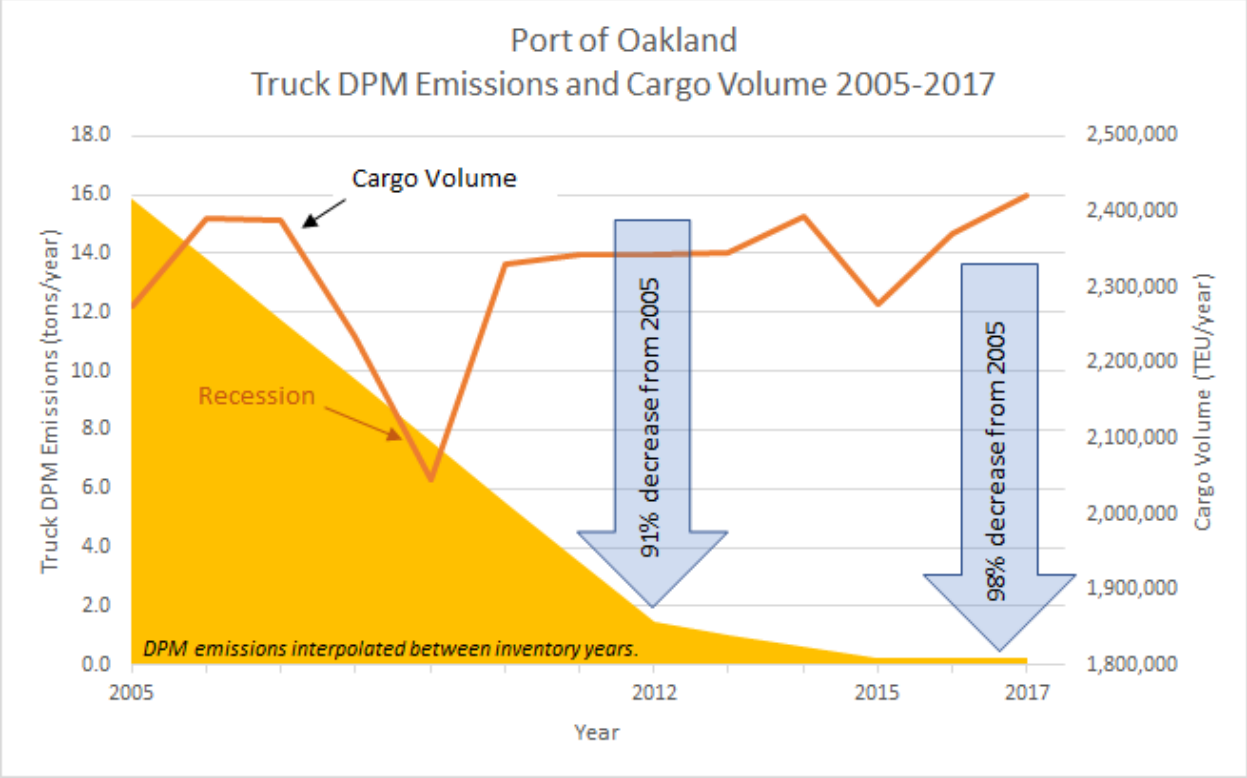
Truck-related fine particulate matter comes from multiple sources, including road dust, brake and tire wear, and engine exhaust. PM2.5 and DPM are a local problem because they have the most impact on the people located near the source.

- Health impacts from PM2.5 include premature mortality, heart disease and respiratory illnesses such as asthma and bronchitis.
- Particulate matter in the exhaust from diesel engines, DPM, is a toxic air contaminant that causes an increase in the risk of cancer to people regularly exposed to it.

The transition to zero-emissions trucks will do little to reduce the PM2.5 emissions from brake and tire wear and road dust. The WOCAP identifies increased street sweeping as the best way to mitigate road dust[11].

The following chart shows that drayage truck DPM emissions at the Port decreased 98% over 2005 baseline levels, even as cargo volumes grew. The orange line shows cargo volume for each year, read off the right-hand vertical axis (the right y-axis). The gold area shows DPM emissions, read off the left y-axis. The data are from the Port's emissions inventories.

Figure 4: Drayage Truck DPM Emissions and Cargo Volume at the Port



Source: Port of Oakland

The 98% reduction in DPM was achieved by fully turning over the truck fleet to model year 2007 and newer engines with installed exhaust treatment systems such as diesel particulate filters.

3.4. Health Impacts in West Oakland

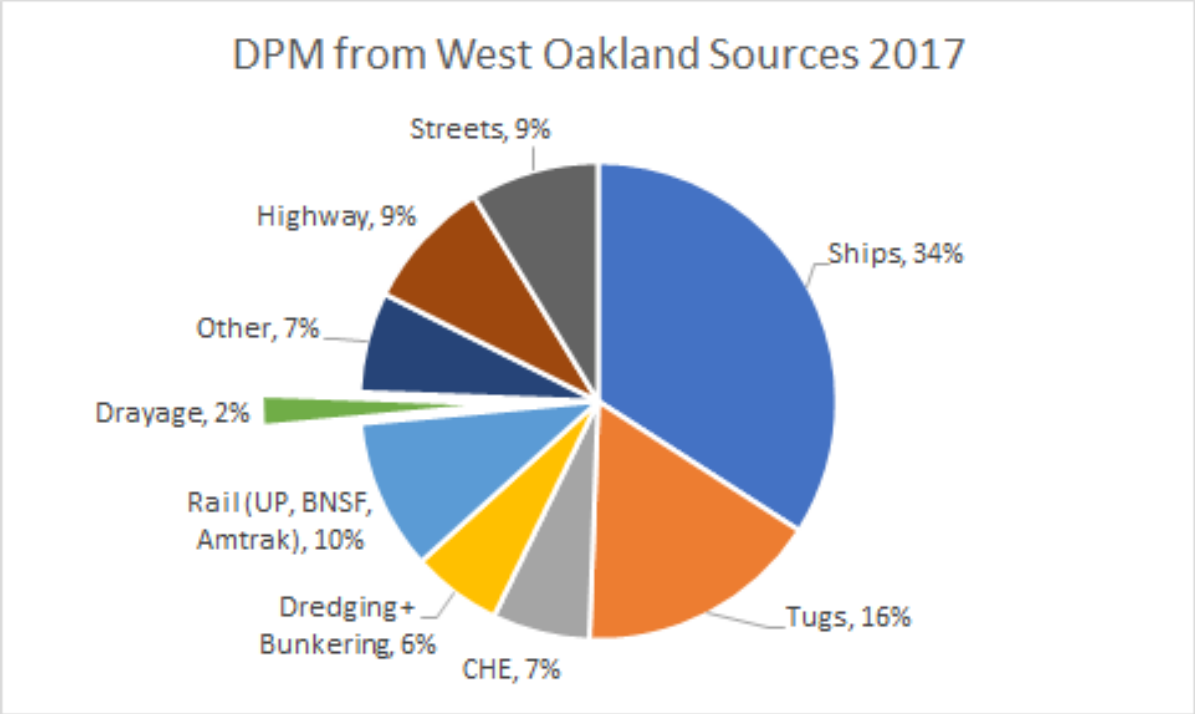
The biggest source of new information since the 2020 and Beyond Plan was approved in June 2019 is from the latest health risk modeling conducted by BAAQMD.

BAAQMD did a health risk assessment to support the WOCAP. The final results were published in the Final Environmental Impact Report (FEIR) on September 26, 2019 (BAAQMD, 2019). The BAAQMD emissions inventory shows that trucks serving the Port emitted 0.50 tons of DPM per year in 2017[12], including when they are driving on local streets and highways. The 0.50 tons accounted for about 2% of DPM from local sources. For context, non-Port trucks on the highways and surface streets contribute

[11] Final WOCAP Strategy #59, page 6-27.
[12] Final WOCAP EIR, Appendix II, Table 2-3 on page A.II-9

about 18% of DPM from local sources. Ships and tugs combined contribute about 51% of DPM from local sources.

Figure 5: DPM from Local West Oakland Sources in 2017

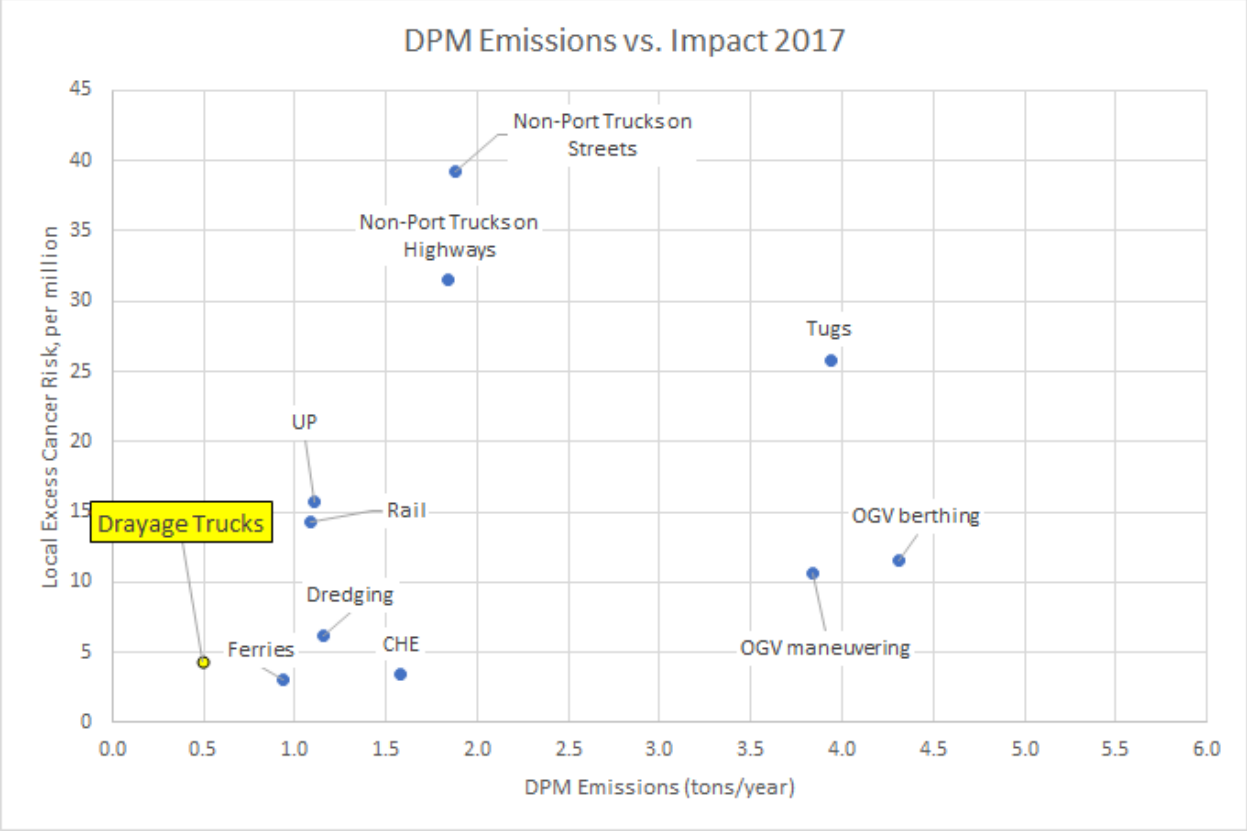


Source: Port of Oakland using BAAQMD data from Public Record Request #2019-10-0109

Figure 6 shows modeled DPM emissions and population-weighted excess cancer risk from different mobile sources in West Oakland in 2017. The x-axis shows the amount of emissions and the y-axis shows local excess cancer risk. Sources in the upper left area have high impact but low emissions. Sources in the lower right area have lower impact but higher emissions. Impacts are lower when the emissions occur farther away from residences.

All trucks serving the Port are in the "Drayage" category, which is highlighted yellow. Trucks serving the Port are low in both emissions and health impact relative to other sources in the Port area.

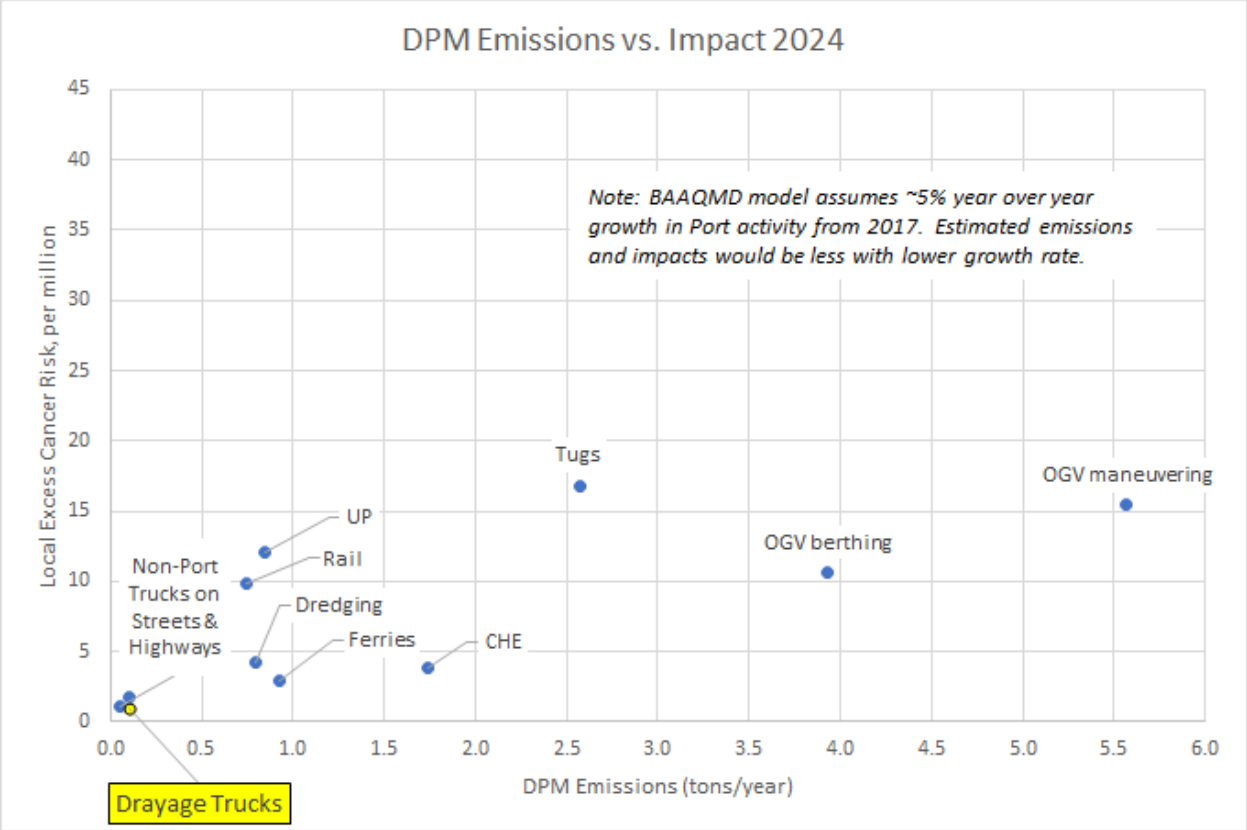
Figure 6: DPM Emissions & Population Weighted Cancer Risk for Local Sources in West Oakland in 2017



Source: Port of Oakland using BAAQMD data from Public Record Request #2019-10-0109

The same information is presented in Figure 7 projected out to the year 2024.

Figure 7: DPM Emissions & Population-Weighted Cancer Risk for Local Sources in West Oakland in 2024



Source: Port of Oakland using BAAQMD data from Public Record Request #2019-10-0109

Figure 7 shows that drayage truck emissions and health impacts decrease by about 80% by 2024 due to measures that are already in place, including CARB's Drayage Truck Rule and the upcoming Heavy-Duty Inspection and Maintenance Rule. (These rules are discussed in more detail in Section 4 of this report.) CARB is developing an Advanced Clean Truck rule which will start requiring manufacturers to sell zero-emissions trucks. However, since the mandates will not go into effect until 2024, the health risk reductions achieved in 2024 will not be due to the adoption of zero-emissions trucks. These reductions will occur even with an entirely diesel fleet.

Non-Port truck emissions and impacts also decrease significantly by 2024 due to the CARB Truck and Bus Rule, which essentially ensures that all trucks become as clean as drayage trucks.

It is important to note that the BAAQMD study assumed that Port activity will increase 5% per year starting in 2017. This is an unrealistic growth forecast not supported by the historic business activity trend shown in Figure 4. The Port has had multiple conversations and written multiple comment letters stating that 5% is not a reasonable growth forecast and suggested that a 2.2% growth rate is more realistic[13]. A 5% compounded annual growth rate applied to 2017 cargo volume means that the Port would be at 3.4M TEU/year in 2024. With a more reasonable 2.2% growth rate, the Port would be at

[13] The Bay Conservation and Development Commission hired The Tioga Group to conduct a study titled "*2019-2050 Bay Area Seaport Forecast*" which was presented to the Seaport Advisory Committee on June 27, 2019. The study is currently being finalized. The 2.2% growth forecast corresponds to the Moderate Growth case in the study.

about 2.9M TEU/year, or 85% of BAAQMD's scenario. Drayage truck emissions and impacts will therefore be about 15% less than what is shown in Figure 7.

The West Oakland Truck Management Plan will further reduce exposure by keeping trucks away from residential areas, see Section 4.7. The benefits of the Truck Management Plan are not included in the health risk analysis detailed above.

4. Status of Truck Regulations and Truck Management Efforts

This section discusses at a high level the status of upcoming truck regulations and legislation as well as different truck technologies.

4.1. Advanced Clean Truck Regulation

CARB is currently developing its Advanced Clean Truck Regulation, which applies to truck manufacturers. CARB held a workshop on August 21, 2019 to present its proposed regulation. The rule will require large manufacturers to sell a certain percentage of zero-emissions trucks starting with model year 2024. The rule will have sales targets for different size trucks, from large delivery vans to box trucks to drayage trucks. For example, in 2024, at least 3% of each manufacturer's California drayage truck sales must be zero-emissions. That percentage increases 2% each year. If a manufacturer cannot sell enough zero-emissions Class 8 drayage trucks to meet their target, they can make up for it by selling a higher-than-required percentage of smaller trucks.

The rule will also require large fleets to report information about their trucks starting in 2021. This will help CARB formulate their next set of rules which will mandate fleet owners to start turning over certain percentages of their fleets to zero-emissions.

The schedule for this regulation shows an initial board hearing in December 2019, followed by a final decision at a second board hearing mid-2020.

4.2. Heavy Duty Inspection and Maintenance Regulation

This is another regulation currently being developed by CARB. The goal of the program is to ensure that all trucks in the state are being maintained well enough that their engines meet the emissions standards for their model year. All truck engines of model year 2013 and newer come equipped with on-board diagnostics (OBD). OBD systems monitor engine and emission control system performance, flag emission control system failures with a malfunction indicator light (MIL) for the driver, and produce reports via a series of codes. Technicians can use the codes to identify and remedy malfunctions that affect emissions. Proposed ideas for implementation include mobile inspectors, telematics, kiosks, and repair facilities. Remote sensing devices can be used to identify and fix faulty emissions abatement devices on trucks and buses between periodic OBD data inspection cycles. CARB anticipates finalizing the regulation some time in 2020.

4.3. AB 5 Worker Status: Employees and Independent Contractors

This is a new California law signed by Governor Newsom on September 18, 2019. The bill makes it much more difficult for workers to be classified as independent contractors instead of employees. This inserts a high degree of uncertainty into how truck drivers will operate after January 1, 2020. It is not clear whether truck owners will be able to continue operating independently or if they will need to be hired

by trucking companies. Trucking associations tried unsuccessfully to get trucking listed as an exemption to the law to help drivers who prefer to operate independently.

4.4. California Senate Bill 210

SB 210 Heavy-Duty Vehicle Inspection and Maintenance Program is a new state bill that will require smog checks for trucks, similar to cars. This will ensure that truck engines are meeting their target emission standards. The bill was signed by Governor Newsom on September 20, 2019. There is no effective date for the regulation itself. The bill states that CARB and the Bureau of Automotive Repair must implement a pilot program first, then no later than two years after the completion of the pilot program, develop and implement the full program.

4.5. Drayage Truck Regulation and Diesel Engine Standards

As previously stated, by the end of 2022, every truck at the Port will have a 2010 engine or newer. The PM reduction to current standards occurred with 2007 engines. Further NOx reductions came with model year 2010 engines, but PM emission levels remained the same. All model year 2013 engines and newer are required to have improved OBD systems which allows drivers, technicians, and inspectors to better identify engine performance issues.

Engine Model Year	PM Standard (g/bhp-hr)	NOx Standard (g/bhp-hr)
1993	0.25	5.0
1994	0.10	5.0
2007	0.01	1.2
2010	0.01	0.2*
2015 Optional Low NOx Standards	0.01	0.10, 0.05, 0.02
* The emission standard for NOx decreased to 0.20 g/bhp-hr with a phased-in approach based on percent of sales starting in 2007 and reaching 100% by 2010.		

Source: Port of Oakland based on Dieselnet.com/standards/us/hd.php, Table 1

Manufacturers rely on diesel exhaust aftertreatment devices to meet engine standards. The typical exhaust device arrangement has a diesel oxidation catalyst (DOC) followed by a catalyzed diesel particulate filter (DPF) which both help remove PM. The DOC oxidizes hydrocarbons, carbon monoxide and unburned fuel. The exhaust then flows through a honeycomb filter in the DPF that traps remaining DPM. The DPM is oxidized as the engine, DOC, and DPF heat up during normal operations, called passive regeneration, or may need active (also called forced) regeneration if the truck is only used for shorter duty cycles and never heats up sufficiently. Noncombustible residuals in engine oil and fuel build up within the DPF over time, reducing its effectiveness. The DP must be removed and the ash cleaned out periodically, about once a year.

Next in the exhaust treatment sequence is a selective catalytic reduction (SCR) unit to reduce NOx emissions. The chemical reaction requires diesel exhaust fluid (DEF, usually a urea solution) as a catalyst, which is stored in a separate tank.

Port of Oakland Drayage Truck Compliance

The compliance rate for trucks serving the Port is very high, about 99%. According to data provided by BAAQMD[14], CARB found only three emissions violations during 198 drayage truck inspections conducted between 2016 and 2018. These inspections were done by CARB enforcement staff in support of the CARB Drayage Truck Regulation.

4.6. Renewable Diesel

A simple way to reduce GHG emissions from diesel engines is to switch to renewable diesel. Renewable diesel is a direct replacement for petroleum-based diesel so there is no modification needed to store or use the fuel in existing engines. It does not clog filters, gel at cold temperatures, or separate and foul in tanks the way biodiesel can. Renewable diesel is made from agricultural products such as waste vegetable oils and animal fats. The Port's fleet of equipment is switching to renewable diesel starting in January 2020, pending Port Board approval. For the Port's contract, renewable diesel costs about 16¢/gallon more than conventional diesel.

The carbon intensity of renewable diesel is much lower than conventional petroleum-based diesel. A carbon intensity (CI) score is a measure of the full life cycle, or "fuel pathway" of GHG emissions resulting from the production, transportation, and consumption of a fuel. The CI score depends on the origin of the fuel, methods used to produce and process it, how it is transported to the end user, and how it is used, e.g., in a particular type of diesel engine. CI is expressed as the grams of CO2 equivalent emissions per mega Joules of fuel energy (gCO2/MJ). The current carbon intensity of conventional diesel as determined by CARB is 100.45 gCO2e/MJ.[15]

The Port will be getting renewable diesel produced by Neste. The carbon intensity of Neste's renewable diesel ranges from 16.89 gCO2e/MJ to 39.06 gCO2e/MJ[16], depending on what feedstocks were used (i.e. agricultural waste or animal fats) and where the fuel was made and shipped from, either their Finland or Singapore refineries.

Comparing carbon intensity scores shows that renewable diesel reduces greenhouse gases by about 60% to 80% depending on the feedstock used to produce it and fuel transportation. Renewable diesel is also reported to reduce DPM and NOx emissions, and has higher cetane, lower sulfur and polyaromatics, and other favorable properties compared with conventional diesel[17].

Renewable diesel is not yet common at public gas stations. According to Western States Oil, Neste's West Coast distributor for renewable diesel, it is available at a few Northern California fueling stations including San Leandro, San Jose, and near Stockton.

4.7. West Oakland Truck Management Plan

The West Oakland Truck Management Plan, a joint effort by the City and Port, was approved in April 2019. It is an action-based plan to reduce the effects of trucks on local streets and residences by

[14] Final WOCAP Volume I (WOCAP, 2019), Table 7-1 page 7-9.
[15] https://ww3.arb.ca.gov/fuels/lcfs/fuelpathways/pathwaytable.htm
[16] Email correspondence on 9/27/19 from Dayne Delahoussaye (Neste) to Tracy Fidell (Port), with subject line: "LCFS question on CI score"
[17] Neste Renewable Diesel Handbook, Table 4 and Figure 8
https://www.neste.us/sites/neste.com/files/attachments/neste_renewable_diesel_handbook.pdf

improving truck routing and signage, improving truck parking rules, increasing enforcement, and using street design to make streets and intersections safer for pedestrians and bicyclists. The goal is to improve the quality of life for people living and working in West Oakland. The Plan has ten strategies, summarized below.

1. Intersection Safety
2. Improve Truck Routing
3. Update Truck Routes
4. Improve Truck Signage
5. Traffic Enforcement
6. Street Design of Truck Routes
7. Training for Parking Tickets
8. Change Parking Regulations
9. Consider Increasing Truck Parking Fines
10. Parking Enforcement

Year 1 of implantation started July 1, 2019. Four of the strategies identified for first-year implementation have already begun, these are: #2 Improve Truck Routing, #3 Update Truck Routes, #4 Improve Truck Signage, and #8 Change Parking Regulations. The City, Port and Police team met with consultants three times in July and August 2019 to start each of the strategies. Technical analyses that support recommended changes to truck routes and parking should be completed by December 2019.

5. Literature Review

Other entities have recently completed studies about zero-emissions trucks and equipment, including the Ports of Long Beach and Los Angeles, CARB, BAAQMD, and the California Energy Commission. Port staff have included the most recent and relevant of these reports and presentations and summarized their findings in this section.

5.1. 2018 Feasibility Assessment for Drayage Trucks

The Ports of Long Beach and Los Angeles released a report dated April 2019 titled "2018 Feasibility Assessment for Drayage Trucks," (Tetra Tech, 2019) on the feasibility of deploying clean truck technology to begin meeting their ambitious goal of 100% zero-emissions trucks by 2035. The two ports will update this study at least every three years, or more frequently if warranted. Some conclusions in the study related to zero emissions trucks are:

- There is currently only one company making battery-electric trucks: BYD. The report describes this as an "early commercial" launch. For background, the BYD trucks at GSC Logistics are a demonstration project funded by the state and administered through SCAQMD and BAAQMD, but BYD also lists the same trucks for sale through HVIP.
- As described in Section 2, battery-electric trucks are currently at Technology Readiness Level (TRL) 6 to 7 which means they are in demonstration and initial systems conditioning and might be at TRL 8 by 2021 with working versions available. The on-going range challenge may limit the usage to short-haul applications.
    - Daimler plans to produce its e-Cascadia truck by 2021.
    - Volvo announced it will commercialize battery-electric trucks in North America after launching them in Europe.
    - Tesla made announcements about a high-performance long-range battery-electric truck, but no information about delivery dates.
- Hydrogen fuel cell trucks are currently at an earlier stage of development of TRL 5 to 6 and might be at TRL 6 or 7 by 2021. The biggest remaining hurdles remain cost of ownership including access to hydrogen fuel and how to store the fuel on the truck.

- A new company, Nikola Motors is testing two different hydrogen fuel cell truck models.
- Toyota and Kenworth are designing and testing hydrogen fuel cell powertrains which could expedite their commercialization.

In August 2019, Port staff contacted their air quality staff counterparts at both POLA and POLB to ask about progress on their zero-emission truck goals. Both ports confirmed that they do not plan to set any interim goals prior to the 2035 target.

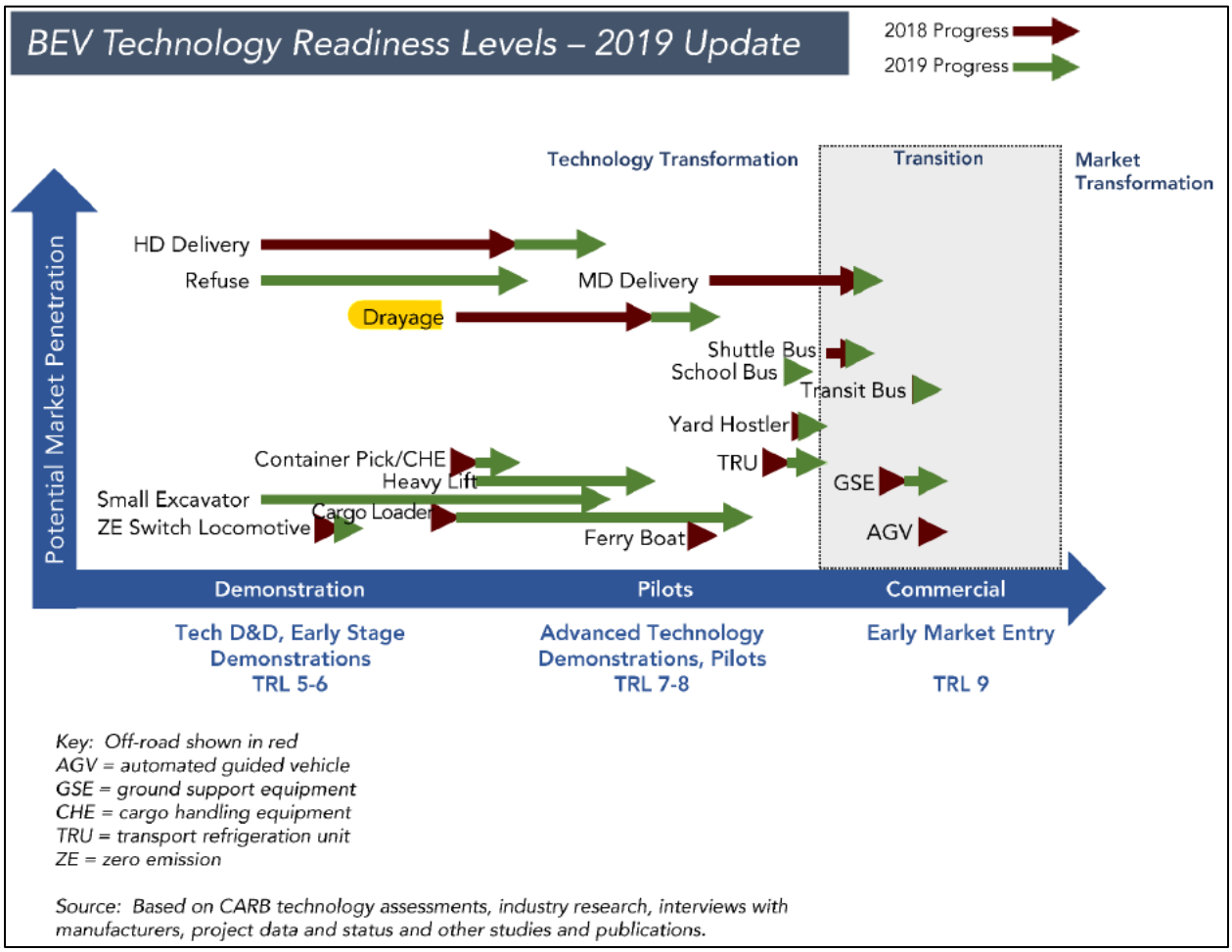
5.2. Charging Infrastructure Strategies: Maximizing the Deployment of Electric Drayage Trucks in Southern California

Ms. Margaret Gordon of West Oakland Environmental Indicators Project sent Port Staff an email on June 17, 2019 with this report attached. This 80-page report, written by UCLA Luskin Center for Innovation, is focused on developing a strategy for rolling out electric truck charging stations (Bradley et al., 2019). It does not cover hydrogen fuel cell trucks. The report is specific to the San Pedro Bay area, and the results section lists possible locations for charging stations in the first five years within 5 and 10 miles of the San Pedro Bay Ports. Interestingly, on page 20 of the report it says the Port of Long Beach "is not considering drayage charger placement within the port property."

5.3. Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives For Low Carbon Transportation Investments and the Air Quality Improvement Program

Appendix D of the "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives For Low Carbon Transportation Investments and the Air Quality Improvement Program" (CARB, 2019b) is intended to guide CARB in choosing investment options for heavy-duty truck technology. CARB released this report on August 1, 2019. For battery-electric trucks, the report identifies transit buses as the most promising application followed by medium-duty delivery trucks. The report states that progress has been made for garbage trucks and heavy-duty trucks and that technology transfer from buses will help speed development. It identifies 2021 as a timeframe for pilot stage for these applications. Figure 8 shows the technological readiness and potential market penetration for battery-electric equipment as presented in the CARB report.

Figure 8: Battery-Electric Technology Readiness Levels



Source: Figure 9, page D-40 of "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives For Low Carbon Transportation Investments and the Air Quality Improvement Program; Appendix D: Heavy-Duty Investment Strategy" (CARB, 2019b).

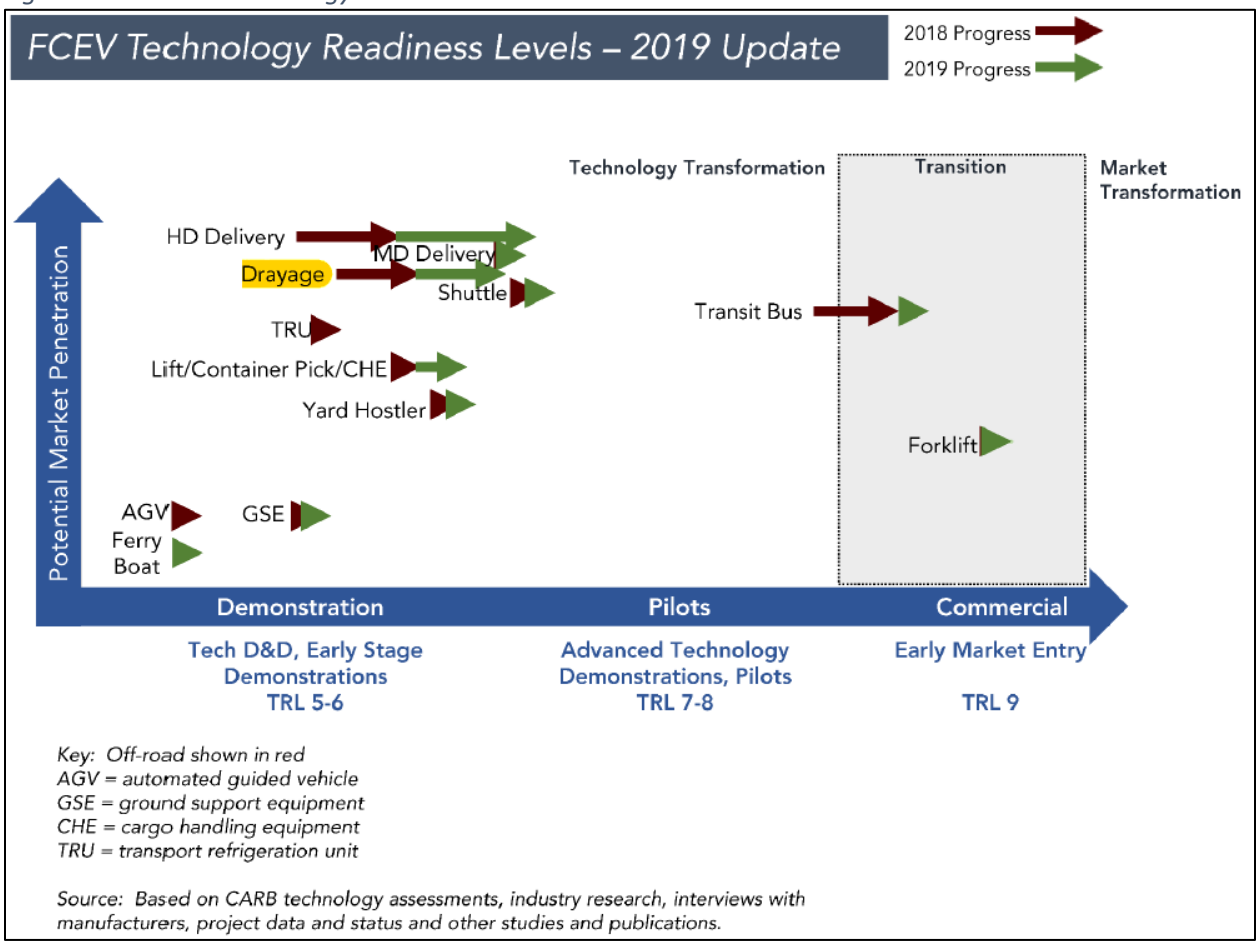
Battery-electric drayage trucks are identified as being between Demonstration and Pilot stages, in TRL 7 and 8. Once developed, battery-electric drayage trucks would have a relatively high Potential Market Penetration.

The report identifies the following barriers to battery-electric adoption:

- Infrastructure
- High cost
- Limited vendors
- Limited range
- Heavy batteries and axle loads

The technology readiness for hydrogen fuel cell trucks lags behind battery-electric, as shown in Figure 9.

Figure 9: Fuel Cell Technology Readiness Levels



Source: Figure 10, page D-46 of "Proposed Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives For Low Carbon Transportation Investments and the Air Quality Improvement Program; Appendix D: Heavy-Duty Investment Strategy" (CARB, 2019b).

Hydrogen fuel cell trucks are at TRL 5 or 6, which means they are not yet in the demonstration phase.

The report identifies the following barriers to hydrogen fuel cell adoption:

- Cost of hydrogen fuel
- Infrastructure
- Limited vendors
- Unknown life cycle
- Unknown business case
- High cost

5.4. Electric Vehicle Outlook 2019

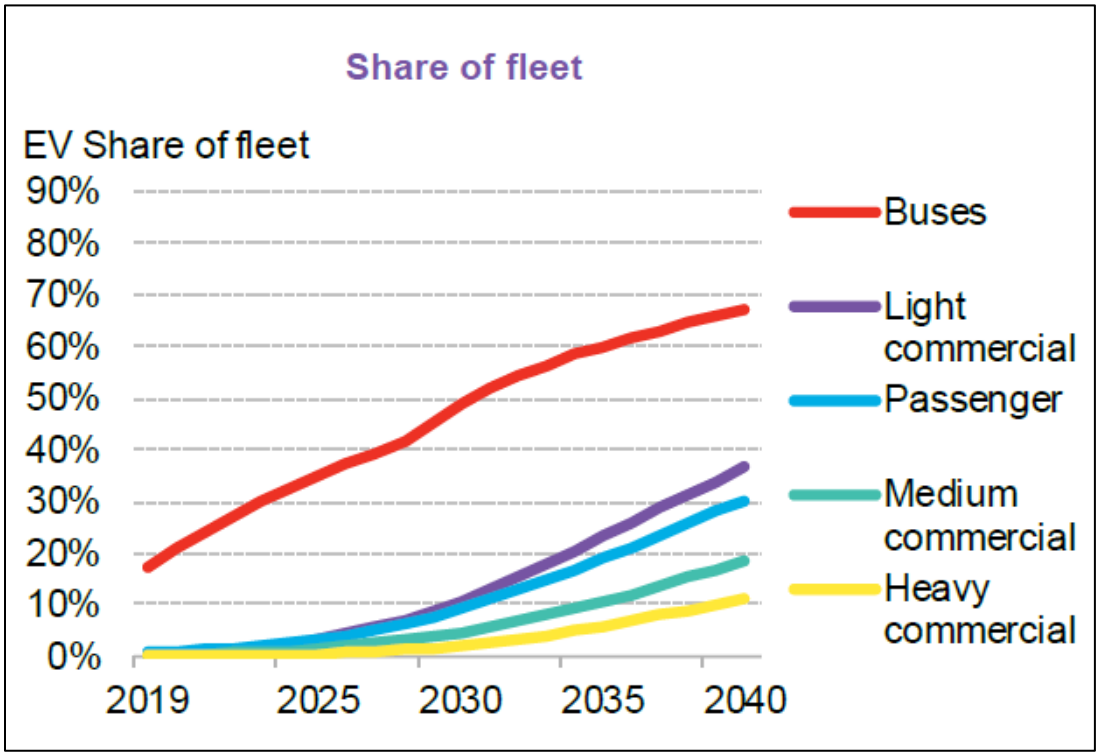
This is a report[18] written by BloombergNEF and presented to the California Energy Commission on August 5, 2019. The presentation was given at the CEC's Advisory Committee Meeting for 2019-2020 Investment Plan Update.

BloombergNEF is a consulting firm providing research and analytics specific to the energy economy. They specialize in clean energy and advanced transport. According to their website, they provide

[18] On-line, interactive report available at: https://about.bnef.com/electric-vehicle-outlook/.

"forecasts that frame financial, economic and policy implications of industry-transforming trends and technologies." Figure 10 shows their electric vehicle fleet penetration forecasts by application type.

Figure 10: Electric Vehicle Predicted Share of Fleet by Year to 2040



Source: Slide 23 of BloombergNEF Electric Vehicle Outlook 2019 presentation to CEC on 8/5/19

BloombergNEF expects about 10% of the heavy commercial vehicle fleet to be electric by 2040. This is a global forecast so it does not reflect California's stricter requirements and faster adoption of clean technology. However, it gives an interesting reference point for the adoption rate of zero-emissions trucks.

5.5. California Sustainable Freight Action Plan

This July 2016 report was co-authored by California Department of Transportation, CARB, California Energy Commission, and the Governor's Office of Business and Economic Development pursuant to Executive Order B-32-15 (CA DOT, 2016). It established a vision of a cleaner, more efficient freight transportation system. Among other things, it establishes a statewide target for transitioning to zero-emissions technology. The goal is to "deploy over 100,000 freight vehicles and equipment capable of zero emission operation and maximize near-zero emission freight vehicles and equipment powered by renewable energy by 2030."

Appendix B of the report has a bottom-up analysis by CARB on what may be possible between now and 2030. It considered incentive programs, market demand and turnover, technology status, and potential future policies. The 100,000 target includes trucks, locomotives, transportation refrigeration units (TRU), cargo handling equipment, commercial harbor craft, and airport ground support equipment.

Port staff requested a state-wide freight equipment population from CARB to get a sense of the percent represented by the 100,000 goal. According to CARB staff, there are about 180,000 TRUs, 4,600 pieces

of cargo handling equipment, and 1,000,000 freight trucks of all sizes in California[19]. Disregarding other types of equipment mentioned in the goal statement (such as locomotives, harbor craft, airside equipment), the 100,000 goal represents about 8% zero-emissions trucks and equipment by 2030.

5.6. Owning Our Air: The West Oakland Community Action Plan

The West Oakland Community Action Plan (WOCAP, 2019) was written jointly by the BAAQMD and West Oakland Environmental Indicators Project as part of AB 617 and included extensive stakeholder involvement. The Port participated in the WOCAP development process as Steering Committee members and panelists at multiple meetings and Town Halls. The Final WOCAP was adopted by the BAAQMD Board on October 2, 2019 and will be presented to the CARB Board for approval in December 2019.

Unlike the other documents in this literature review section, the WOCAP is not a study focused on the adoption rate of zero-emissions trucks. However, it includes a relevant assumption in Section 6 that truck owners operating in West Oakland and at the Port will "replace eight diesel trucks with zero emission trucks annually."[20] Port staff confirmed with BAAQMD that their assumption of 40 zero-emissions trucks from 2020 to 2024 is for a mix of light-duty, medium-duty, and heavy-duty trucks and is in addition to the 21 BYD and Peterbilt trucks coming to the Port as demonstration projects (see Section 7 for an update on the Port's demonstration projects). If all 40 of the assumed replacement trucks are trucks serving the Port - which is unlikely - this indicates that the BAAQMD expects less than 1% turnover to zero-emissions by 2025.

The BAAQMD assumption is based on "the current interest/availability of zero-emission trucks, expected future availability of zero-emission trucks, details from recent truck replacement projects, and estimated vehicle costs"[21]. The BAAQMD has access to the best and most recent sources of information as far as grant applications and level of interest, so their informed assessment provides another useful reference point.

6. Current Truck Fleet Information

This section gives background information about the current makeup of the fleet of trucks serving the Port, the weight limits for trucks on roadways, and the available mechanisms for reaching truck drivers.

6.1. Overview of Trucks Serving the Port

The Port started its Secure Truck Enrollment Program (STEP) in June of 2010. All trucks entering one of the Port's marine terminals are required to register in the STEP system. In 2018 there were 8,867 trucks registered. As of June 2019, there were 9,938 trucks registered. The STEP registry may not provide an accurate picture of the current truck fleet because trucks are rarely de-registered, therefore the data set includes an unknown number of older and inactive trucks. Starting January 2020, the Port will charge a one-time sign-up fee as well as annual fees for the STEP program. The registry will become more

[19] Email correspondence on 9/27/19 from Ajay Mangat (CARB) to Tracy Fidell (Port), with subject line: "question about Sustainable Freight Action Plan target"
[20] WOCAP (2019), page 6-8, 3rd bullet
[21] Email correspondence on 9/26/19 from Areana Flores (BAAQMD) to Tracy Fidell (Port), with subject line: "Question on WOCAP ZE truck assumption"

accurate once inactive trucks are removed. Until then, existing data provide a sense of the makeup of the drayage truck fleet[22].

- Over 700 Licensed Motor Carriers operate at the Port
  - 35% of LMCs have three or fewer trucks
  - 70% of LMCs have ten or fewer trucks
  - 4% of LMCs have over 50 trucks
- Almost 50% of registered trucks are model year 2010 or older. Most of these trucks probably have engines that are year 2009 or older. Many of these trucks may no longer come to the Port, but that will not be known until the STEP Registry is updated in early 2020.
  - Trucks with engines older than model year 2007 were banned from the Port starting in 2013 (2006 engines were allowed if they had a PM filter installed)
  - Trucks with engines years 2007-2009 will be banned from the Port starting January 1, 2023

Table 5: Drayage Truck Compliance Schedule Summary

Truck Engine Model Year	Emission Requirements
Class 8 Compliance Schedule (33,001 lbs. GVWR or greater)	
1994-2006 (pre-1994 not allowed)	After Dec. 31, 2012, PM Filter and; After Dec. 31, 2013, meet 2007 engine standard
2007-2009	Compliant through 2022
2010 and newer	Fully compliant

Source: CARB Handout

6.2. Overweight Corridors

Overweight corridors are an issue because the batteries in battery-electric trucks are so heavy that they increase the weight of the truck which means the driver can haul less cargo. A conventional diesel truck weighs about 17,000 - 18,000 lb with no load, compared to over 26,000 lb for a Generation 2 BYD electric truck.

Trucks on public roadways are governed by Federal and State rules limiting them to a maximum of 80,000 lb overall gross weight. In addition to the overall gross weight, there are per-axle weight restrictions. The front axle, underneath the driver's cab can be no more than 12,500 lb. The axles underneath the container can be no more than 16,500 lb each. Roadways and bridges are designed to handle these weights safely. The additional weight of batteries in battery-electric trucks has to come out of the payload being hauled for a truck to stay under the 80,000 lb limit.

Drivers who need to transport heavy containers can apply for Port and City permits allowing them to carry overweight loads in 40-ft containers only (no 20-ft containers) on special chassis that have three axles in the back instead of the typical two axles. The chassis must have revised Gross Axle Weight Rate

[22] It is important to note that the STEP registry records the model year of the truck, which is usually different from the engine model year. For example, a 2015 truck probably has a 2014 engine in it. However, trucks engines are sometimes replaced, so a model year 2009 truck could plausibly have a 2014 engine in it. For emissions standards, it is the engine year that matters, not the model year of the truck.

plates and a California Highway Patrol Safety Inspection Sticker (renewed every 90 days). The overall gross weight has a maximum of 95,000 lb, or 15,000 lb more than otherwise allowed.

Drivers must first get a Port permit, which involves a Certificate of Insurance, detailed vehicle information, description of load being carried including the weight, description of route, and whether the permit is for a single trip or for continuous operation. Next the driver must get a City permit. The City permit requires that the route be limited to ground-level surface streets with no operation between 7am-9am or 4pm-6pm. Trucks are limited to 30 mph maximum speed and must have signage reading "Vehicle Maximum 30 mph." The Port does not charge for permits; the City charges $50. The permits are good for three months.

Truck scales are located in Fremont, Gilroy, Cordelia, Roseville, Truckee, and Livermore/Pleasanton. If an axle is overweight the driver can try to shift the container front-back on the chassis to move the weight away from a specific axle. If the gross weight is surpassed the truck cannot move. A lighter truck (perhaps with a smaller day cab) can come take the load if that works. If not, they have to contact the cargo owner and get permission to break the seal, open the box, and remove cargo. This is a major ordeal, so drivers are very conscientious of not exceeding the weight limit.

The Port is planning to update its overweight corridor program to consider various maximum weights from 80,000 lb up to 110,000 lb, including different types of chassis and tractors, safe stopping distances, and infrastructure impacts. The Port issued a Request for Proposals on August 30, 2019, and will execute an agreement with the selected consultant in November 2019.

6.3. Trucker Outreach

There are a few different mechanisms for reaching out to truck drivers to convey information.

Trucking Associations

Multiple trucking associations advocate on behalf of truck drivers. Western States Trucking Association (WSTA) publishes a very informative weekly newsletter. This is a good source for staying apprised of current regulations, legislation, and lawsuits affecting drivers. California Trucking Association (CTA) advocates for sound transportation policies and works to maintain a safe, efficient, and environmentally responsible transportation system in the State. CTA recently partnered with PG&E to host a WebEx about incentives for electric truck charging stations, for example. Harbor Trucking Association (HTA) is a coalition of intermodal carriers serving the U.S. West Coast ports advocating for truck efficiency, emission reductions, and more cargo and jobs to West Coast ports. HTA hosts dinner meetings in Oakland following meetings of the Trucker Working Group.

Locally, the Trucker Working Group (TWG) is assembled and run by the Port and an industry representative. It has an email list for broadcasting information such as terminal closures, holidays, and events such as marathons. TWG has lunch time meetings every two months, held at the Port's Harbor Facilities Center. At these meetings, terminal operators provide information about their gates, truck processes, chassis availability, and turn times. Chassis pool operators present information about their operations. Port staff present upcoming projects and Port statistics. For example, at the July meeting, the Port demonstrated its new Oakland Portal on the Port's website.

Environmental Office Hours

Port staff from the Environmental Programs and Planning department have been hosting Office Hours at the SeaLogix building at the Port on a weekly basis since August 2018. The location at SeaLogix is ideal because it is in the same building as the STEP registration office which means a lot of truckers stop by. Port staff greet each driver and ask them about their truck and the type of work they do. Port staff give information about grant and incentive programs to each driver with trucks older than 2010. Port staff also take phone calls during the week from drivers trying to find out more about clean truck grants.

As of early November 2019, Port staff have met with 78 drivers in person plus an additional 20 drivers by phone or email to convey information about clean truck grants.

7. Status of Demonstration Projects at the Port

Two separate zero-emission truck demonstration projects are currently underway at the seaport. This section gives a short overview of each along with a status update as of September 2019.

7.1. ZANZEFF

The Port entered into a Memorandum of Understanding with the Port of Long Beach dated February 7, 2019 to implement a Zero and Near Zero Freight Facilities (ZANZEFF) grant project as part of CARB's transportation electrification program. The Port committed to design and install ten charging stations and provide for a financial match of at least $1.25 million up to $2 million. The ten Level 2 charging stations are being installed at Shippers Transport Express (STE). The design for the chargers is almost complete and the project should begin construction in the next few months. STE will be getting ten Peterbilt trucks, which cost about $470,000 each.

7.2. CARB/SCAQMD/BAAQMD Grant

In early 2017 the South Coast AQMD entered into contracts with several truck manufacturers to demonstrate pre-commercial zero-emission and near zero-emission Class 8 drayage trucks in revenue service at the Ports of Oakland, Los Angeles, Long Beach, and San Diego. Currently, three BYD 8TT battery-electric trucks are in service at GSC Logistics, a Port tenant. Up to eight more trucks are planned for Oakland, but Port staff are not aware that any licensed motor carriers serving the Port has executed an agreement with BYD to demonstrate its trucks.

7.3. Other Grant and Incentive programs

Carl Moyer: The On-Road Heavy-Duty Voucher Incentive Program (VIP) is operated as part of the Carl Moyer Program. Unlike other programs, this voucher grant allows applicants to replace old diesel equipment with newer diesel equipment or other lower emissions technology. For trucks, the old engine must be model year 2009 or older, and it must be replaced with a 2013 or newer or cleaner engine. The old truck must be destroyed; it cannot be sold. The driver needs to apply early enough to get a full year of emission reductions in advance of the regulation barring trucks older than 2010 by the end of 2022. The driver must front the money and wait for reimbursement. The driver is responsible for the taxes on the full sales price of the vehicle, not just their portion. The maximum grant amount is $60,000.

In the most recent grant cycle, ten truck drivers in Alameda County were awarded grants ranging from $15,000 to $60,000 to replace older diesel trucks with newer diesel trucks. It is not known whether these were trucks serving the Port.

Port staff often hear feedback about the Carl Moyer Program during Environmental Office Hours. Some of the feedback Port Staff hear from truck drivers is:

- The rules are complicated and hard to understand
- The application process is difficult
- They don't want to scrap their old truck because it still has resale value
- They can find better prices and bigger selection from dealerships outside the Bay Area that are not on the list of BAAQMD-approved dealerships
- If they don't use one of the BAAQMD-approved dealerships then they have to navigate the application process on their own
- Technical difficulties with the application

The rules and application instructions are hard to understand for drivers with limited English proficiency. Port staff have requested application materials to be printed in multiple languages, particularly Spanish, Punjabi, Chinese, and Vietnamese. Port staff have also invited BAAQMD staff to attend Office Hours to provide in-person help to truckers.

One of the difficulties with the Carl Moyer grant is that the old truck must be scrapped; it cannot be sold. More drivers might be willing to replace their trucks earlier if they could realize the resale value of their truck instead of scrapping it. One solution would be for BAAQMD to allow what's known as a 3-way transaction. This is when, for example, the drayage driver gets a grant to buy a 2015 truck, then sells his 2009 truck to a driver outside of California who in turn scraps his 2003 truck. In this way, the newest truck operates in the Bay Area, the older truck with useful life gets used outside of California, and an even older truck gets scrapped. BAAQMD staff have said they might be willing to consider a 3-way transaction if the applicant is replacing their equipment with a zero-emissions truck.

California HVIP: This is the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project launched by CARB in partnership with CALSTART. In general, equipment owners prefer voucher programs because the voucher is applied directly at the point-of-sale so applicants do not need to front or finance large sums of money and wait for reimbursement. As of July 23, 2019, all funds for fiscal year 2018-2019 were requested, so there is now a waitlist. Additional funds should be available in January 2020. According to the HVIP website mapping tool for deployed vehicles, the program has paid out three vouchers for zero-emissions trucks in West Oakland totaling $525,000.[23]

As of this writing there is one zero-emissions truck model offered in the HVIP program – a BYD truck. The incentive amount is $150,000. The applicant can try to stack grants or can cover the difference.

Proposition 1B Goods Movement Funds: The last application cycle for good movement funds ended in January 2018. Fourteen truckers serving the Port applied for low NOx LNG/CNG or zero-emissions drayage trucks. Grantees are supposed to order the trucks within three months after signing a contract with BAAQMD, but Port staff are unaware that any trucks have been ordered. Trucks should be purchased by December 2021, an extended deadline. One trucker who came to Office Hours stated that

[23] https://www.californiahvip.org/tools-results/#program-numbers, HVIP website accessed 9/27/19, filtered by zip code 94607 and Other Truck for Vocation.

he is having a hard time keeping his replacement vehicle stored while he waits for something to buy. The owner is potentially interested in Daimler's Freightliner eCascadia.

VW Environmental Mitigation Trust Funds: This is a future program with $90M proposed allocation for zero-emissions Class 8 Freight and Port Drayage Trucks. This allocation represents about 21% of the total $423M in California's VW Mitigation Trust. The funding will be split into three equal cycles and awarded on a first-come, first-served basis with a maximum limit of $200,000 per vehicle. This amount includes supportive infrastructure. It is open to drayage trucks, garbage trucks, concrete mixers, and dump trucks. The first cycle is expected to open in Q4 2019. CARB's goal is that at least 50% of the money benefit disadvantaged communities. These will be replacement projects, for equipment with 2012 engines or older.

8. Conclusion

In conclusion, based upon the feasibility analysis, zero-emissions trucks are not currently affordable, cost-effective, commercially available, or operationally feasible. The demonstration projects underway at various California ports, including Oakland, will provide more information which will help address these feasibility issues.

Through this study, the Port has found a few reference points for interim metrics on the pathway to zero emissions. One is the WOCAP assumption for eight new zero-emissions trucks per year starting in 2020. This assumption includes light-duty, medium-duty, and heavy-duty trucks, so it is likely that all eight will be light-duty in the early years. Even if all eight were drayage trucks every year, this would be about 0.4% by 2025. California's Sustainable Freight Action Plan has a combined goal for trucks, trains, TRUs, and CHE that comes to about 8% statewide by 2030. The two Southern California ports do not offer any interim goals before their aspirational 100% by 2035 goal. BloombergNEF forecasts the adoption rate will be about 10% by 2040.

In summary, the transition to zero emissions drayage truck will happen, but it is not clear when or how fast.

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