Maritime Clean Air Strategy

March 2021

Discussion Draft

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Preface

The Port of San Diego (Port) has been investing in and deploying new technologies to improve overall air quality and reduce greenhouse gas emissions in the region in support of collective thrivability for our communities, environment, and regional economy. The Port is positioned to be an innovative leader and good neighbor advancing the next level of clean air investments to benefit everyone who lives, works and plays on and around San Diego Bay.

As an environmental champion, the Port is developing a Maritime Clean Air Strategy (MCAS) as part of continued effort to identify projects that will improve air quality and reduce greenhouse gas emissions, while continuing the transition to more efficient, modern, and sustainable maritime operations.

The MCAS will help the Port determine which efforts are feasible and how they should be prioritized and/or phased in over time. The MCAS is also intended to help clarify the role the Port may play in supporting our tenants and terminal operators with transitioning to zero and near-zero technologies.

The MCAS is an informational document that identifies potential options to improve air quality in and around the Working Waterfront. Public participation has been key to the drafting process, which includes your review of the MCAS Discussion Draft. The MCAS Discussion Draft is available for a four-week public review period beginning on March 23, 2021 and ending on April 20, 2021.

During this review period Port staff will facilitate a Community Conversation on April 7, 2021 to answer questions and solicit feedback on the MCAS Discussion Draft, and will also present to several community-based organizations, including but not limited to the following:

- AB 617 - Portside Community Steering Committee
- Barrio Logan Community Planning Group
- Environmental Advisory Committee
- Maritime Stakeholder Forum
- San Diego Port Tenants Association - Environmental Committee

In addition to providing general feedback, once you have completed review of the MCAS Discussion Draft, please feel free to suggest an aspirational vision statement to include in the final document. Please email your comments to MCAS@portofsandiego.org by Tuesday, April 20, 2021.

Executive Summary

Background Context

The Port's Maritime Clean Air Strategy (or MCAS), is intended to serve as a guidance document that will assist the Board of Port Commissioners (Board) with identifying, prioritizing, and implementing emission reduction initiatives in a holistic and comprehensive manner. The MCAS supports emission reduction efforts that are being advanced as part of the Portside Environmental Justice Neighborhoods (Portside Community) Assembly Bill 617 Community Emission Reduction Plan (AB 617 CERP) by focusing on emissions that are associated with the maritime and the goods movement industry.

As an update to the Port's 2007 Clean Air Program, the MCAS identifies goals and objectives to reduce emissions associated with the following seven maritime-related sources: cargo handling equipment, commercial harbor craft, heavy duty trucks, the Port's fleet, shipyards, ocean-going vessels, and freight rail. These goals and objectives are the result of an extensive stakeholder engagement process that involved representatives from public agencies, non-governmental organizations, businesses, industry, and community residents. The MCAS includes a high-level summary of how emission reduction initiatives can be funded and financed, and it identifies goals to help broaden emission reduction funding opportunities and to promote ongoing collaboration with stakeholders on emission reduction initiatives in an open, transparent and deliberative manner. The goals and objectives for all seven emission sources, as well as funding, are summarized below. The two icons provided below help illustrate which objectives align with State regulatory requirements, and which ones go beyond current State regulatory requirements.

Aligns with State requirements **Goes beyond State requirements**

Goals and Objectives

Cargo Handling Equipment

CHE Goal – Attain substantial reductions for CHE related emissions by facilitating upgrades to ZE/NZE equipment alternatives.

CHE Objective 1: Reduce emissions from cargo handling equipment by approximately 90% for NOx, 80% DPM, and 50% for CO2e below 2019 levels by 2026.

CHE Objective 2: Continue to stay engaged with CARB Rule-making development.

Commercial Harbor Craft

CHC Goal – Reduce emissions from Harbor Craft by advancing emerging zero emission technologies through 2031.

CHC Objective 1: Support ZE Tugboats and Ferries in advance of State regulations, as opportunities become available.

CHC Objective 2: Advance the State's goals for commercial harbor craft by supporting short-run ferry-operators with implementing ZE ferries ***for all new*** short-runs, and by assisting tug-operators with implementing hybrid/electric technologies ***for all new*** excursion vessels.

Heavy Duty Trucks

TRK GOAL 1 – To improve the air quality of the Portside Community, accelerate the phase-out of diesel trucks that call to the Port's marine terminals, in alignment with the State's long-term goal to reach 100% ZE Drayage Trucks by 2035.

TRK Objective 1A: Develop a short-haul on-road ZE Truck Shuttle Program comprised of a trucking company and/or independent drivers to displace approximately 20,000 diesel vehicle miles traveled (equal to about 12% of community miles) by 2024 and continuing through 2026.

TRK Objective 1B: Reduce 10% of the 2016 Maritime Air Emissions Inventory's truck emissions (DPM and NOx) by 2023 by working with stakeholders to deploy: a) technologies; or b) fuels; or c) by modifying current business practices and operations.

TRK Objective 1C: Use the truck registry system to promote that all fixed, short-haul drayage truck routes are ZE by 2031.

TRK Objective 1D: Collaborate with community residents, stakeholders, and agencies to identify up to three locations for ZE truck charging with each site capable to serve ten trucks simultaneously by 2023.

TRK Objective 1E: Work with SDG&E and community stakeholders to develop sites identified in Objective 1D to provide the best available charging technology, and to ensure that the sites are accessible to both fleet and independent truckers and that there is a fair and reasonable rate structure for the customers by 2026.

TRK GOAL 2 – Support the designated truck route to avoid truck impacts to the local community.

TRK Objective 2A: Work with partners to create a connected and flexible freight and transit haul route that provides more efficient freeway access and encourages truck drivers to avoid residential neighborhoods by leveraging technology to support dedicated lanes, signal prioritization and/or geofencing.

Port of San Diego Fleet

FLT Short Term Goal 1 – Update Port procurement policies to acquire zero emission vehicles and best available alternative fuels or technologies.

FLT Objective 1A: Update the Port's vehicle procurement policy to identify a hierarchy of procurement considerations which targets zero emission vehicles and then best available alternative fuels to ensure the lowest emitting option available.

FLT Objective 1B: Create a zero emission vehicle transition plan in FY 2022 for the Port's fleet of vehicles and equipment which identifies a long-term acquisition schedule for when current vehicles and equipment will be phased-out and new electric vehicles and equipment is anticipated to be procured.

FLT Short Term Goal 2 – Procure zero emission vehicles and necessary electric vehicle service equipment for charging beginning in FY 2022.

FLT Objective 2A: Procure at least two battery electric medium- to heavy-duty vehicles in FY 2022.

FLT Objective 2B: Apply to SDG&E's Power Your Drive for Fleets Program in calendar year 2021 which aims to install infrastructure to support power needs and electric vehicle charging located at the General Services facility.

FLT Long Term Goal 1 – Shift to battery-electric vehicles with a target of all light-duty vehicles becoming electric by 2030 and all medium- to heavy-duty vehicles becoming electric by 2035.

FLT Long Term Goal 2 – Transition emergency vehicles to alternative fuels including hybrid, electric, and/or low carbon fuels.

FLT Long Term Goal 3 – Convert equipment such as forklifts, small powered generators, and lawn maintenance equipment to zero emissions, hybrid technologies, and/or low carbon fuels, where feasible and commercially available.

FLT Long Term Goal 4 – Seek opportunities to advance lower emitting solutions for marine vessels (few options exist for zero emission vessels).

Shipyards

The Ports three major shipyards have committed to the following emission reduction strategies as part of the Portside Community's AB 617 Draft Community Emission Reduction Plan (November 2020), and are summarized below.

AB 617 Draft CERP Action G5: Reduce DPM and NOx Emissions from Portable Air Compressors and Other Diesel Sources at Shipyards.

The shipyards have committed to requiring on site portable air compressors to be powered by either electric or diesel Tier 4 engines, in addition to continuing ongoing actions to reduce emissions from on and off-road diesel equipment, no later than May 1, 2021.

AB 617 Draft CERP Action G6: Promote Best Practices for Reducing Diesel, VOC, and other Emissions from Ship Repair Activities

The shipyards have committed to conduct trainings and events focused on best practices for ship repair contractors to reduce emissions.

AB 617 Draft CERP Action G7: Reduce Emissions from Shipyard Employee Transportation.

The shipyards have committed to promoting and increasing participation in alternative transportation.

Ocean Going Vessels

OGV In-Transit Goal 1 – Reduce OGV in-transit annual emissions by 243 tons for NOx, 5 tons for DPM and 9,685 metric tons for CO_2e.

OGV Objective 1A: Implement an expanded VSR Program that achieves upwards of 90% compliance.

OGV At-Berth Goal 2 – Reduce OGV At-Berth emissions by expanding existing and/or developing new shore power systems and/or equivalent technologies at the Port's marine terminals.

OGV Objective 2A: At CST, add additional plug to existing shore power system by 2023.

OGV Objective 2B: At NCMT, add new shore power system with at least two plugs by 2025.

OGV Objective 2C: At TAMT, add additional plug to existing shore power system by 2031.

Rail

RL Goal 1 – Implement Rail Upgrades identified in TAMT EIR.

RL Objective 1: Complete TAMT rail upgrades including a rail lubricator and compressed air system for air brake testing.

RL Goal 2 – Promote the use of Single Engine Tier 4 Switcher if applicable to operations at TAMT and NCMT.

RL Objective 2 – Tenants that rely on rail operations to move cargo shall be encouraged to use cleaner switchers.

Funding

FND Goal 1 – Establish a process that allows stakeholders and the public to provide input in the selection, deployment, and on-going monitoring of emission reduction projects.

FND Goal 2 – Create a Clean Air Clearinghouse Program to holistically support deployment, operation and maintenance of large emission reducing projects, with clean air benefits.

FND Goal 3 – Enter into a Memorandum of Understanding (MOU) with the San Diego Air Pollution Control District (SDAPCD) to administer CARB Funding to help fund ZE/NZE Trucks and/or Cargo Handling Equipment.

FND Goal 4 – Establish an Emission Reductions Incentive Program.

FND Goal 5 – Prepare a market study / feasibility analysis for the Board that explores a range of potential fees that can support zero and near-zero emission reduction projects, as well as any implications that the fee may have on the Port's revenue and maritime business opportunities.

Introduction

Environmental stewardship and the development and promotion of harbor-related operations are the core objectives of the San Diego Unified Port District (Port) as state trustee of the public tidelands in and around San Diego Bay (Tidelands). Port operations involve the transport of goods and services throughout the San Diego region and beyond. Overall direct and indirect economic impacts from the maritime industry operating in and around the Tidelands generates approximately $4.3 billion and supports nearly 25,000 jobs[1] in the San Diego County region. Many of these operations and activities utilize ocean-going vessels, railroads, heavy-duty trucks and vehicles, and equipment primarily powered by diesel engines, all of which produce air pollutant emissions. Advancing maritime operations and environmental stewardship are central to the Port's mission and are also prioritized by the California Coastal Act:

> **California Coastal Act Section 30708**
> **Location, Design and Construction of Port-related Developments**
>
> *All port-related developments shall be located, designed, and constructed so as to: (a) Minimize substantial adverse environmental impacts. (b) Minimize potential traffic conflicts between vessels. (c) Give highest priority to the use of existing land space within harbors for port purposes, including, but not limited to, navigational facilities, shipping industries, and necessary support and access facilities. (d) Provide for other beneficial uses consistent with the public trust, including, but not limited to, recreation and wildlife habitat uses, to the extent feasible. (e) Encourage rail service to port areas and multicompany use of facilities.*

The Port's Maritime Clean Air Strategy (or MCAS), is intended to serve as a guidance document that will assist the Board of Port Commissioners (Board) with identifying, prioritizing, and implementing emission reduction initiatives in a holistic and comprehensive manner. Based on Port specific assets, inventories, and operations, as well as current and anticipated future harbor uses, the MCAS identifies emission reduction strategies that can be achieved in the near-term through 2026 (1 to 5 years), as well as the mid-term through 2031 (5 to 10 years). It provides background information on seven maritime-related operational sources and recommends potential emission reduction goals, objectives, and strategies for the Board's consideration. It also includes technology assessments and high-level cost estimates for certain technologies and strategies that can be used by Port tenants wishing to do business with the Port. More generally, the MCAS seeks to provide recommendations and pathways to help accomplish the following objectives:

- Promote environmental stewardship and maritime activities, in accordance with the California Coastal Act, the Public Trust Doctrine, the Port Act, and other applicable laws and regulations.
- Advance emission reduction efforts that are ambitious and that provide direct benefits to the Portside Community residents and workers through ongoing engagement with a diverse group

[1] Economic Impacts of the San Diego Unified Port District in 2017. Economic & Planning Systems, Inc., February 28, 2019.

of community stakeholders, including the Assembly Bill (AB) 617 Portside Community Steering Committee and subcommittees.

- Address equity and environmental justice through transparency, broad community engagement efforts, and by providing meaningful opportunities for residents to participate in the decision-making. Community engagement efforts shall continuously recognize and acknowledge that the nearby Portside Community has a high cumulative pollution exposure burden and that it includes several census tracts that have been designated as disadvantaged communities by the State.
- Support and endeavor to exceed California's 2035 Zero- and Near-Zero Emission Heavy- and Medium-Duty Vehicle goals and emission reduction targets and align with the California Sustainable Freight Action Plan and related sustainability initiatives.

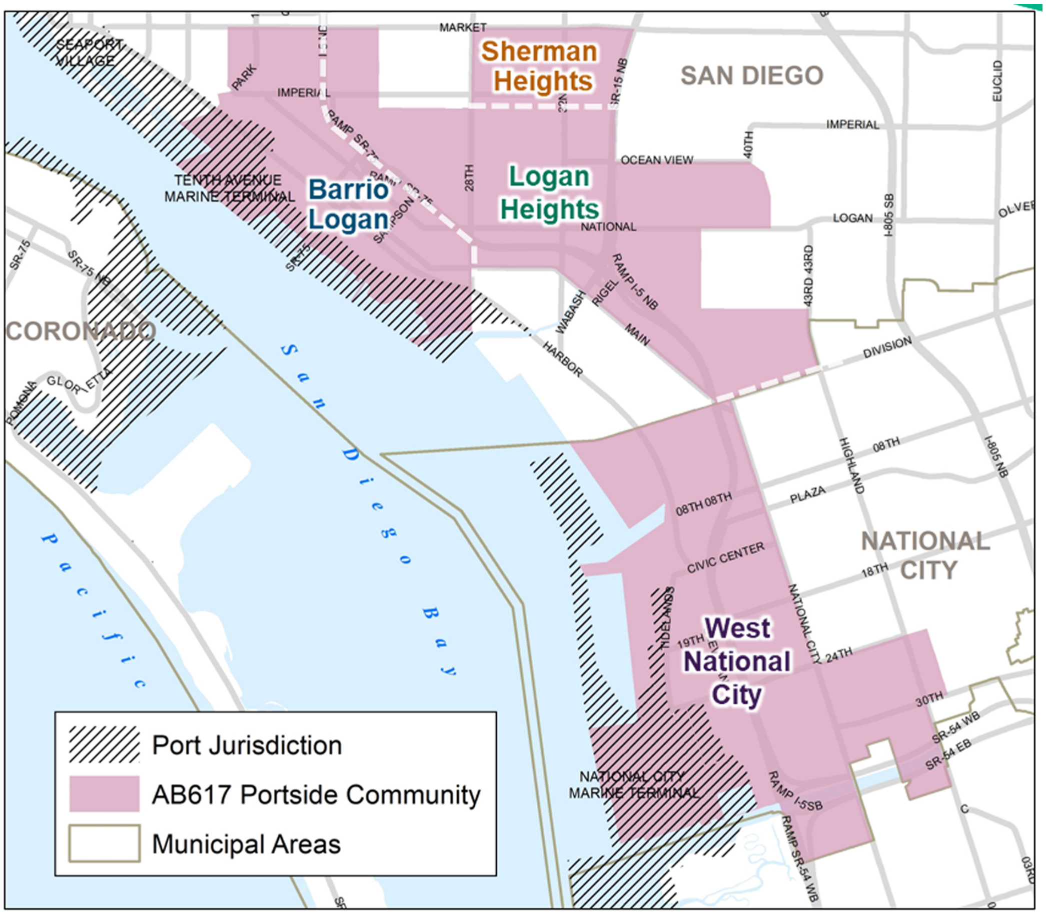
It should be noted that while these broad objectives are likely to remain unchanged, emission reduction regulations and technologies are rapidly evolving, which could affect the costs, feasibility, and prioritization of several emission reduction strategies. As such, the MCAS may be updated periodically with supplemental technology reviews that considers regulatory changes at the federal, State and local levels, new and/or expanded technologies, as well as cost estimates, market availability, and funding opportunities.

Background

The MCAS was developed pursuant to direction provided by the Board of Port Commissioners, California Assembly Bill 617, as well as an extensive and robust public engagement process. Background is provided below and is followed by a discussion of the four broad objectives the MCAS seeks to accomplish.

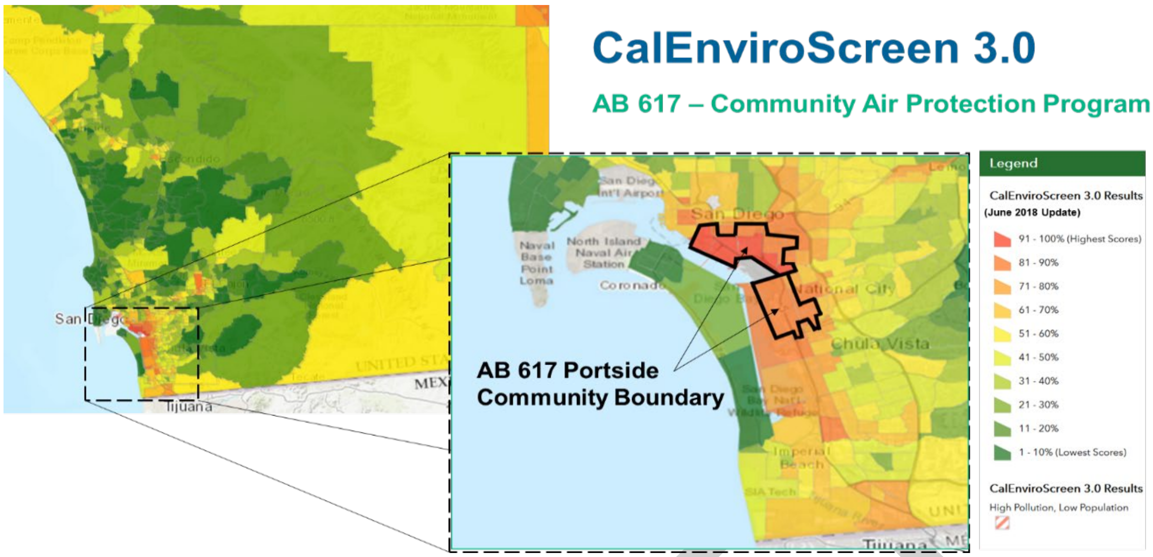
Assembly Bill 617 – Community Air Protection Program

The California Air Resources Board (CARB) established the Community Air Protection Program (or AB 617 Program) in 2018, which tasks local air pollution control districts to work with communities to develop community focused emission reduction programs. In September 2018, CARB selected the Portside Community, which includes the neighborhoods of Barrio Logan, West National City, Logan Heights, and Sherman Heights, for air monitoring. The Portside Community includes Port tidelands between the Tenth Avenue Marine Terminal (TAMT) and the National City Marine Terminal (NCMT), commonly referred to as the working waterfront.



INTRO Figure 1 - AB 617 Portside Community Boundaries

The Portside Community was selected for the AB 617 Program because it is identified as having a high cumulative air pollution exposure burden, a significant number of sensitive receptors, and includes census tracts that have been designated as disadvantaged communities, as shown in California's Environmental Protection Agency's (CalEPA) CalEnviroScreen 3.0 results. It should be noted that a Draft CalEnviroScreen 4.0 version is currently being circulated for public comment.



INTRO Figure 2 - CalEnviroScreen 3.0 and AB 617 Portside Community Boundary

The San Diego Air Pollution Control District (SDAPCD) is responsible for implementing the AB 617 Program and established the AB 617 Steering Committee in October 2018. The AB 617 Steering Committee currently includes 28 members who represent residents, agencies, industry, non-profits, and other pertinent stakeholders. Since its inception, Port staff have been active participants on the AB 617 Steering Committee.

In December 2019, CARB designated the Portside Community for a Community Emissions Reduction Plan (AB 617 CERP). The purpose of the AB 617 CERP is to focus and accelerate actions that go beyond existing State and regional programs to provide reductions in air pollution emissions and exposure. The SDAPCD is currently working with the Portside Community Steering Committee to prepare the AB 617 CERP, which is scheduled to go to the San Diego Air Pollution Control Board and CARB for consideration in 2021.

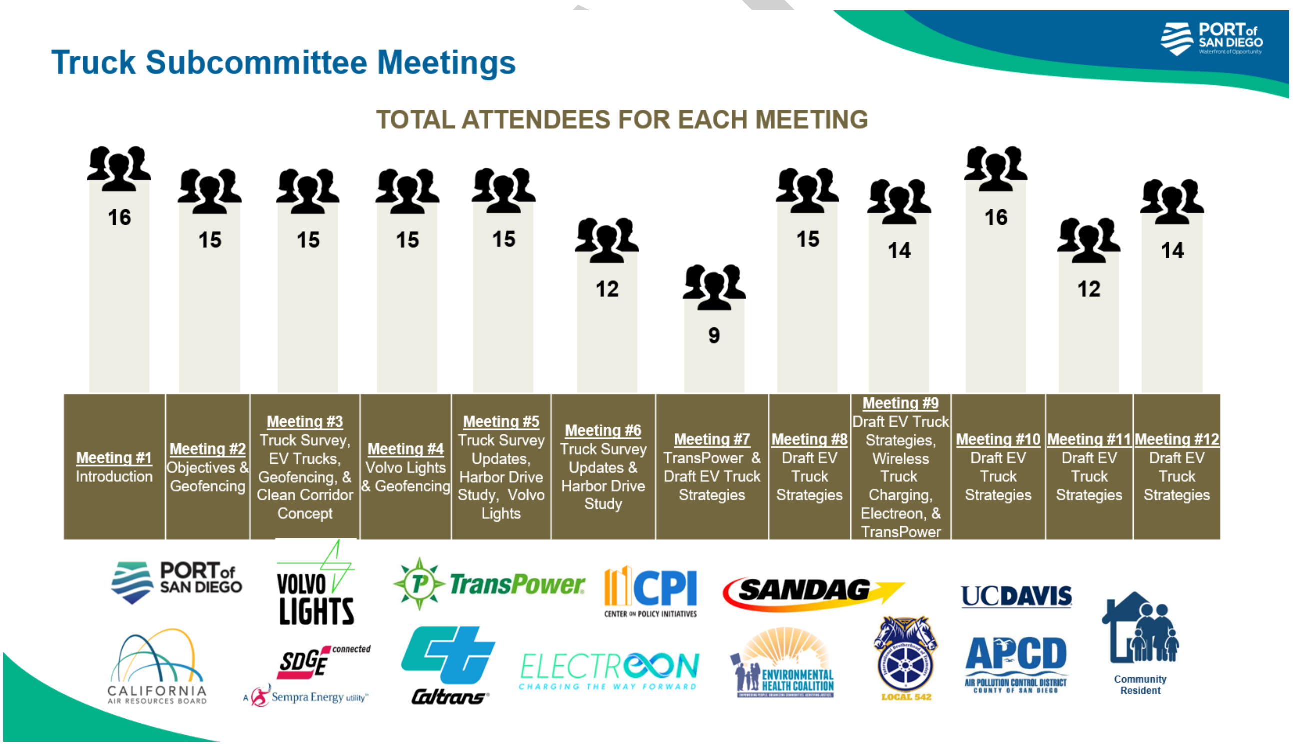
Board of Port Commissioners

Based on the AB 617 Program and the State's ongoing efforts to reduce emissions, improve air quality, and combat climate change, the Board of Port Commissioners (Board) adopted Board Resolution #2019-084 in June 2019 authorizing staff to update the Port's 2007 Clean Air Program. The resolution also directed staff to develop Port-related plans and projects that reduce emissions and improve air quality. Acknowledging the complexity of emission reduction efforts, particularly on Port tidelands, the Board also directed staff to do additional research to help inform the establishment of potential emission reduction targets. The Board emphasized their desire for the Port to lead in emission reduction efforts and encouraged staff to develop emission reduction targets and/or goals that were Specific, Measurable, Achievable, Relevant and Timebound (S.M.A.R.T). Finally, the Board directed staff to work closely with community residents, Port tenants, public agencies, and other pertinent stakeholders, including the AB 617 Portside Community Steering Committee, while preparing the MCAS.

Stakeholder Engagement

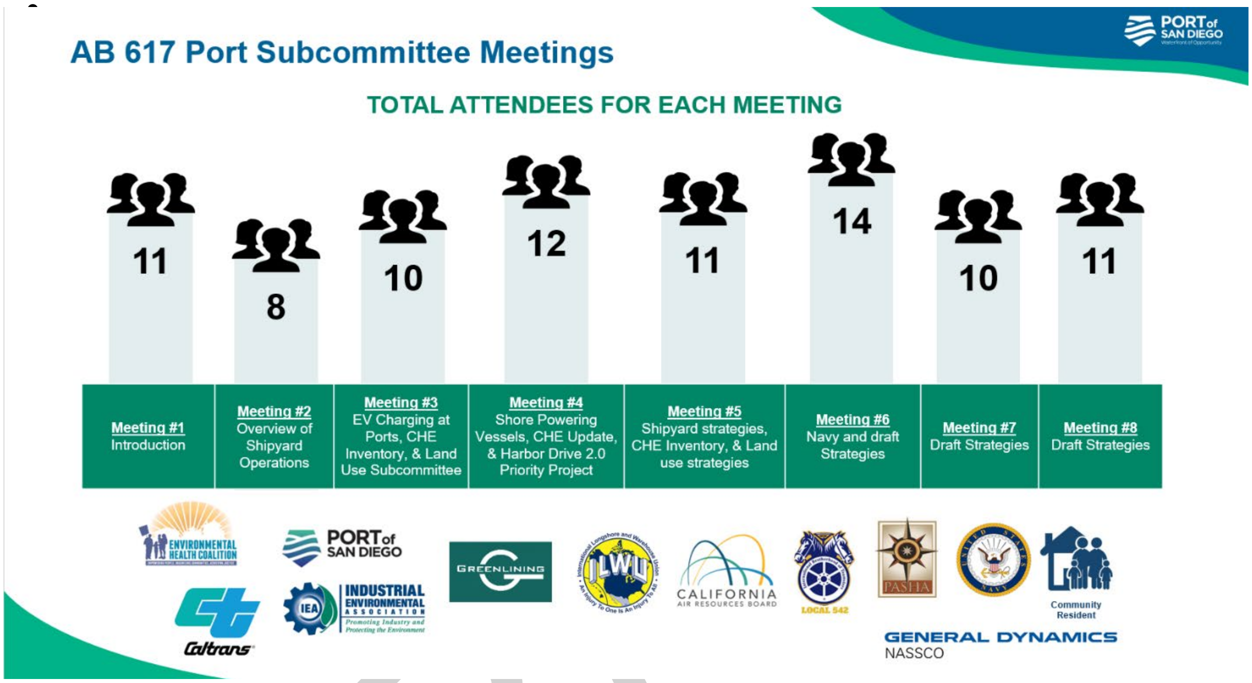
Extensive stakeholder involvement has been the cornerstone of the MCAS. Initially, the AB 617 Portside Community Steering Committee served as the primary vehicle for stakeholder engagement. However, the subsequent establishment of several AB 617 subcommittees enabled staff to work more closely on emission reductions efforts with community residents, tenants, and several public agencies including staff from CARB, the San Diego Association of Governments (SANDAG), SDAPCD, the California Department of Transportation (Caltrans), San Diego Gas and Electric (SDG&E), City of San Diego, City of National City, and the U.S. Navy. The subcommittee structure proved to be ideal because it allowed for a sustained, transparent, and meaningful exchange of ideas. The following AB 617 Subcommittee's helped review, identify, develop, and refine much of the information included in the MCAS:

- **AB 617 Truck Subcommittee:** This subcommittee met twelve (12) times between May and July 2020 to discuss the technological and institutional obstacles to greater electrification of truck fleets, particularly trucks serving the Port's cargo terminals. Membership included representatives from the Environmental Health Coalition (EHC), San Diego Association of Governments (SANDAG), Caltrans, SDG&E, Teamsters Local Union No. 542 and SDAPCD staff. Other participants from CARB, Volvo Lights, TransPower, Electreon, and UC Davis participated in certain meetings to cover specific topics.



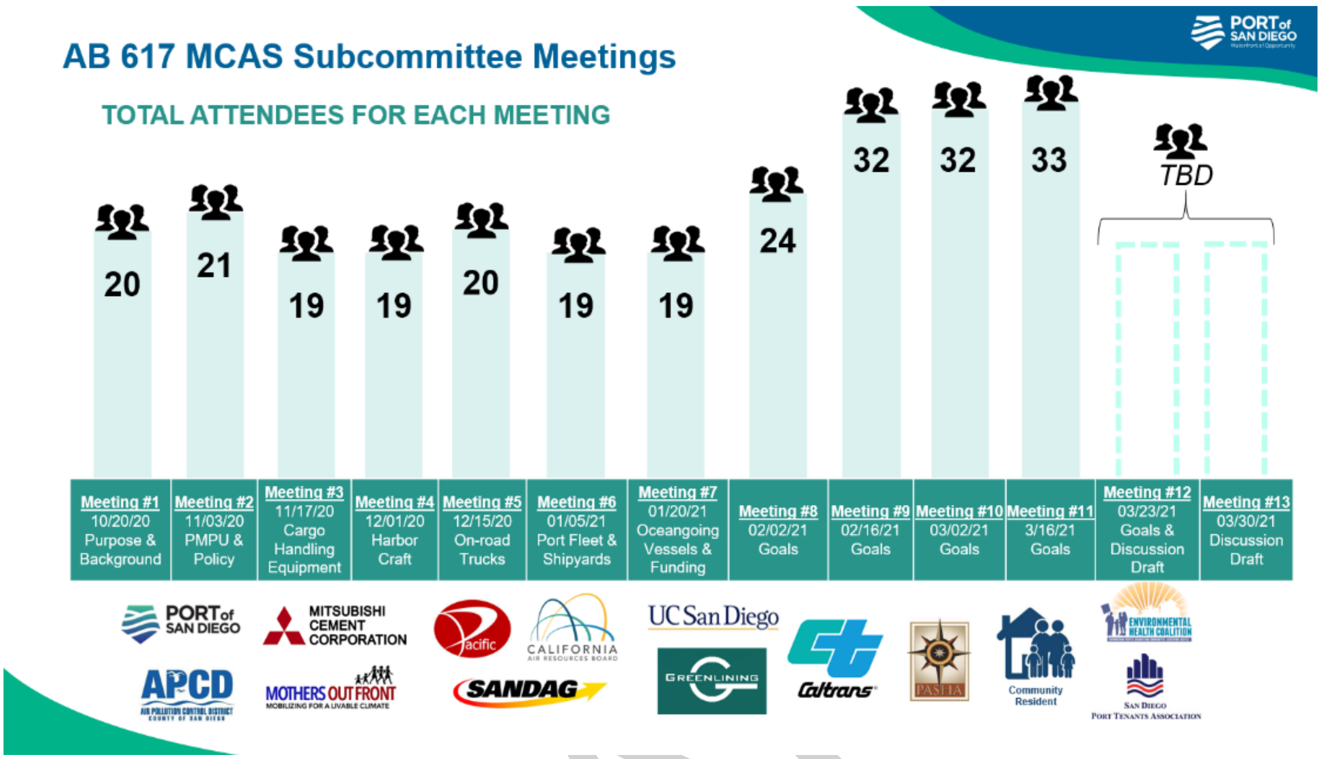
INTRO Figure 3 – AB 617 Truck Subcommittee Meeting Summary

- **<u>AB 617 Port Subcommittee:</u>** This subcommittee met eight (8) times in June and July 2020 to produce a set of recommendations that addressed emissions along the working waterfront. Representatives from NASSCO, Pasha Automotive Services, U.S. Navy, the Environmental Health Coalition (EHC), and the Teamsters Local Union No. 542 served on the Port subcommittee. Other meeting attendees included representatives from CARB, Caltrans, ILWU, Industrial Environmental Association (IEA), and the Greenlining Institute.



INTRO Figure 4 - AB 617 Port Subcommittee Meeting Summary

- **<u>AB 617 MCAS Subcommittee:</u>** Building off the work of the Truck and Port Subcommittee, the MCAS Subcommittee met thirteen (13) times between October 2020 and March 2021. This subcommittee worked with Port staff to help prepare the MCAS by reviewing emissions data and other background information and with identifying potential emission reduction goals, objectives and strategies. Attendance ranged between 19 and 31 people and included several Port tenants. Formal subcommittee membership included 16 people representing agencies and groups as follows:
    - Mothers Out Front
    - Greenling Institute
    - Environmental Health Coalition
    - Portside Community Residents
    - SDAPCD
    - Caltrans
    - CARB
    - NCMT Operator
    - Pacific Tugboat
    - UCSD PhD Student
    - Port staff



INTRO Figure 5 - AB 617 MCAS Subcommittee Meeting Summary

Purpose and Need

As noted earlier, the MCAS aims to reduce maritime-related emissions within the context of several broader structural underpinnings, as described below.

Promote the Maritime Industry

The Port of San Diego is a grantee of certain Tidelands and submerged lands in and around San Diego Bay used for Public Trust purposes. In 1962, the Port Act created the San Diego Unified Port District to develop and manage the waters and tidelands of San Diego Bay, in public trust, "for multiple purpose use for the benefit of the people" (Port Act Section 2). Specifically, the Port was established by the Legislature for the acquisition, construction, maintenance, operation, development and regulation of harbor works and improvements, including rail and water, for the development, operation, maintenance, control, regulation, and management of the harbor of San Diego upon the tidelands and lands lying under the inland navigable waters of San Diego Bay, and for the promotion of commerce, navigation, fisheries, and recreation and the protection and enhancement of natural resources and water quality (Port Act Section 4). The California Coastal Act, (in Chapter 8 titled Ports), recognizes that activities and development related to ports may have adverse effects on coastal resources or coastal access, but are necessary for the continued economic prosperity of the State.

Advance Emission Reduction Efforts that are Ambitious and Provide Direct Benefits to the Portside Community

As noted earlier, the AB 617 Portside Community, (which includes the Port's working waterfront), is identified as having a high cumulative air pollution exposure burden, a significant number of sensitive receptors, and includes census tracts that have been designated as disadvantaged communities, as shown in California's CalEnviroScreen 3.0 results. CalEnviroScreen is a mapping tool administered by the California Office of Environmental Health Hazard Assessment (OEHHA) that helps identify California communities that are most affected by many sources of pollution, and where people are often especially vulnerable to pollution's effects. CalEnviroScreen uses environmental, health, and socioeconomic information to produce scores for every census tract in the state. The scores are mapped so that different communities can be compared. An area with a high score is one that experiences a much higher pollution burden than areas with low scores. CalEnvioScreen ranks communities based on data that are available from state and federal government sources. The score is calculated using a suite of 19 indicators to characterize pollution burden (12 indicators) and population characteristics (seven indicators).[2] The individual indicator scores are weighted and added together within the two groups to derive a pollution burden score and a population characteristic score. Those scores are multiplied to give the final CalEnviroScreen score.

Concentrations of Ozone and Diesel Particulate Matter (DPM) are two indicators that are included in the CalEnviroScreen 3.0 model. The AB 617 Portside Community Draft CERP notes that DPM is a known carcinogen and the greatest toxic air pollutant risk in the County, and that NOx emissions (a precursor to Ozone) are dominated by mobile sources, mostly off-road commercial harbor craft, ocean going vessels, light-duty vehicles, and heavy duty vehicles.

Although the Port has very limited or no ability to influence most of the CalEnviroScreen 3.0 indicators, it is well positioned to help reduce some NOx and DPM emissions. As such, the MCAS focuses on strategies that can reduce these two pollutants. The MCAS also includes data and analyses on CO2e (or greenhouse gas emissions), to assist with aligning with the State's greenhouse gas reduction goals and because community stakeholders wanted to make sure that the Port's emission reduction efforts also helped to address climate change mitigation.

Ultimately, the MCAS is intended to support and complement the Portside Community's AB 617 CERP by identifying ways that the Port and its tenants might reduce emissions. In addition to identifying potential strategies and projects, it also identifies potential goals and objectives for certain operating sources that are ambitious and achievable.

Address Equity and Environmental Justice

Equity means increasing access to power and eliminating barriers to opportunity to empower marginalized groups such as low-income communities of color to thrive and reach their full potential.

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[2] Pollution burden indicators include: air quality - ozone; air quality – PM2.5; Children's Lead Risk from Housing; Diesel Particulate Matter; Drinking Water Contaminants; Pesticide Use; Toxic Releases from Facilities; Traffic Density; Cleanup sites; Groundwater Threats; Hazardous Waste Generators and Facilities; Impaired Water Bodies; and Solid Waste Sites and Facilities. Population indicators include: Asthma; Cardiovascular Disease; Low Birth Weight Infants; Educational Attainment; Housing Burden; Linguistic Isolation; Poverty; and Unemployment *(oehha.ca.gov/calenviroscreen/indicators, accessed March 4, 2021).*

Environmental justice can be defined as the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Portside Community residents have been marginalized and have suffered a disproportionate burden of environmental afflictions. Barrio Logan and Logan Heights, for example, were physically divided when the Interstate 5 was built in 1963. Community residents were also adversely affected when the San Diego Coronado Bay Bridge was built in 1969 and their community was rezoned from residential to mixed use, which allowed medium- and heavy-industrial uses to be sited next to residential uses. CalEnviroScreen 3.0 show that parts of the Portside Community rank within the 95th percentile for asthma and poverty rates, as well as the 90th percentile for housing burden statewide. Community residents acknowledge these historic disparities and understand the ongoing impacts to their health and quality of life.

Port staff has attempted to address these disparities by ensuring that the MCAS was developed in an open and transparent manner with extensive stakeholder engagement. Moving forward, the MCAS recommends providing annual updates on emission reductions efforts and other Port activities at various community forums. It also recommends collaborating with community residents, industry representatives, and other stakeholders prior to identifying and selecting an emission reduction project for implementation. Finally, the emission reduction strategies included in the MCAS seek to improve air quality and the Portside Community's environmental conditions.

Support California's ZE/NZE Mobile Source Goals and its GHG Reduction Targets

In 2015, Governor Brown issued Executive Order B-32-15, which directed State agencies to establish targets to improve freight efficiency, transition to zero emission technologies, and increase the competitiveness of California's freight transport system. In 2019, Governor Newsom signed Executive Order N-19-19, which directed the State Transportation Agency to align the state's climate goals with transportation spending on planning, programming and mitigation to achieve the objectives of the State's Climate Change Scoping Plan, where feasible. Finally, in September 2020, Executive Order N-79-20 established that State's goal is for 100% of the State's drayage truck fleet to be zero emission by 2035, and for 100% of medium- and heavy-duty vehicles to be zero emission by 2045. These executive orders set the State's long-term vision for a sustainable freight transport system.

The MCAS supports the State's Executive Orders by focusing on zero emission/ near zero emission (ZE/NZE) technologies to reduce emissions for all seven maritime-related emission sources and by recommending goals, objectives, and strategies that enable the Port to meet CARB's forthcoming regulatory requirements.

Operational Sources

Introduction

At the June 18, 2019 Board meeting, the Board adopted a resolution authorizing Port staff to update the Port's 2007 Clean Air Program to align with State programs and to develop Port-related plans and identify projects that would reduce emissions and improve air quality. To help the Port identify, understand, and prioritize potential emission reduction opportunities, the Port's Maritime Clean Air Strategy (MCAS) focuses on the following seven emission sources:

- Cargo Handling Equipment (CHE)
- Commercial Harbor Craft (CHC)
- Heavy Duty Trucks
- Shipyards (Stationary Maritime Industrial Uses)
- Ocean Going Vessels (OGV)
- Freight Rail
- Port of San Diego Fleet

This effort builds on the Port's 2016 Maritime Air Emissions Inventory, and updates emission estimates for CHE, CHC, OGVs within and around San Diego Bay, and the Port's fleet, based on 2019 calendar year activity. It also includes two new sources, Port Fleet and Shipyards, which have not been addressed in previous maritime inventories. While the Port's fleet is not technically a maritime-specific use, the Port has direct control over its own fleet and this category presents a unique opportunity for the Port to demonstrate leadership in emission reduction efforts. Therefore, it was included as one of the seven emission sources. Similarly, the shipyards operating on Port tidelands have not been included in the Port's previous maritime air emissions inventories, because these operations fall under the purview of the San Diego Air Pollution Control District (SDAPCD) and issues air pollution control permits and regulates industrial stationary sources. However, with the formation of the Assembly Bill (AB) 617 Portside Community Steering Committee in 2018, the Port's three shipyard tenants have committed to several emission reduction strategies in the AB 617 Community Emission Reduction Plan (AB 617 CERP). As such, the MCAS addresses the Shipyards qualitatively by describing their operations and the strategies that the shipyards have committed to as part of the AB 617 Draft CERP, are included in here as reference.

As shown in INTRO Table 1, CHC and OGV's make up approximately 88% and 91% of total NOx and DPM emissions from or associated with the Port operations. It is worth providing context in terms of where emissions occur. Maritime emissions occur within terminal boundaries, within neighboring communities along truck and rail routes, within San Diego Bay, and outside of the terminals, neighboring communities, and San Diego Bay. As shown in INTRO Table 2, most emissions occur away from the terminals and outside of the San Diego Bay. As shown, 55% of NOx and DPM occur out at sea or along regional trucking and rail routes, beyond San Diego Bay and away from the Portside Community's residents and workers. All CHE emissions occur at the marine terminals and in closer proximity to the Portside Community's residents and workers. CHC emissions occur in disperse locations throughout San Diego Bay and in the open ocean.

Most OGV emissions occur in transit outside of the bay. While truck emissions represent a small percentage of total emissions and occur mostly outside the Portside Community boundaries, reducing truck-related emissions has been identified as a high-priority goal by residents and the AB 617 Portside Community Steering Committee.

INTRO Table 1. MCAS Emissions Inventory Estimates Summary (tons)

Source	NOx		DPM		CO_2e	
Cargo Handling Equipment (CHE) [1]	8.4	1%[3]	0.1	1%	2,439	3%
Commercial Harbor Craft (CHC) [1]	283.6	38%	9.1	52%	25,495	35%
On-road Trucks [2]	51.4	7%	0.3	2%	16,095	22%
Oceangoing Vessels (OGV's) [1]	378.3	50%	6.7	38%	25,770	35%
Rail [2]	30.3	4%	1.2	7%	2,916	4%
Total	**752**	**100%**	**17.4**	**100%**	**72,715**	**100%**

[1] Updated based on 2019 activity

[2] Estimates based on Maritime Air Emissions Inventory 2016

[3] Percent of total maritime emissions based on 2016 Inventory data

INTRO Table 2. MCAS Emissions Inventory Portions by Location

Source	At or Near Terminal and Within Bay			Away from Terminal and Bay		
	NOx	DPM	CO_2e	NOx	DPM	CO_2e
Cargo Handling Equipment (CHE)	100%	100%	100%	0%	0%	0%
Commercial Harbor Craft (CHC)	57%	54%	52%	43%	46%	48%
On-road Trucks	6%	3%	6%	94%	97%	94%
Oceangoing Vessels (OGV's)	42%	38%	31%	58%	62%	69%
Rail	24%	25%	24%	76%	75%	76%
Total	**45%**	**45%**	**35%**	**55%**	**55%**	**65%**

The subsequent sections in this chapter provide background on each of these emission sources, including a brief history of previous emission reduction efforts, as well as existing and forthcoming regulations and requirements. Source specific emission reduction technology and/or other emission reduction strategies are presented, followed by high-level cost estimate. Finally, each section concludes with recommended emission reduction goals and objectives specific to each source.

Cargo Handling Equipment

Cargo handling equipment (CHE) is used to support terminal activities and move cargo on and off ocean-going vessels (OGVs), harbor craft, rail, and trucks. CHE is necessary for coastal dependent maritime trade operations and water-based commerce. A wide range of CHE types operate within the Port's jurisdiction due to the diversity of cargo handled at each maritime terminal, which ranges from large containers to dry bulk; CHE is also needed to support cruise ship activity. Equipment operates at each of the Port's three terminals: National City Marine Terminal (NCMT), Tenth Avenue Marine Terminal (TAMT), and the Cruise Ship Terminal (CST).

Background and Context

Source Description

Types of CHE at the terminals include container handling equipment (e.g., reach stackers), yard tractors (also known as UTRs, yard trucks, or hostlers), forklifts, construction equipment (e.g., rubber-tired loaders), and general industrial equipment. The majority of CHE is electric or diesel-powered, although some smaller pieces are powered by gasoline or propane. CHE is only used at the Port's marine terminals and not on public roadways. Below is a description of the most common equipment types.

Yard Tractors

Yard tractors are designed to move cargo containers and are the most common type of CHE used at ports. These tractors are used at container ports, intermodal rail yards, distribution centers, and other intermodal facilities. Other CHE is used to load containers onto yard tractors, which are then used to move the containers around the facility for stacking and storing.

Yard tractors are similar to heavy-duty on-road truck tractors, but the majority are equipped with off-road engines. Per CARB's CHE Regulation, all yard tractors at California ports are required to be powered by engines that meet US EPA model year 2007 or newer on-road, or Tier 4 off-road engine emission standards. Yard tractors have a horsepower (hp) range of approximately 150 – 250 hp. There are 30 yard tractors in the Port's 2019 CHE inventory; 22 at TAMT and 8 at NCMT, all of which are owned and operated by Port tenants.

Forklifts

Forklifts are industrial equipment that lift and transport materials using one or more steel forks, which are inserted under the load. Forklifts are designed to move and/or lift empty cargo containers, stacked or palletized cargo, and/or move or rotate truck chassis. They are found at container and bulk cargo facilities and vary by size and cargo handling abilities. Forklifts can be powered by electric motors or internal combustion engines, including compression ignition (diesel) and spark ignition (propane). Forklifts are broken out into classifications by applications, fuel options, and features: the higher the class, the greater the lifting capacity. Classes 1, 2, and 3 forklifts are typically electric, powered primarily by lead-acid batteries, while classes 4 and 5 use internal combustion engines, usually fueled by propane, but can also be natural gas, gasoline, and diesel. Class 6 can be either electric for internal combustion and are used for a variety of indoor and outdoor applications. Class 7 forklifts are for rough terrain and are typically diesel. Because they are designed for higher lift capacity, forklifts powered by diesel engines are the majority of forklifts used in typical port cargo handling operations.

Cargo handling forklifts used at ports typically range between 45 and 280 horsepower. Forklifts can be separated by horsepower into light-, medium-, and heavy-lift size categories for planning and emission purposes. Light-lift forklifts are less than 75 hp and typically lift up to 9,000 pounds; medium lifts range between 75 and 120 hp and lift between 9,000 and 20,000 pounds; and heavy lifts are greater than 120 hp and lift greater than 20,000 pounds, A summary of forklift categories by size is shown in CHE Table 5 below.

Stackers

Stackers, or "Reach Stackers" are CHE that have telescopic booms that move upward and outward to reach over two or more stacks of containers. The stacker boom locks onto the top of containers and can transport them short distances. Reach stackers have a horsepower range of approximately 250 – 400 hp. There are four reach stackers in the Port's 2019 CHE inventory, all owned and operated by Port tenants at TAMT.

Handlers

Handlers are designed to stack containers for temporary storage or load them on and off yard tractors, and include top handlers and side handlers. Top handlers are a common type of CHE and are truck-like vehicles that have an overhead boom to lock onto the top of containers. Top handlers have a horsepower range of approximately 250 – 400 hp and can lift loaded containers weighing as much as 45,000 pounds. There are two top handlers in the Port's 2019 CHE inventory, both owned and operated by Port tenants at TAMT.

Side handlers are similar to top handlers, except that their boom arm extends the width and locks onto the sides of containers, and they are usually used to lift empty containers. Side handlers generally have a horsepower range of approximately 120 – 400 hp. There are no side handlers in the Port's 2019 CHE inventory.

Cranes

Cranes used for general port operations include rubber-tired gantry cranes (RTGs), rail-mounted gantry cranes (RMGs), ship-to-shore cranes, and mobile harbor cranes.

Gantry cranes are designed to load and unload containers from yard tractors and stacks at a very fast pace. Both types of cranes operate a lifting mechanism that is mounted on a cross-beam supported on vertical legs running on either rubber tires (RTGs) or rails (RMGs). RTG and RMG cranes have a horsepower range of approximately 200 – 1,000 hp. While the propulsion of the crane is very slow (about three miles an hour), the lifting mechanism is very quick.

Ship-to-shore cranes are designed to load and unload containers directly from vessels at port. They are generally fixed and move containers from ships to yard tractors. Safe working loads from 44 to 132 tons (40 to 120 metric tons) are available in single, twin, and tandem lift configuration.

Mobile harbor cranes are designed to lift all types of cargo from containers to bulk commodities, general cargo and even heavy lifts. They can move on rubber tires to provide lifting where needed. Generally, mobile harbor cranes can lift up to 330 tons (300 MT) with a single crane or up to 440 tons (400 MT) with a dual crane.

There is one mobile harbor crane within the Port's 2019 CHE Inventory at TAMT. Because the Port has no plans to add gantry or ship-to-shore cranes to the CHE Inventory in the foreseeable future, the analysis below will focus solely on emission reduction potential associated with the mobile harbor crane.

Other Equipment

The CHE used at the Port also includes construction equipment such as rubber-tired loaders, lifts, and trailers, as well as other general industrial equipment such as carts, sweepers, and lighting. Most of these pieces powered by gasoline and are relatively insignificant sources of emissions, in large part, because they are not housed and/or used at the terminals regularly or with any level of frequency. Furthermore, any significant amount of construction activity at the marine terminals would be subject to subsequent environmental review and would be looked at on a project by project basis. As such, construction equipment is not the focus of the MCAS and will not be discussed further. There are also six solar powered signal boards within the inventory: four at CST and two at TAMT.

Existing Fleet Summary – 2019 Port CHE Inventory

In Spring 2020, Port staff conducted a Maritime Cargo Handling Equipment Inventory (Inventory) to update the prior iteration from 2016, identify the higher-emitting equipment that is in use, and to determine the feasibility of cleaner upgrades to reduce emissions. The scope of the Inventory includes all CHE utilized by the Port and participating tenants at the three marine terminals (Cruise Ship Terminal or CST, TAMT, and NCMT) in 2019. This is the fourth Maritime Cargo Handling Equipment Inventory conducted by the Port, past inventories were conducted in 2006, 2012 and 2016. Emissions were calculated based upon CARB's CHE methodology.[1] CHE inventory emissions are summarized in Appendix A. Inventory data and emissions inform the analysis below.

The breakdown of CHE by fuel type by terminal is provided in CHE Table 1 and further shown in CHE Figure 1 for the Port as a whole and for TAMT. As shown, of the 184 total CHE pieces, the largest portion (84 pieces) is comprised of electric- or solar- powered (approximately 45%). Diesel comprises the next largest share, making up approximately 35% of the equipment inventory. However, as shown in CHE Figure 1, diesel pieces comprise most of the equipment at TAMT, and the majority of diesel pieces Port-wide operate at TAMT. While the NCMT has the most pieces of CHE of the three terminals, most of these pieces are non-emitting or smaller gasoline or propane pieces. Most equipment at the CST are small electric pieces.

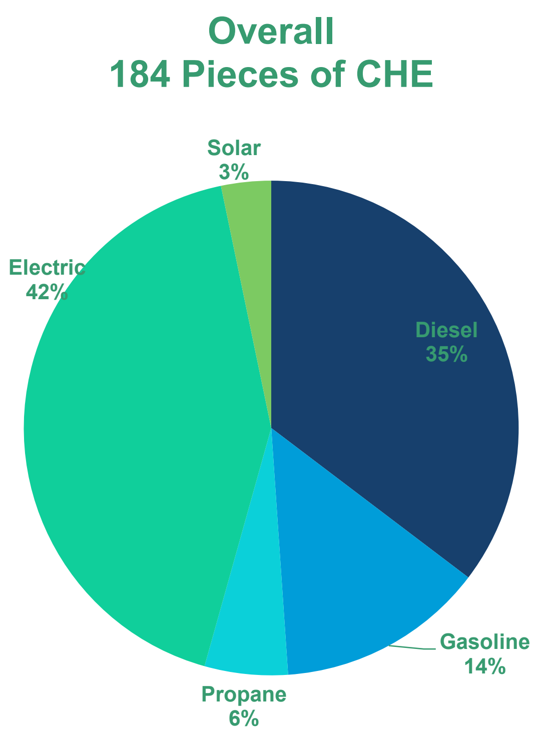
[1] CARB, *Cargo Handling Equipment Emissions Inventory Methodology*, 2011. Available at https://ww3.arb.ca.gov/regact/2011/cargo11/cargoappb.pdf

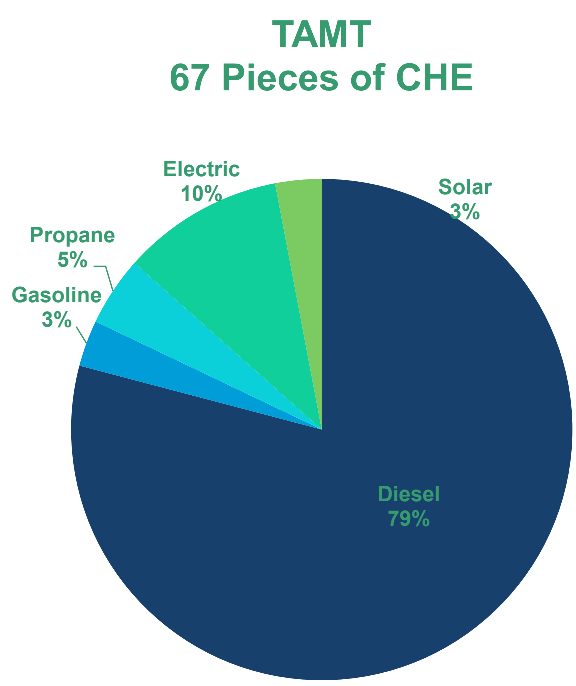
CHE Table 1. Summary of Cargo Handling Pieces by Fuel Type*

Terminal	Diesel	Gasoline	Propane	Electric	Solar	Total
TAMT	53	2	3	7	2	67
NCMT	11	23	6	48	0	88
CST	1	0	1	23	4	29
Total	**65**	**25**	**10**	**78**	**6**	**184**

*Please note that the Port owns one diesel mobile harbor crane that operates at the TAMT. All other pieces of equipment identified in the Port's CHE Emission Inventory are owned and operated by Port tenants.

CHE Figure 1. Cargo Handling Equipment Portions by Terminal





CHE Table 2 summarizes the portion of emissions by pollutant type by terminal, which shows most CHE emissions occur at TAMT. CHE Table 3 summarizes the portion of emissions by fuel type, which shows diesel equipment being responsible for all the DPM emissions and for most of the NOx and GHG emissions. Therefore, while there are more non-diesel pieces of equipment than diesel at the Port, most emissions are emitted from diesel equipment, primarily at TAMT.

CHE Table 2. Portion of Total Cargo Handling Equipment Emissions by Terminal

Terminal	NOx	DPM	CO_2e
TAMT	81%	72%	73%
NCMT	18%	23%	21%
CST	1%	5%	6%

CHE Table 3. Portion of Total Cargo Handling Equipment Emissions by Fuel

Terminal	NOx	DPM	CO_2e
Diesel	90%	100%	83%
Gasoline	8%	-	5%
Propane	2%	-	2%
Electric	-	-	10%
Solar	-	-	-

History of Previous Efforts

The Port has encouraged and supported its tenants' efforts to electrify the marine terminals, including assisting to secure and manage outside funding sources. Port tenants have been the recipients of various grant awards to demonstrate pre-commercial zero emission CHE. Most notably, the San Diego Port Tenants Association, on behalf of five Port Tenants (Dole Fresh Fruit Company, Pasha, Marine Group Boat Works, Terminal Lift, and Continental), was awarded $5.9 million in funding from the California Energy Commission (CEC) to demonstrate pre-commercial zero emission medium and heavy-duty equipment. The grant included *ten battery-electric yard tractors, drayage trucks, and forklifts* on tidelands adjacent to the Portside Community.[2] The purpose of the demonstration was to advance the commercialization of zero emission CHE and to allow users to better understand how zero emission technology operates. The success of these zero emission CHE demonstration projects has continued to progress electrification at the Port's marine terminals. Electric CHE located at the marine

[2] California Energy Commission. 2020. *San Diego Port Sustainability Freight Demonstration Project*. Available: https://www.energy.ca.gov/showcase/driving-cleaner-transportation/san-diego-port-sustainability-freight-demonstration-project. Accessed December 2020.

terminal include: three (3) yard tractors; one (1) reach stacker; 21 electric forklifts; and several pieces of electric automobile processing equipment (vehicle lifts, tire processing, car washing, compressors) at NCMT. In addition, four message boards were converted from diesel to solar for use at the CST. Finally, since the 2019 Inventory, Dole has acquired one additional electric forklift.

Legislative and Regulatory Framework

Emissions from cargo handling equipment are managed by regulations and emission limits implemented at the federal, state, and local levels. The EPA has established a series of increasingly strict emission standards for new off-road diesel engines. Tier 1 standards were phased in on newly manufactured equipment from 1996 through 2000 (year of manufacture), depending on the engine horsepower category. Tier 2 standards were phased in on newly manufactured equipment from 2001 through 2006. Tier 3 standards were phased in on newly manufactured equipment from 2006 through 2008. Tier 4 standards, which require advanced emission control technology to attain them, were phased in between 2008 and 2015.

In December 2005, CARB approved the Regulation for Mobile Cargo-Handling Equipment at Ports and Intermodal Rail Yards (13 CCR 2479) designed to use best available control technology (BACT) to reduce DPM and NOx emissions from mobile cargo handling equipment at ports and intermodal rail yards. Since January 1, 2007, the regulation has imposed emission performance standards on terminal equipment that vary by type.

Additionally, CARB has promulgated more stringent emissions standards for hydrocarbons and NOx combined emissions and test procedures for gasoline-powered forklifts and other industrial equipment. The engine emission standards and test procedures were implemented in two phases. The first phase was implemented for engines built between January 2007 and December 2009. The second, more stringent, phase was implemented for engines built starting in January 2010. The regulation was amended in 2010, establishing fleet average emissions requirements for existing engines and those amendments took effect on October 14, 2012. All in-use non-yard truck equipment had to be fully compliant with the regulation by December 31, 2013, and yard truck equipment must be fully compliant with the CHE Regulation by December 31, 2017. All in-use non-yard truck engines must have a Verified Diesel Emission Control Strategy (VDECS) installed. VDECS are emissions control strategies that reduce PM and/or NOx. Diesel particulate filters (DPFs), which reduce PM emissions, are the most common type of VDECS. All newly purchased yard truck and non-yard truck equipment brought onto a port or intermodal rail yard must have either a Tier 4 Final off-road engine or a model year (MY) 2010 or newer on-road engine.

In March 2018, CARB staff presented to its Board a proposed plan to develop regulations to minimize emissions and community health impacts from CHE.[3] The regulatory concepts proposed by CARB staff focus on zero emission CHE. The regulatory amendments would enact an implementation schedule for new equipment and facility infrastructure requirements, with effective dates beginning in 2026. In this potential action, all mobile equipment at ports and rail yards, including but not limited to diesel, gasoline, natural gas, and propane-fueled equipment, would be subject to new requirements. CARB staff would

[3] CARB. 2018. Available: https://ww2.arb.ca.gov/resources/documents/cargo-handling-equipment-regulation-transition-zero-emissions. Accessed March 2021.

also consider opportunities to prioritize the earliest implementation in or adjacent to the communities most impacted by air pollution. The amendment is anticipated to be considered by CARB in 2022 or 2023.[4]

Finally, it's important to recognize the federal Occupational Safety and Health Act of 1970 (OSHA), which assures the safe and healthful working conditions for men and women by authorizing enforcement of standards under the Act and by assisting and encouraging the states in their efforts to meet this objective. Many OSHA standards include explicit safety and health training requirements to ensure that workers have the required skills and knowledge to safely do their work. OSHA identifies several operational and training standards for marine terminals in general, as well as operational and training requirements for CHE more specifically.

Technology and Strategies

While there are several options to electrify CHE operated at the Port, it is important to note that several ZE/NZE CHE alternatives are not necessarily commercially available for purchase. Many ZE/NZE pieces of CHE are still being built to specifications provided by the customer on a case by case basis and are not yet mass produced. However, it is expected that ZE/NZE CHE pieces will be commercially available for purchase in the coming years. Electrification options are described below.

Forklifts

A summary of existing forklifts by fuel, by terminal operation, and by size is shown in CHE Table 4. Note that the forklift sizes are broken down by lift for all fuel types and for diesel forklifts only.

CHE Table 4. Summary of Forklifts by Fuel, Terminal, and Size at the Port*

	All Pieces				By Lift All Fuels (Diesel Only)		
Terminal	**Gasoline**	**Propane**	**Electric**	**Diesel**	**Light**	**Medium**	**Heavy**
TAMT	1	3	1	22	7 (5)	3 (1)	17 (16)
NCMT	0	6	4	4	3 (0)	6 (0)	5 (4)
CST	0	1	16	1	2 (0)	1 (1)	15 (0)
Total	**1**	**10**	**21**	**27**	**12 (5)**	**10 (2)**	**37 (20)**

* All of the forklifts are owned and operated by Port tenants.

The size of existing forklifts for all terminals is further broken down in CHE Table 5. As shown, most forklifts at the Port are heavy-lift forklifts (37 out of 59) and diesel fueled (27 out of 59).

[4] CARB's Website (linked in CHE Footnote 3, above) identifies 2022 as the estimated timeframe for Board consideration on CHE regulations. However, in December 2020, CARB released an updated graphic entitled "Suite of CARB Regulations", that shows that the 1st Board hearing date for Port and Railyard Cargo Handling Equipment will be in year 2023.

CHE Table 5. Summary of Forklifts by Size at the Port

			All Pieces			Diesel Only		
Lift Category	Horsepower Range	Lift Capacity (lbs)	Total	Model Year	Average Hours	Total	Model Year	Average Hours
Light	<75	up to 9,000	12	2012	324	5	2012	307
Medium	75-120	9,000 to 20,000	10	2012	334	2	2011	490
Heavy	>120	Greater than 20,000	37	2008	368	20	2008	226
Total	-		**59**	-	-	**27**	-	-

Electric forklifts (Classes 1, 2, and 3) built today are often used in similar applications as the fuel-powered counterparts and can do the work of most Class 4, and many Class 5 forklifts. Specifications for available electric forklifts are provided in CHE Table 6 and include energy potential (volts [V]), lift capacity in pounds (lbs), and designed use. As shown, electric forklifts are commercially available for up to 40,000-lb lift capacity. For lift capacities above 40,000 lbs, diesel forklifts are still required. Replacing current heavy-lift forklifts with Tier 4 forklifts would result in significant NOx and DPM emission reductions but negligible GHG reductions.

CHE Table 6. Specifications for Available Electric Forklifts

Class	Voltage	Lift Capacity (lbs)	Use
Class 1	36 V, 48 V, or 80 V	Typical: 3,000 – 12,000 Max: 40,000	Indoor or outdoor, ideal for loading and unloading tractor-trailers, or handling pallets.
Class 2	24 V, 36 V, or 48 V	Typical: 3,000 – 5,500	Indoor narrow aisle, designed for compact vertical spaces
Class 3	12 V, and 24 V	3,500 – 8,000	Electric hand (“walkie”) or rider models

Source: Electric Power Research Institute. 2015. *Electric Forklifts.*

Batteries for electric forklifts are sized to accommodate the typical hours of daily use. There are two battery charging methods available, including conventional charge and rapid/opportunity charge. Conventional charging is the most common for electric forklifts and operates on a regular cycle where the forklift is in use for 8 hours, is charging for 8 hours, and cooling for 8 hours. Because even the most demanding operations only typically require forklift use about 50% of the time, most pieces are able to be used for two 8-hour shifts on a single battery and charge. With rapid/opportunity charging, the battery charges for about 1-2 hours during the day, and only requires an 8-hour equalization charge once a week. This charging method is ideal for forklifts needed for 2 or more shifts.

Select manufacturers of electric forklifts (brand/supplier) are listed below.

- CAT/ Mitsubishi Caterpillar Forklift
- Clark/ Clark Material Handling International
- Crown/ Crown Equipment Corp.
- Doosan/ Doosan Industrial Vehicle
- HC Hangcha/ Hangcha Group Co.
- Heli/ Heli Americas
- Hyster/ Hyster-Yale Materials Handling
- Hyundai/ Hyundai Heavy Industries
- Jungheinrich/ Mitsubishi Caterpillar Forklift
- Kalmar/ Cargotec USA
- Komatsu/ Komatsu Ltd.
- Linde/ KION Group
- Mitsubishi/ Mitsubishi Caterpillar Forklift
- Raymond/ Toyota Industries Corp.
- Toyota/ Toyota Industries Corp.
- UniCarriers, Nissan/ UniCarriers Americas Corp.
- Yale/ Hyster-Yale Materials Handling

CHE Figure 2 shows electric forklift models of various lift sizes offered by Toyota, Yale, and Hyster. Electric forklifts have been demonstrated at both the San Pedro Bay ports (SPBPs) as well as the Port of San Diego. Electric forklifts are currently in use at all three Port terminals, operated by the Port, Pasha, and NOAA. These forklifts include Jungheinrich, Caterpillar, DOOSAN, and Toyota models with horsepower ratings ranging from 28 – 149 hp.

CHE Figure 2. Electric Forklifts

Toyota THDE400-24

Light Lift

Yale ERP155-190VNL

Medium Lift

Hyster J155-190XNL

Heavy Lift

Mobile Harbor Crane

Mobile harbor cranes come in a variety of lift capacities (from 100 to 308-ton lifts). Currently, they have two potential power configurations. The first configuration has both the crane's movement and the crane's lift powered by a diesel engine. The second configuration is called a hybrid-electric crane, where movement is powered by a diesel engine and the lift is powered by electricity from a plug. While not commercially available at this time, a third potential configuration under development is a fully electric mobile harbor crane with movement powered by a battery and the lift would be powered by electricity over a plug.

The Port currently owns one "Kone Gottwald" mobile harbor crane that is used by the Port's customers at TAMT. The Gottwald mobile harbor crane is nearly 20 years old and is diesel-powered by a tier one engine with 1,030 horsepower. It has a maximum lifting capacity of 100 metric tons (with a much lower capacity when extended over a ship). At this time, it is operated for approximately 245 hours annually (See Appendix B, Cargo Handling Equipment Inventory). Based on CARB regulations, this piece of equipment must be phased out by January 1, 2029, or potentially sooner based on the proposed amendment to CARB's current Mobile Cargo Handling Equipment Regulation mentioned above. Additionally, based on the Gottwald's age, the Port anticipates substantially increased maintenance costs prior to its retirement.

The Port needs a mobile harbor crane to provide a back-up option for Dole, to lift heavy breakbulk cargoes off ships, and to move some cargoes around the TAMT yard. Options for mobile harbor cranes to replace the Gottwald are presented below. It should be noted that Federal government funding normally is not awarded to purchase mobile harbor cranes because that type of CHE is produced in Germany, and Federal grant funds typically have a "buy America" preference provision that makes projects to purchase these foreign-built cranes highly unlikely to receive Federal grant funds.

Diesel-powered Cranes (Diesel Lift, Diesel Positioning)

Traditional diesel-powered cranes such as the Port's Gottwald mobile harbor crane utilize a diesel engine over a hydraulic distribution gearbox to move and complete lifts. Since the Port is not considering the purchase of a traditional diesel-powered mobile harbor crane to replace the Gottwald, options for diesel-powered mobile harbor cranes are not presented below.

Electric Hybrid Cranes (Electric Lift, Diesel Positioning)

The cleanest mobile harbor cranes currently on the market are called electric hybrid cranes. They use Tier 4 diesel engines to drive and position the crane around the terminal, and they use electricity (carried over a wire from a plug) to power their lifting activities. While the hybrid electric crane models are equipped with two power supply methods, the two work separately, not concurrently. These electric hybrid cranes are much cleaner than the traditional diesel-powered cranes, since most of the power used by the crane is for lifting cargo.

CHE Figure 1. Mobile Harbor Cranes

Liebherr LHM 420

Konecrane Model 4 Mobile Harbor Crane

Hybrid electric cranes are currently in use in Europe and the U.S., including nine demonstrations at the San Pedro Bay Ports (SPBP). Additionally, operators at the Port of Hueneme purchased the hybrid model of the Liebherr LHM 420 for their operations in 2019. The crane and accompanying infrastructure cost approximately $7 million, and will plug into Port Hueneme's electrical infrastructure, which was recently upgraded as part of their Zero and Near Zero-Emission Freight Facilities (ZANZEFF) grant funded by California Cap and Trade dollars.[5]

[5] *Port Welcomes First Zero-Emission Crane.* July 9, 2019. *Available:* https://www.portofhueneme.org/zero-emission-crane/ Accessed January 2021.

Electric Cranes (Electric Lift, Battery-powered positioning)

Full-electric mobile harbor cranes are not yet commercially available, nor is there an option to retrofit cranes with an electric motor. In theory, fully electric mobile harbor cranes would have all the same capabilities as their diesel and hybrid counterparts, except that they would use battery-provided electricity to drive and position the crane. Similar to the hybrid electric cranes, they would need to be plugged in for the duration of lifting operations. The Port is tracking the development of these all-electric cranes, and there is currently no estimate for when they will come to market.

Potential Replacements for the Gottwald Mobile Harbor Crane

In exploring potential replacements, the Port has determined that there are opportunities to secure additional heavy-lift cargoes by increasing crane lift capacity to 300 metric tons, while also pursuing zero or near-zero crane technologies. Through coordination with the Port, the manufacturers Kone and Liebherr were selected as the top crane candidates for replacements. The following three crane models were identified:

- Liebherr LHM 800 (single crane with lift capacity of 180-300 metric tons depending on positioning of the cargo aboard the vessel)
- Liebherr LHM 600 (tandem/dual crane operation of up to 300 metric tons depending on positioning of the cargo aboard the vessel)
- Konecranes Model 8 G HMK 8710 (tandem/dual crane operation of up to 300 metric tons depending on positioning of the cargo aboard the vessel)

A breakdown of crane characteristics can be seen in CHE Table 7. The candidate cranes would need to be plugged in and fully powered by electricity instead of diesel, and so the Port would need to install additional plugs at the terminal that are similar to those being completed at the Port of Hueneme.

CHE Table 7. Specifications for Available Replacement Cranes

Specifications	Crane Manufacturer and Model		
	Liebherr LHM 600	Liebherr LHM 800	Kone Crane Model 8 G HMK 8710
Cost: Electric Crane – diesel positioning only ("Hybrid")	$6.2-6.8 million	$8.1-8.7 million	$6.4 million
All Electric (battery powered positioning) STILL IN DEVELOPMENT – DATE AVAILABLE FOR PURCHASE TBD	$ TBD	$ TBD	$ TBD
Maximum Lift Capacity (MT) (Single & Tandem)	208 & 416	308 & 616	200 & 400
Weight (MT)	594	795	600
Crane Reach (m)	58	64	56

Source: Liebherr and Kone.

Yard Tractors

A summary of existing yard tractors by terminal and by fuel is shown in CHE Table 8. As shown, most yard tractors are diesel that operate at TAMT. As of the 2019 Inventory, there are three electric yard tractors – two at TAMT and one at NCMT – and 20 diesel yard tractors – 20 at TAMT and 7 at NCMT.

CHE Table 8. Summary of Yard Tractors at the Port

Terminal	Electric	Diesel
TAMT	2	20
NCMT	1	7
CST	0	0
Total	3	27

Along with the electric yard tractors in use at the Port, electric yard tractors are also currently being demonstrated at the Ports of Long Beach and Oakland. In the spring of 2019, the Ports of Long Beach and Oakland acquired 38 electric yard tractors as part of CARB's ZANZEFF program. The tractors are all-electric drivetrain systems with Meritor axles and brakes, and TransPower electric powertrain, capable of hauling 130,000 pounds of cargo. The 38 tractors feature automated charging technologies, which further reduce operating costs.[6,7]

Charging methods for electric yard tractors are the same as those for electric forklifts, and include conventional charging, and rapid/opportunity charging. Conventional charging is the most common for 1-shift operation, as it follows a regular cycle where the tractor is running for eight hours, is charging for eight hours, and cooling for eight hours. With rapid/opportunity charging, the battery charges for about 1-2 hours during the day, and only requires an 8-hour equalization charge once a week. This charging method is ideal for yard tractors needed for two or more shifts.

Electric yard tractors are available from several manufacturers, including BYD 8Y, Kalmar Ottawa T2, and Orange EV T-Series. Yard tractor options are shown in CHE Figure 4. All three have been certified under CARB's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP). Specifications for these electric yard tractor options are provided in CHE Table 9, and include tractor range, battery size, gross vehicle weight rating (GVWR), top speed, estimated endurance in hours, and estimated price (MSRP low-high estimates).

At the Port, there are three electric yard tractors in use, one at NCMT (Pasha) and two at TAMT (Dole). All the electric tractors currently operating at the Port are BYD 8Y model, with 241 HP.

[6] *Meritor to electrify Port of Long Beach tractors.* April 25, 2019. Available: https://www.freightwaves.com/news/greentrucking/meritor-to-electrify-port-tractors Accessed January 2021.
[7] *Meritor readies improved e-axle, wins contract with California ports.* April 25, 2019. *Available:* https://www.fleetowner.com/running-green/article/21703750/meritor-readies-improved-eaxle-wins-contract-with-california-ports Accessed January 2021.

CHE Figure 4. Electric Yard Tractor Options

BYD Battery-Electric Yard Tractor | *Kalmar Ottawa Battery-Electric Yard Tractor* | *Orange EV Battery-Electric Yard Tractor*

Source: San Pedro Bay Ports, Draft 2018 Feasibility Assessment for Cargo-Handling Equipment

CHE Table 9. Electric Yard Tractor Specifications

Specification	Manufacturer/ Model		
	BYD/ 8Y	Kalmar Ottawa/ T2E	Orange EV/ T-Series
Battery Size (kWh)	217	220	80-160
GVWR (lbs)	>26,000	>26,000	40,900
Top Speed (mph)	32	45	25
Estimated Endurance on single charge (hours)	12-16	12-16	9-12
MSRP ($ low-high)	-	-	$199,000 - $285,000

Source: ICF, San Pedro Bay Ports, Draft 2018 Feasibility Assessment for Cargo-Handling Equipment.

Top Handlers & Reach Stackers

As of 2019, there are two top handlers and five reach stackers operating across the Port. One of the reach stackers is electric-powered, while the remaining four pieces are diesel. As shown CHE Table 10 below, diesel reach stackers operate for an average 328 hours annually, while top handlers operate an average 853 hours annually.

While electric options for top handlers and reach stackers are not commercially available, several crane manufacturers are working to develop such models by 2021.

In October of 2019, the Port of Los Angeles announced that it will begin a one-year demonstration of two battery-electric top handlers, which cost $1.8 million each. The battery-electric top handlers were designed and built in the U.S. by Taylor Machine Works, Inc., which is currently the largest supplier of top handlers at the Port of Los Angeles. The battery-operated top handlers have a one-megawatt battery and can operate for up to 18 hours on a single charge. For optimum performance, the top handlers are outfitted with data loggers that track hours of operation, charging frequency, energy usage, and various additional performance indicators.[8,9] As of August of 2020, the top handlers were integrated into normal daily operations at the Everport Container Terminal.[10]

At the Port of San Diego, there is one electric reach stacker operating at the TAMT by TerminalLift. The stacker is a retrofitted Fantuzzi Siemans with 354 hp. TerminalLift is in the process of converting additional reach stackers and a top handler to electric motors.

Emission Reductions and Cost

Emission Reductions

The projects herein include conversion of forklifts (light-, medium-, and heavy-lift), the crane, yard tractors, top handlers, and reach stackers from diesel to electric. Moreover, given the limited options for heavy-lift forklifts, the analysis below also considers replacing equipment with a new Tier 4 piece to serve as a transition and to further reduce emission below current equipment. Emission reductions are based on replacing diesel pieces only and do not consider replacing in-use electric pieces.

Emission reductions are based on the average specs for each equipment type. This allows for a more useful ballparking of emissions, given the fact that the specific piece equipment of equipment to replace is not always known. Diesel equipment averages by type, based on the 2019 Inventory, are shown in CHE Table 10.

CHE Table 10. 2019 Diesel Equipment Averages at the Port

Type	Lift	Quantity	Engine MY	HP	Annual Hours
Forklifts	Light	5	2012	64	307
	Medium	2	2011	105	490
	Heavy	20	2008	191	226
Yard Tractors	-	27	2011	201	578
Reach Stacker	-	4	2011	344	328
Top Handler	-	2	2002	327	853
Harbor Crane	-	1	2002	1030	245

[8] The Port of Los Angeles. 2019. *Port of Los Angeles Unveils World's First Zero-Emissions Top Handlers.* October. Available: https://www.portoflosangeles.org/references/news_100219_top_handler
[9] *Ports of Long Beach, L.A. unveil new zero-emission vehicles.* October 2, 2019. Available: https://www.presstelegram.com/2019/10/02/ports-of-long-beach-l-a-unveil-new-zero-emission-vehicles/ Accessed January 2021.
[10] *Eco-friendly technology now fully operational at the Port of LA.* August 7, 2020. Available: https://www.porttechnology.org/news/eco-friendly-technology-now-fully-operational-at-the-port-of-la/ . Accessed January 2021.

A summary of emissions per piece of CHE is presented in CHE Table 11. Emissions are presented as annual average tons. It was assumed that the replacement pieces would operate the same number of average hours per year and would be the same size as its diesel counterparts. Emissions are based on the averages shown in CHE Table 10.

As shown in CHE Table 11, replacing diesel CHE equipment with electric alternatives would result in the elimination of all NOx and DPM emissions, while emissions of CO_2e would decrease by substantially due to the fact that the electrical grid results in lower emissions per unit of activity than diesel. Note that grid emissions are based on SDG&E's emission rate as of 2018. Because SDG&E's procurement of carbon-free renewable energy sources will increase over time, so too will the GHG benefit of electric replacement equipment, leading to increases in the GHG reduction estimates presented here.

CHE Table 11. Summary of Annual Average Emissions per Piece (Tons per Year)

Equipment Type	Option	Tier	Emissions Per Year			Emission Reductions Per Year		
			NOx	DPM	CO_2e	NOx	DPM	CO_2e
Light-Lift Forklifts (<75 hp)	Existing Diesel	3	0.02	0.001	4	-	-	-
	Electric	-	-	-	1	0.02	0.001	3
Medium-Lift Forklifts (75-120 hp)	Existing Diesel	2	0.05	0.004	10	-	-	-
	Electric	-	-	-	3	0.05	0.004	7
Heavy-Lift Forklifts (>120 hp)	Existing Diesel	3	0.04	0.002	8	-	-	-
	Tier 4	*4*	*0.004*	*0.0001*	*8*	*0.03*	*0.002*	*0*
	Electric	-	-	-	3	0.04	0.002	6
Yard Tractors	Existing Diesel	4i [1]	0.13	0.007	29	-	-	-
	Electric	-	-	-	9	0.13	0.007	20
Reach Stackers	Existing Diesel	4i [1]	0.19	0.009	42	-	-	-
	Electric	-	-	-	13	0.19	0.015	29
Top Handlers	Existing Diesel	2	1.10	0.040	104	-	-	-
	Electric	-	-	-	33	1.10	0.040	71
Cranes	Existing Diesel	1	0.53	0.015	69	-	-	-
	Hybrid	-	-	-	*22*	*0.53*	*0.015*	*47*
	Electric	-	-	-	22	0.53	0.015	47

[1] Tier 4 standards for the 75-750 hp rated power engines, the standards were phased-in over a few years. The initial standards, which affect PM emissions only, are sometimes referred to as Tier 4 interim, or Tier 4i. The final standards, which include NOx and hydrocarbon standards as well as PM, are sometimes referred to as Tier 4 Final, or Tier 4f.

The range in reductions per pieces depends on various factors, including but not limited to the amount each piece is used in a given year. Also, because electric hybrid crane models only use diesel during infrequent movement at the terminal, the emissions due to diesel would be effectively insignificant and the emissions reductions would be essentially the same as replacement with a full-electric model.

Cost

A summary of technology capital cost and cost per emissions saved for CHE is presented in CHE Table 12. The lower the cost per emission saved indicates a higher cost effectiveness. Cost effectiveness is a useful metric because it allows us to compare investments reducing CHE emissions, with investments in other maritime-related emission sources, such as shore power and ZE/NZE on-road trucks. Technology costs were obtained from various sources including Port staff, tenants, and online research.

As shown, cost-effectiveness per pound of emissions saved tends to be highest for light- and medium-lift forklifts, the yard tractors, and the top handlers. In effect, the cost effectiveness is highest for the cheaper pieces. An underlying assumption here is that the activity is assumed to be the same as existing conditions. If replacement pieces would be used more frequently, cost effectiveness is likely to increase. Note that the technology cost here does not include any cost associated with electrical charging infrastructure at the terminal. Based on early demonstration project for ZE/NZE CHE Equipment, charging infrastructure can be up to $750,000 per outlet, which could substantially increase the cost per pound of emissions saved, shown below.

CHE Table 12. Summary of Cost and Emission Savings per Cost

Equipment Type	Option	Technology Cost	Cost per Pound of Emissions Saved		
			NOx	DPM	CO_2e
Light-Lift Forklifts (<75 hp)	Electric	$25,000[a]	$645	$11,638	$5
Medium-Lift Forklifts (75-120 hp)	Electric	$50,000[a]	$480	$5,835	$4
Heavy-Lift Forklifts (>120 hp)	Tier 4	$150,000[b]	$2,308	$44,176	no reduction
	Electric	$250,000[c]	$3,452	$68,986	$22
Yard Tractors	Electric	$250,000[d]	$957	$17,781	$6
Reach Stackers	Electric	$1,850,000[e]	$4,954	$17,781	$6
Top Handlers	Electric	$1,850,000[e]	$839	$98,274	$32
Cranes	Kone Hybrid	$6,355,900[f]	$5,996	$210,753	$67
	Kone Electric	$6,595,261[f]	$6,221	$218,689	$70
	Liebherr 600 Hybrid	$6,200,000[g]	$5,850	$205,583	$66
	Liebherr 600 Electric	$6,800,000[h]	$6,415	$222,500	$72
	Liebherr 800 Hybrid	$8,650,000[g]	$8,160	$286,822	$92
	Liebherr 800 Electric	$8,290,000[h]	$7,820	$274,885	$88

[a] Toyota. 2021. *Forklift Pricing 1010: What You Should Know*. Available: https://www.toyotaforklift.com/resource-library/material-handling-solutions/finance/forklift-pricing-101-what-you-should-know. Accessed January 2021.
[b] CostOwl. *Average Forklift Prices*. Available: https://www.costowl.com/b2b/forklift-cost.html. Accessed January 2021.
[c] CostOwl. *Average Forklift Prices*. Available: https://www.costowl.com/b2b/forklift-cost.html. Accessed January 2021.
[d] Price provided by the Port.
[e] Retrofit estimate from discussion with existing terminal operator.
[f] Price of Two Kone Crane Model 8 G HMK 8710.
[g] Price represents high estimate for Liebherr LHM 600 and 800 hybrid cranes.
[h] Price represents high estimate for Liebherr LHM 600 and 800 full-electric cranes.

Commercial Availability

As discussed above, electric forklifts, hybrid-electric cranes,[11] and electric yard trucks are currently commercially available. While electric-powered top handlers and reach stackers are not currently available for purchase, demonstrations are currently underway for these pieces on Port tidelands and at other nearby Ports.

Overall Feasibility

Prioritizing the highest emitting diesel pieces of CHE for electrification results in significant reductions. Based on the 2019 Inventory, CHE Table 13 identifies the highest emitting CHE, which are all operated at TAMT.

CHE Table 13. Highest Emitting CHE

Type	Name	Emissions Rank			
		#	NOx	DPM	CO_2e
Crane	Gottwald HMK300 Mobile Harbor Crane	1	3	1	3
Reach Stacker	TAYLOR RS9968 OSM11-C	1	4	3	4
Yard Tractor	CAPACITY TJ5000	15	1	2	1
Loader	CAT 928 G	1	6	6	18
Top Handler	TAYLOR TEC-9501	1	5	4	6
Top Handler	Taylor TEC950L Cummins C260	1	2	5	2

If these 20 pieces of diesel CHE were upgraded to electric or lower emitting alternatives, NOx could be reduced by approximately 89% (6.79 tons), DPM by approximately 80% (0.097 tons) and CO2e by 49% (885 tons) annually.

At the July 2020 Board Meeting, staff presented a preliminary draft of these findings[12] and received support from the Board to target and prioritize upgrading or replacing the higher emitting CHE with zero and near-zero emission alternatives. The Board directed staff to work with tenants to upgrade or replace high emitting CHE where feasible.

Practically, however, there continues to be several obstacles associated with acquiring ZE and NZE CHE alternatives. The cost of ZE/NZE CHE still tends to be more expensive than its diesel counterpart. Although there are multiple programs and grant opportunities for ZE/NZE CHE, there are often

[11] Electric hybrid

[12] At the July 2020 Board Meeting, staff initially identified 28 higher emitting CHE to upgrade to zero or near zero models. However, as staff began working with Port tenants and terminal operators, staff discovered that the Preliminary Inventory overestimated activity at TAMT. The Preliminary Inventory relied on CARB's EMFAC default hours for several pieces of equipment which was significantly greater than actual hours of use. For example, EMFAC lists 1,409 annual hours of operation per forklift annually as a default whereas when staff received updated information based on actual hours used, staff discovered that the forklifts operate for an average of 196 hours annually. As a result, this yielded a substantially lower amount of emissions, as well as a different set of CHE targeted for upgrades. The updated information was shared with the AB 617 MCAS Subcommittee on November 17, 2020 and it was incorporated into staff's status update on the MCAS to the Board of Port Commissioners on February 11, 2021.

restrictions that limit this funding source from reaching the Port of San Diego and/or its tenants. For example, some programs require an existing piece of diesel equipment to be destroyed in exchange for grant funding, which deters equipment owners from pursuing lower-emitting alternatives, particularly if the diesel piece is only a few years old and/or still within its useful life. For a case in point, staff worked with a tenant looking into replacing yard tractors that were a few years old. However, the grant program did not allow them to move the equipment out of state, but rather, required that the existing equipment be destroyed. This reduced the cost effectiveness of the replacement and proved to be suboptimal for the environment. Additionally, the owner needs to be confident that the lower-emitting alternative will meet their operational needs.

Finally, recent grant programs have not provided adequate funding for zero and near-zero CHE. Based on four pieces of high-emitting CHE at TAMT, which was estimated to cost a total of $6.1 million, a recent analysis demonstrated that the maximum award potential would only be $736,000, or about 12%. Conversations with SDAPCD staff have indicated that the reason that these maximum award amounts are so low is because the diesel emissions, which are based on MY Engine, Engine Tier and annual hours of operation, are not that high at TAMT when compared to other pieces of equipment in San Diego County and the State of California. That said, SDAPCD staff have recognized the limitations of existing grant opportunities and have committed to try to increase the flexibility of various programs. More specifically, the Portside Community's AB 617 Community Emission Reduction Program (CERP) includes Action B1: Create Additional Flexibility for Mobile Source Incentives, which states:

Work with the [AB 617] Community Steering Committee and the public to identify and prioritize opportunities that could benefit from incentive funding. Work with CARB to increase flexibility to provide funding for other projects in the Portside Community through the Community Air Protection Incentives Guideline process. Potential flexibilities include:

- *Modified cost-effectiveness limits for zero-emission Moyer-type projects*
- *Eligibility for new purchase without scrappage requirements*
- *Eligibility for supporting infrastructure*
- *Provide mechanism for funding pilot projects to demonstrate new technologies*
- *Eligibility for projects to reduce exposure including air filtration, tree and vegetation plantings*
- *Eligibility for projects that reduce emission from passenger car use, including incentives for zero and near-zero emission vehicles, transit passes, bicycle and pedestrian projects, and others*
- *Consideration of proximity of emissions to sensitive receptors, such as schools*

Despite these obstacles, various electrical pieces are already in use at the Port, and various tenants have secured funding and/or have expressed an interest in future electrification efforts. Electric forklifts are readily available under a certain size. Electric yard tractors are in use at both cargo terminals, with more anticipated. The Port should track the demonstrations for the electric reach stackers and top handlers, particularly since one reach stacker and two top handlers are identified in CHE Table 13 as some of the highest emitters in operation at the Port. The Port has expressed interest in replacing the mobile harbor crane, another high emitter identified in CHE Table 13, to not only service existing needs with a zero emissions equipment, but to expand service by increasing lift capacity. Some operational changes may be required.

The TAMT Final EIR requires a specific number of CHE to be replaced with electric alternatives by 2020, 2025, and 2030. The Port has been working with tenants to meet these targets and will continue to do so. Based on the 2019 Inventory, the Port will be able to focus on the highest emitting equipment in use, so that limited funds can be used to attain the maximum amount of emission reductions. Although, these commitments are clearly identified in the TAMT Final EIR, correlating references and commitments are included here too.

Goals and Objectives

CHE Goal – Attain substantial reductions for CHE related emissions.

CHE Objective 1: Reduce emissions from cargo handling equipment by approximately 90% for NOx, 80% DPM, and 50% for CO2e below 2019 levels by 2026.

Discussion

The baseline for CHE emission reductions was established by the 2019 CHE Inventory. The near-term goal to be completed by 2026 is to reduce emissions from cargo handling equipment by approximately 90% for NOx, 80% for DPM and 50% for CO_2e by replacing the 20 highest emitting pieces of equipment identified in the 2019 Inventory with electric models. These pieces are not necessarily the oldest or highest emitting, but some of these pieces are the most activity at the cargo terminals and could greatly benefit from electrification.

CHE Objective 2: Continue to stay engaged with CARB rulemaking development.

Discussion

The next benchmark in reducing emissions from cargo handling equipment will be identified once CARB adopts the amendment to the Regulation for Mobile Cargo Handling Equipment, which is anticipated to occur in either 2022 or 2023 for an implementation schedule to begin in 2026. Once CARB adopts the amendment, Port staff will make a recommendation to the Board of Port Commissioners on next steps. The objective will be to look for additional opportunities to deploy zero/near zero emission technologies prior to 2035.

Harbor Craft

Commercial harbor craft (CHC) include all commercial marine vessels that are not considered ocean-going vessels (OGVs). Unlike OGV, CHC typically spend most of their operating time in or near a single port or region.

Non-commercial harbor craft, including recreational boats, are used solely for personal enjoyment on San Diego Bay. These include a variety of gasoline- and diesel-powered vessels and spend most of their operating hours within the Bay. Recreational boating includes personal watercraft (jet skis), sailboats, jet boats, and yachts. Smaller watercraft are usually gasoline powered and larger yachts are usually diesel powered. However, because CARB has excluded recreational boats from current and future harbor craft rules, they are not addressed in this chapter.

Background and Context

CHC include a variety of vessel and boat types that serve many functions within and near San Diego Bay, including crew and supply boats, charter fishing vessels, commercial fishing vessels, ferry and excursion vessels, pilot vessels, towboats or push boats, tug boats, barges, and work boats.

CHC represent a substantial portion of bay-wide emissions. Based on the 2019 Inventory Update, harbor craft accounted for 45% of NOx, 60% of DPM and 40% of CO_2e of maritime-related emissions. However, these emissions occur during transit throughout the Bay and within 24 nautical miles of Point Loma. As such, they likely contribute less to localized health risk impacts than other sources since most of their emissions occur while on the water and not while at berth adjacent to the community. Nevertheless, they are a significant source of harbor-related maritime emissions.

Source Description

CHC engage in a wide variety of activities in San Diego Bay: assist in moving ocean-going vessels (OGVs) through the harbor and in and out of berth; move cargo and people into and out of the harbor area; provide fuel to OGVs; provide police, fire, pilot, and other services to harbor users; transport crew and supplies to offshore facilities; provide recreation opportunities; and transport crew and passengers to offshore fishing destinations. Most CHC are U.S. Environmental Protection Agency (EPA) Category 1 or 2 vessels, vessels with diesel engines less than 30 liters per cylinder. CHC Table 1 lists CHC vessel types and their typical function within the Bay.

CHC Table 1. Commercial Harbor Craft Vessel Types

Vessel	Description
Assist tugboats	Help OGVs maneuver in the harbor during arrival and departure and shifts from berth, and can also provide escort for OGVs
Towboats/push boats/ocean-going tugboats	Self-propelled vessels that tow or push barges within and outside of the port
Ferries and excursion vessels	Ferries transport people and property. Excursion boats provide harbor cruises and whale watching.
Crew boats	Carry personnel and supplies to and from off-shore and in-harbor locations
Work boats	Include utility, inspection, survey, spill/response, research, mining, training, and construction
Government vessels	Belong to U.S. Coast Guard; U.S. Navy, Fish and Game; and fire, police, and harbor departments[1]
Commercial and Sport Fishing Vessels	Carry crew and/or passengers to fishing areas both within and outside 24 nautical miles of the Port

Tugboats, Towboats, Push Boats, and Assist Tugs

Tugboats, towboats, push boats, assist tugs, and ocean-going tugs are typically processed together. Assist tugs, tow boats, and push boats perform a variety of general work functions within the harbor, including assisting OGVs maneuvering into and out of berth and pushing and pulling barges. Assist tugs ensure safe navigation for large cargo vessel movements upon arrival to and departure from marine terminals. Assist tugs have unique power levels, rudders, and other equipment designed and designated specifically to support the variety in size and maneuverability of the cargo vessels. Ocean-going tugs active within San Diego Bay primarily include tugs that pull fuel barges to and from the Ports of Los Angeles and Long Beach, and lumber barges to and from the Pacific Northwest. There were eight assist tugs, two tow or push boats, and five ocean-going tugs operated by Port tenants in San Diego Bay in 2016.

Commercial and Sport Fishing

Commercial fishing includes those vessels harbored at commercial fishing areas located at Shelter Island and Tuna Harbor, along the Embarcadero. The commercial fishing fleet varies in size due mainly to the specialization in geographic range and space requirements by type of catch for each vessel. Sport fishing, or charter fishing, vessels are fishing boats that are commercially chartered by passengers. These vessels are operated by sport fishing operations located out of Shelter Island including Fisherman's Landing, H&M Landing, and Point Loma Sport Fishing. Similar to commercial

[1] Note that US military operations are excluded here. Generally, states cannot require emission reductions from federal vessels. Additionally, Port fleet vessels are not included in this source and are discussed in the Port Fleet section.

fishing, the sport fishing fleet varies in size depending on the location and range of the vessels. Generally, sport fishing vessels have greater engine power than commercial fishing vessels due to the demands of moving passengers and equipment.

Ferry and Excursion

Ferry and excursion vessels are used to move passengers for public transportation, sightseeing, whale watching, dinner cruises, and other similar recreational opportunities within and near the Bay. Ferry and excursion services operate from the Embarcadero area along the northeastern shore of San Diego Bay within the vicinity of Broadway and B Street. Two companies primarily provide ferry and excursion services: San Diego Harbor Excursion (a.k.a. Flagship) and Hornblower Cruises and Events. Passenger ferries and excursion vessels rarely travel beyond 24 nautical miles (nm) from the Port.

Other Commercial Harbor Craft

Other CHC include boats that perform a variety of functions within the Bay. In this analysis, these were broadly treated as crew, supply, pilot, work, and other vessels. Crew and supply boats are smaller boats that are used for carrying personnel and supplies. Work boats perform inspections, survey, and assist with construction. As OGVs approach the Bay, a pilot boat carries a Bay pilot that then boards OGVs in the vicinity of the Whistle Buoy[2] to ensure safe navigation to the berthing location within San Diego Bay. A fuel barge (auxiliary engines only) is considered in this category and the boat pushing the barge (carrying fuel or something else) is considered an ocean-going tug.

Non-Commercial Harbor Craft

San Diego Bay has numerous marinas and yacht clubs as well as four public boat launch ramps. Recreational boating occurs from boats that are permanently in the water (i.e., docked at marinas throughout the Bay and region) and boats that are stored elsewhere and launched for day use only. The types of recreational boats include personal watercraft (jet skis), sailboats, jet boats, and yachts that are used for fishing, cruising, swimming, and water skiing. Most recreational boats are smaller gasoline-powered vessels that are used for a day at a time within the Bay, while some larger yachts dock and remain in the Bay for up to weeks at a time.

Existing Fleet Summary – 2019 Port CHC Inventory

In Spring 2020, Port staff conducted a Maritime Commercial Harbor Craft Inventory (Inventory) to update the prior iteration from 2016, identify the higher-emitting equipment that is in use, and to determine the feasibility of cleaner upgrades to reduce emissions. The scope of the Inventory includes all CHC that are based in Port jurisdiction or that visited one of the three marine terminals (CST, TAMT, and NCMT) in 2019. This is the fourth CHC Inventory conducted by the Port, past inventories were conducted in 2006, 2012 and 2016. Emissions were calculated based upon CARB's methodology.

CHC is broken into two major groups: harbor craft associated with commercial and sport (charter) fishing, and all other types of harbor craft. The CHC inventory for the fishing fleet relies on the 2016

[2] The Whistle Buoy marks the approach to San Diego Bay from the open ocean (32 deg 37.3 min N, 117 deg 14.7 min W). It is designed to make noise to alert mariners in reduced visibility, using an airflow chamber and the motion from wind and wave action to create a whistling sound.

inventory because it was based on several months of research and extensive outreach to the fisherman and marinas.

The inventory for all other harbor craft was updated based on 2019 activity. All harbor craft in operation are diesel-fueled. The CHC inventory includes several one-off ship visits for activities such as repairs. In 2019, a few work boat and research boats that are not based in San Diego visited and made up a large share of emissions. While these emissions are accounted for, the recommended strategies and options at the end of the chapter focus on emission sources that are consistently in the bay, such as assist tugboats, excursions, and ferries. Inventory data and emissions are summarized in CHC Table 2 and inform the analysis below. CHC inventory emissions are provided in greater detail in Appendix A.

CHC Table 2. Portion of Commercial Harbor Craft Pieces and Emissions by Type

Type	Pieces	NOx	DPM	CO_2e
Crew Supply	10%	13%	9%	17%
Dredge	2%	1%	1%	1%
Escort/Ship Assist Tug	6%	4%	3%	6%
Excursion	26%	20%	18%	23%
Ferry	2%	4%	4%	4%
Bunker Barge	1%	0%	0%	0%
Pilot Boat	2%	2%	1%	2%
Push Tow Tug	28%	18%	17%	17%
Research Boat	11%	23%	23%	14%
Work Boat	13%	16%	16%	16%
Total	100%	100%	100%	100%

History of Previous Efforts

With the exception of CARB establishing minimum engine compliance standards for various CHC in 2007 and 2011, there have been relatively few strategies to reduce CHC-related emissions. However, given that ferries and tugs owned by Port tenants account for the vast majority of CHC emissions, Port tenants, have been advancing zero and near zero emission technologies including applying for grants to electrify a ferry vessel and obtaining a grant award for electric tug vessels.

Electric Ferry

In 2017, the Port applied to the CARB *Off-Road Advanced Technology Demonstration Project* grant program in part to fund the purchase of a 74-ft lithium-ion battery electric ferry to provide hourly passenger service between the Broadway Pier, San Diego Convention Center, and the City of Coronado. The proposal, which also included funds for seven high-capacity forklifts and a boat hoist, totaled $13.9M, with $9.7M from CARB, and a Port match of $4.2M.[3] The project was expected to reduce emissions by 658 $MTCO_2e$, 0.7 tons NOx, and 0.02 tons of DPM annually.[4] While this particular grant application was not successful in 2017, the Port may consider pursuing a similar electric ferry application with a ferry operator in the future, given that the Portside Community was officially designated by CARB for the AB 617 Community Air Protection in 2018.

Electric Tug

In 2019, Crowley Marine Services was awarded over $8M from the 2019 San Diego County APCD and CARB *Clean Air for All Grant Campaign* for the design, build, and demonstration of an all-electric tugboat[5]. The proposed "E-Tug" is expected to save 107 tons of NOx, and over 3 tons of DPM over its expected lifetime, amounting to approximately $46,320 per ton of pollutant saved. At the time of this report (2021), the E-Tug was in its engineering/design phase; the E-Tug is anticipated to be in operation by 2023.

Legislative and Regulatory Framework

Commercial Harbor Craft

At the federal level, the EPA has adopted emission standards for new Category 1 (0 to 7 liters per cylinder) and Category 2 (between 7 and 30 liters per cylinder, which includes most harbor craft) diesel engines rated over 50 horsepower (hp) (or 37 kilowatts) used for propulsion in most harbor craft. The new Tier 3 engine standards began phase-in starting in 2009 and the more stringent Tier 4 engine standards were phased in beginning in 2014 and only for commercial marine diesel engines greater than 800 hp. The regulation also includes requirements for remanufacturing commercial marine diesel engines greater than 800 hp. Additionally, the EPA has set sulfur limitations for non-road diesel fuel, including locomotives and marine vessels (though not for the marine residual fuel used by very large engines on OGVs). Under this rule, diesel fuel used by locomotives and harbor craft was limited to 500 parts per million (ppm) sulfur content starting June 1, 2007, and further limited to 15 ppm sulfur content (ultra-low-sulfur diesel) starting January 1, 2010, for non-road fuel and June 2012 for marine and locomotive fuels.

At the state level, CARB adopted a regulation that reduces DPM and NOx emissions from new and in-use commercial harbor craft operating in Regulated California Waters (i.e., 24 nm off the California shoreline). CARB adopted this regulation on November 17, 2007, and it became effective on January 1, 2009. CARB's definition for commercial harbor craft includes tugboats, towboats, ferries, excursion vessels, workboats, crew boats, and fishing vessels that do not otherwise meet the definition of OGVs or recreational vessels. All in-use, newly purchased, or replacement engines must meet the EPA's current emission standards up to Tier 3 according to the compliance schedule set by CARB. In addition, propulsion engines on all new ferries acquired after January 1, 2009, with a capacity of more

[3] Port of San Diego. 2020. *AB 617 MCAS Subcommittee Meeting #4*. December 2021.
[4] CARB. 2017. *Low Carbon Transportation Investments: Fiscal Year 2016-2017 Off-Road Advanced Technology Demonstration Project Solicitation*. October 12. Available: https://ww2.arb.ca.gov/sites/default/files/classic//msprog/aqip/solicitations/fy1617offroaddemoapplications.pdf. Accessed February 2021.
[5] SDAPCD. 2019. *Clean Air For All 2019 Funded Applications- AB 617 Projects.* Available: https://www.sdapcd.org/content/dam/sdc/apcd/PDF/Grants/2019%20Apps%20AB617%20Funded%20List.pdf. Accessed February 2021.

than 75 passengers are required to apply best available control technologies (BACT) to engines to meet EPA Tier 2 or Tier 3 marine engine standards at the time of vessel acquisition. CARB amended the commercial harbor craft regulation in 2010 to include crew and supply vessels, barges, and dredge vessels as well as to clarify requirements and address issues that arose during implementation of the initial regulation. CARB set sulfur limitations for diesel fuel sold in California for use in on- and off-road motor vehicles (13 CCR 2281–2285; 17 CCR 93114). Harbor craft and intrastate locomotives were originally excluded from the rule but were later included by a 2004 rule amendment. Under this rule, diesel fuel used in motor vehicles except harbor craft and intrastate locomotives has been limited to 500 ppm sulfur since 1993. The sulfur limit was reduced to 15 ppm on September 1, 2006. A federal diesel rule similarly limited sulfur content nationwide to 15 ppm by October 15, 2006.

CARB is in the process of updating the commercial harbor craft rule to include additional vessel categories and require Tier 3 or Tier 4 engines with a diesel particulate filter for all vessels below 600 kW (such as excursion boats and ferries), and Tier 4 engines with a diesel particulate filter for all vessels above 600 kW (such as tugs, work boats and many research vessels). If the proposed update to the rule goes into effect, by 2025, all new excursion vessels will need to be hybrid electric, and by 2026, all in-use and new short run (< 3 nm) ferries will need to be zero emission. Commercial fishing boats, historic boats and Coast Guard/Military boats are excluded from the rule. The US EPA has already certified 40 unique Tier 4 marine engine families, ranging from 600 to 7,485 horsepower; the agency has delayed Tier 4 engine certification requirements for high power density engines until 2022 or 2024. CARB staff does not expect the delay will impact the proposed compliance schedules. Also, under the proposed update, facilities that receive more than 50 visits per year would be required to install and maintain dock power by 2024. The amendment to the commercial harbor craft rule is anticipated to be adopted by CARB November 2021.

Non-Commercial Harbor Craft

Recreational boating includes personal watercraft (jet skis), sailboats, jet boats, and yachts. Smaller watercraft are usually gasoline powered and larger yachts are usually diesel powered. CARB has proposed and adopted regulations for certain marine vessels and regulations have been proposed for other spark-ignition engines used in boats for propulsion to reduce hydrocarbons and NOx emissions. Spark-ignition auxiliary marine engines (power generators, winches, or auxiliary propulsion engines for sail boats) are defined as small off-road spark-ignition engines (below 25 hp) or large off-road spark-ignition engines (25 hp and greater) depending on their size. Compression-ignition auxiliary and propulsion marine engines under 50 hp are defined as off-road diesel (compression-ignition) engines. CARB excluded recreational vessels from both current and future harbor craft rules.

Research and Analysis

Description of Emission Reduction Technology Options

Electric Tugs

All-electric technology is typically a valuable option when vessels have predictable duties, with specific routes and speeds, and with scheduled downtimes, which are necessary for charging the vessel battery. While tugboats typically have more inconsistent duties than ferries and passenger ships, electric tug technology is emerging as an option for reducing emissions at ports around the world.[6]

The world's first all-electric tug went into service at the Port of Tuzla in Istanbul in 2020. The ZEETUG, short for "Zero Emission Electric Tug Boat", was designed and built by Navtek Naval Technologies at the request of GISAS Shipbuilding. The boat has a 35-ton bollard pull[7] and a service speed of 10 knots, drawing power from two Corvus Energy 1,450-kW lithium-ion battery packs. While the time to charge can vary based on the charger, a full charge for the ZEETUG can be accomplished in as little as one hour. The tug is also equipped with the Smart Tug Energy Management System (STEMS), which is designed to optimize power consumption by tracking tug and motor speed, and battery temperature and state of charge, and providing feedback to the user. Additionally, remote monitoring of Navtek's client fleet means that any issues pertaining to battery life, charging, or performance, can be resolved quickly. The ZEETUG is projected to save approximately 210 $MTCO_2$, and 9 MT of NOx on an annual basis. Two additional ZEETUGs are planned for delivery to GISAS, with construction currently underway.[8] Based on conversations with Navtek, tugboats can be customized up to 80-ton bollard pull, can utilize quick charging, and batteries can be exchanged at the end of their useful life. Navtek's estimate for a 55-ton bollard pull tug (equivalent to the current Crowley tugs) is $8.5 million euros ($10.1 million USD).

There have been similar requests recently for all-electric tugboats in New Zealand and Japan. The Port of Auckland signed a contract with Damen Shipyards in 2019 to purchase a fully electric port tug, which is expected for delivery in 2021.[9] The Damen RSD-E Tug 2513 is expected to have the same power as the port's strongest diesel tug, with an approximately 77-ton bollard pull and a maximum service speed of 12 knots.[10] The Damen electric tug will also be equipped with two 1,000 kW generator sets, which will allow the tug to operate at 44-ton bollard pull if there is a failure of the electrical system or the vessel needs to operate beyond the battery capacity. Under normal conditions, the tug will be operational for about 3-4 hours of work on a full charge. A full charge will take at least two hours with a 1.5MW charger.[11] The charging system is not complex, featuring four on-board cables that connect directly to the station.[12] The Damen RSD-E Tug 2513 is shown in CHC Figure 1.

The Tokyo-based company e5 Lab is currently working on a battery-and-hydrogen-powered tugboat that is expected for delivery in 2022. The tug will have 50-ton bollard pull and a service speed of 14

[6] Pessa, A.J. 2020. *The Zero-Emissions Tug*. January 24. The Maritime Executive: https://www.maritime-executive.com/magazine/the-zero-emissions-tug. Accessed September 2020.
[7] Bollard Pull is a measure of the pulling power of a vessel, comparable to the horsepower rating of conventional vehicle engines.
[8] Navtek Naval Technologies. 2020. *World's First All-Electric Tugboat Delivered, Three More on the Way.* August 4. The Maritime Executive: https://www.maritime-executive.com/features/world-s-first-all-electric-tugboat-delivered-three-more-on-the-way-1. Accessed September 2020.
[9] Pessa, A.J. 2020. *The Zero-Emissions Tug.* January 24. The Maritime Executive: https://www.maritime-executive.com/magazine/the-zero-emissions-tug. Accessed September 2020.
[10] Damen. 2020. *RSD Tug 2513 Electric.* Available: https://products.damen.com/en/ranges/rsd-tug/rsd-tug-2513-electric. Accessed September 2020.
[11] The Maritime Executive. 2019. *Ports of Auckland Buys World-First Electric Tug.* August 5. Available: https://www.maritime-executive.com/article/ports-of-auckland-buys-world-first-electric-tug. Accessed September 2020.
[12] Labrut, Michele. 2019. *Damen signs contract with Ports of Auckland for first fully-electric tug.*

knots[13]. While the e5 Lab electric tub will be mostly operated via battery, hydrogen fuel cells and auxiliary generator will provide supplementary power.[14]

The vessels described above operate completely on electric-power, with bollard pull ratings ranging from 35- to 77-tons. For context, the Crowley tugs have a bollard pull of around 50 tons.[15]

While the examples above show promise, the industry is in its infancy and there are still several barriers that must be overcome before all-electric tugboats will be available for widespread commercial deployment. CARB will be collaborating with a broad range of stakeholders over the next year to make sure that the forthcoming regulatory requirements consider economic, technical, and logistical barriers to widespread deployment. The Port and its tenants are well-positioned to help promote and advance these new technologies, as discussed later.

CHC Figure 1. All Electric Tug in Auckland, New Zealand

Hybrid-Electric Tug

The *Carolyn Dorothy* was the world's first hybrid tug, built in 2008 by the Foss Maritime Shipyard in Rainier, Oregon. The tug was built to retain the power and maneuverability of previous models, equipped with two Tier II Cummins QSK50 diesel engines, two Siemens Motor generators, and two Cummins QSM11 diesel generators.[16] The tug also contains 126 gel cell, lead acid batteries, which are recharged using shore power. The *Carolyn Dorothy* has a bollard pull of 60 tons and can reach speeds of up to 8 knots. In 2012 Foss Maritime added the *Campbell Foss* to the fleet of hybrid tugs, which was converted from a conventionally powered tug. When compared to conventional tugs, the hybrid-electric tugs reduce emissions of particulate matter by 73 percent, NOx by 51 percent, and CO_2

[13] Tokyo Kisen. 2019. *"e5 Tug"—Electric Tug Powered By Battery and Hydrogen Fuel Cell*. October 29. Available: https://e5ship.com/pdf/2019-10-29.pdf. Accessed September 2020.
[14] Pessa, A.J. 2020. *The Zero-Emissions Tug.* January 24. The Maritime Executive: https://www.maritime-executive.com/magazine/the-zero-emissions-tug. Accessed September 2020.
[15] Crowley Fleet. Available: https://www.crowley.com/shipping/sae/fleet/#san-diego. Accessed: March 2021.
[16] Tugboat Information. 2020. *Carolyn Dorothy*. Available: http://www.tugboatinformation.com/tug.cfm?id=1274. Accessed September 2020.

by 27 percent. In addition to emission reductions, hybrid tug technology has been found to reduce fuel consumption by 20-30 percent and main engine maintenance costs by 50 percent.[17] The *Carolyn Dorothy* is pictured in CHC Figure 2.

Baydelta Maritime introduced the *Delta Teresa*, the first hybrid tugboat since the *Carolyn Dorothy,* in 2019. The tug was built by Nicholas Brothers Boat Builders, and unlike the hybrid tugs before it, the *Delta Teresa* has no battery power storage on board, due to operators' concerns related to heat, weight, and space.[18] Instead, the *Delta Teresa* is powered with two Tier III Caterpillar C3516 C diesel engines (2 x 2,675 hp), and two Rolls-Royce 424 kW electric motors. The tug is also equipped with three CAT C9.3 300 kW generators, and one C7.1 150 kW harbor generator to provide electrical service.[19] The tug has a 90-ton bollard pull, and can reach approximately 12.5 knots, or 9 knots in electric mode.[20] Since the *Delta Teresa*, several companies have introduced similar battery-less hybrid tugs into their fleets, including Great Lakes Towing Co. of Cleveland, and Harbor Docking & Towing of Lake Charles, Louisiana. In addition to reduced fuel consumption and less wear on the main engines, the towing companies cite ability to achieve the same bollard pull ratings with smaller engines as an appeal. Given these advantages, cost remains a drawback, with the price of hybrid tugs typically exceeding that of conventionally powered vessels by approximately $1-$2 million.[21] The Delta Teresa cost more than $10 million.[22]

In December 2020, two hybrid tugs, *Pennsylvania* and *Wisconsin*, began operation on the Great Lakes for the Great Lakes Towing Company. The 64-ft harbor tugs were built by the Great Lakes Shipyard and are powered by two 1,000-hp MTU 8V4000 Tier III diesel engines, generating over 30-tons of bollard pull. The tugs utilize electric power for idling and low speeds, and only use the main engines for higher speeds.[23]

The vessels described above operate on hybrid-electric-power, with horsepower ratings ranging from 5,080 to 5,350. The most powerful tugs currently operating at the Port are in the 4,400 to 4,800 hp range.

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[17] Foss Maritime. 2020. *The Green Assist™ Hybrid Tug.* Available: https://www.foss.com/foss-innovation/the-hybrid-tug/. Accessed September 2020.
[18] Conley, Casey. 2019. *Industry closely watching hybrid tug performance.* July 1. Professional Mariner: http://www.professionalmariner.com/American-Tugboat-Review-2019/Industry-closely-watching-hybrid-tug-performance/. Accessed September 2020.
[19] Tugboat Information. 2020. *Delta Teresa*. Available: http://www.tugboatinformation.com/tug.cfm?id=10215. Accessed September 2020.
[20] Professional Mariner. 2019. *Delta Teresa Specifications*. July 1. Available: http://www.professionalmariner.com/American-Tugboat-Review-2019/Delta-Teresa-specifications/. Accessed September 2020.
[21] Conley, Casey. 2019. *Industry closely watching hybrid tug performance.* July 1. Professional Mariner: http://www.professionalmariner.com/American-Tugboat-Review-2019/Industry-closely-watching-hybrid-tug-performance/. Accessed September 2020.
[22] Baydelta's Hybrid Tug: Batteries Not Included. https://www.pacmar.com/story/2019/07/01/features/baydeltas-hybrid-tug-batteries-not-included/710.html. Accessed: October 2020.
[23] Blenkey, Nick. 2020. *Great Lakes Towing christens two latest hybrid tugs.* December 17. Available: https://www.marinelog.com/coastal/tugs-barges/video-great-lakes-towing-christens-two-latest-hybrid-tugs/. Accessed February 2021.

CHC Figure 2. Hybrid-Electric Tug

Electric Ferries

As mentioned previously, vessels that have predictable routes are ideal for all-electric technologies, as this allows for ease of planning range and charging schedules. For this reason, ferries are obvious candidates for electrification. Sample electric ferries are shown in CHC Figure 3.

CHC Figure 3. Electric Car/Passenger Ferries

MV *Ampere* | MF *Tycho Brahe* | E-ferry *Ellen*

The *Ampere* was the world's first all-electric ferry, introduced in Norway in 2015. The ferry has a 120-car/ 360-passenger capacity and makes 34 trips per day between Lavik and Oppedal. With on-board battery capacity of 1 MWh, *Ampere* can reach a maximum speed of 14 knots and completes its 3.5-mile route in approximately 20 minutes. There is an additional 10 minutes of loading and unloading at each stop, during which time the lithium-ion batteries are recharged.[24] Operators have found that compared to its fuel-powered counterparts, the all-electric ferry has cut GHG emissions by 95 percent, and costs by 80 percent.[25]

In 2017, two ferries operated by ForSea were converted from conventional diesel operations to all-electric battery power. The *Tycho Brahe* and *Aurora* were originally built in 1991 and operate between Helsingør, Denmark, and Helsingborg, Sweden, transporting at least 7.4 million passengers and 1.9 million vehicles per year. While the two ferries are still equipped with their original diesel engines, they were updated in

[24] ShipTechnology. 2020. *Ampere Electric Powered Ferry.* Available: https://www.ship-technology.com/projects/norled-zerocat-electric-powered-ferry/. Accessed September 2020.

[25] Lambert, Fred. 2018. *All-electric ferry cuts emission by 95% and costs by 80%, brings in 53 additional orders*. February 3. electrek: https://electrek.co/2018/02/03/all-electric-ferry-cuts-emission-cost/. Accessed September 2020.

2017 to include 640 lithium batteries, with a total charge power of 11 MW and battery capacity of 4.16 MWh. Both ferries have a cruising speed of 14.5 knots. The ferries can run on exclusively battery power or diesel power, or in a hybrid set-up with a combination of both. ForSea reports that the ferries have saved approximately 65 percent of CO_2 emissions.[26]

The world's current most powerful electric ferry is the *Ellen E-Ferry* that operates the 22-nm crossing between the Danish Islands of Ærø and Fynshav. The *Ellen*, designed by Jens Kristensen Consulting Naval Architects and built by the Søby Værft shipyard, began operation in Denmark in June 2019. The 60-m long, 13-m wide ferry can carry up to 198 passengers and 31 cars at one time. The ferry is equipped with 840 lithium-ion batteries, which provide a total battery capacity of 4.3MW, and are recharged within 25 minutes using a mechanical arm plug in.[27] With maximum speeds of 13-15.5 knots, the *Ellen* has cut travel time by 21 percent compared to a fuel-powered vessel traveling the same route.[28] It is estimated that the ferry will save 2,000 tons of CO_2 annually.[29]

The U.S. first all-electric ferry was introduced in Alabama in early 2019. The *Gee's Bend Ferry* operates in the Alabama River between Gee's Bend and Camden with a capacity of 15-vehicles/132-passengers. The ferry was gutted and retrofitted with four 150-hp electric motors and Spear Power Systems batteries after issues with the conventional diesel engines made ferry schedules consistently unreliable.[30] There are chargers on both sides of the river, and a full charge takes approximately 25 minutes.[31] The new all-electric ferry has a service speed of eight knots and cost $1.8 million.

Hybrid-Electric Ferries

The *Enhydra* hybrid-electric ferry was introduced to the San Francisco Red and White Fleet in September 2018. The 128-foot long vessel has a 600-passenger capacity and is intended to help the fleet reach their goal of zero emissions by 2025. The ferry is equipped with a 410-hp Cummins QSL9 diesel engine and twin Corvus Energy 80-kW lithium-ion battery banks. The battery-electric hybrid propulsion system allows the ferry to run over two hours at seven knots in all-electric mode. Depending on weather conditions, this means that typical cruises can run half the time in all-electric, and slower-speed cruises can operate in electric mode for their entire trip.[32] The hybrid-electric ferry provides 20-30 percent fuel savings, and reduces GHG emissions by 30-80 percent, as it is paired with Tier 3

[26] DEIF. 2020. *Ferries of the future save 65% carbon dioxide.* Available: https://www.deif.us/marine-and-offshore/cases/tycho-brahe. Accessed September 2020.
[27] Murray, Adrienne. 2020. *Plug-in and sail: Meet the electric ferry pioneers*. January 14. BBC: https://www.bbc.com/news/business-50233206. Accessed September 2020.
[28] Tunnicliffe, Andrew. 2019. *Ellen E-ferry: the world's glimpse of the future of ferries*. September 3. ShipTechnology.
[29] Danfoss. 2019. *World's most powerful fully-electric ferry got her name and is getting ready for Danish waters*. June 3. Available: https://www.danfoss.com/en/about-danfoss/news/cf/world-s-most-powerful-fully-electric-ferry-got-her-name-and-is-getting-ready-for-danish-waters/#:~:text=Ellen%20is%20the%20world's%20most,operation%20anywhere%20in%20the%20world.. Accessed September 2020.
[30] Gauvin, Brian. 2020. *Alabama River ferry reborn with electricpropulsion.* January 30. Professional Mariner: http://www.professionalmariner.com/February-2020/Alabama-River-ferry-reborn-with-electric-propulsion/. Accessed September 2020.
[31] DuPont, Dale K. 2020. *First all-electric ferry in U.S. reaches milestone.* WorkBoat: https://www.workboat.com/news/passenger-vessels/first-all-electric-ferry-in-u-s-reaches-milestone/. Accessed September 2020.
[32] Conley, Casey. 2020. *2019 Ship of the Year: Enhydra*. Professional Mariner: http://www.professionalmariner.com/American-Ship-Review-2019/2019-Ship-of-the-Year-Enhydra/. Accessed September 2020.

magnet generators that run exclusively on biofuel.[33] The *Enhydra* hybrid-electric ferry is pictured in CHC Figure 4. For context, the Coronado commuter ferries travel at an average speed of 5.5 knots and take about 15-minutes to travel between downtown and Coronado.

Washington State Ferries also has plans to electrify their ferry system within the next couple years. As the world's second-largest ferry system, they currently consume approximately 20 million gallons of diesel per year. By 2021, the state's three largest polluting vessels will be upgraded to hybrid-electric propulsion with Siemens battery systems, an upgrade that is anticipated to cut GHG emissions by 48,000 $MTCO_2$ per year.[34] The state is also working with the Seattle shipyard, Vigor, to build Olympic-class hybrid ferries with 144-car/1,500-passenger capacity each. Construction on these new vessels is set to begin this year and be completed by 2022.[35] The ferry agency's long-range plans include a goal that 22 of the 26 vessels in the fleet are hybrid-electric by 2040.[36]

CHC Figure 4. Hybrid-Electric Ferry in San Francisco, CA

Emission Reductions and Costs

Emission Reductions

A summary of emissions for existing tugs and ferries, as well as their emission-reducing replacement options is presented in CHC Table 3. Each technology is compared to the average existing diesel vessel at the Port and assumes that the replacement piece would operate the same number of hours per year and would be the same size as the current fleet.

Emission factors for the replacement vessels were based on best available information from models currently in operation. Conventional hybrid vessels tend to utilize battery power while idling and at low

[33] Red and White Fleet. 2020. *Enhydra*. Available: https://redandwhite.com/enhydra/. Accessed September 2020.
[34] Deign, Jason. 2019. *World's Second-Largest Ferry Operator Switching From Diesel to Batteries.* November 29. Green Tech Media: https://www.greentechmedia.com/articles/read/worlds-second-largest-ferry-operator-switching-from-diesel-to-batteries. Accessed September 2020.
[35] Stiffler, Lisa. 2019. *How Washington state plans to create the world's largest hybrid-powered, auto-carrying ferries*. Geek Wire: https://www.geekwire.com/2019/washington-state-plans-create-worlds-largest-hybrid-powered-auto-carrying-ferries/. Accessed September 2020.
[36] Giordano, Lizz. 2019. *Washington State Ferries plans for an electric-hybrid fleet*. November 4. HeraldNet: https://www.heraldnet.com/news/washington-state-ferries-aiming-for-a-fleet-energy-sea-change/. Accessed September 2020.

speeds and employ the main engines for higher speeds.[37] Emissions for the hybrid vessels are based on an assumed 35% reduction in fuel consumption from a Tier 3 engine.[38] For the emissions from the fully electric vessels, there are no tailpipe emissions, and the only emission are from the SDG&E's grid. The GHG benefits over time would increase over the estimates presented here as SDG&E increases its procurement of carbon-free renewable energy sources.

CHC Table 3 also provides the emission reductions with replacement of the existing diesel vessels. As shown, emissions of all pollutants would decrease with electric and hybrid replacements.

CHC Table 3. Summary of Annual Average Emissions per Vessel (tons per year)

		Tons of Emissions Per Year			Emission Reductions Per Year		
Vessel	**Option**	**NOx**	**DPM**	**CO_2e [a]**	**NOx**	**DPM**	**CO_2e [a]**
Assist Tug	Existing Diesel	1.44	0.05	135	-	-	-
	Electric	-	-	49	1.44	0.05	86
	Hybrid Electric	0.49	0.03	88	0.95	0.02	42
Ferry	Existing Diesel	4.41	0.16	339	-	-	-
	Electric	-	-	136	4.41	0.16	203
	Hybrid Electric	1.22	0.06	220	3.19	0.10	119

[a] CO_2e emissions in metric tonnes.

Costs

A summary of technology capital cost and cost per emissions saved is presented in CHC Table 4. Technology costs were obtained from various sources including online research, and personal communication. As shown in CHC Table 4, the cost per emissions saved is better (higher) for the fully electric tug and ferry relative to the hybrid counterparts. Note that the technology cost here does not include any cost associated with electrical infrastructure at the terminal.

[37] Blenkey, Nick. 2020. *Great Lakes Towing christens two latest hybrid tugs*. December 17. Available: https://www.marinelog.com/coastal/tugs-barges/video-great-lakes-towing-christens-two-latest-hybrid-tugs/. Accessed February 2021.

[38] Squatriglia, Chuck. 2008. *G.E. Developing a Diesel Hybrid…Tugboat?*. May 21. Available: https://www.wired.com/2008/05/ge-developing-a/. Accessed February 2021.

CHC Table 4. Summary of Total Cost and Cost per Emissions Saved

		Technology Cost	Cost per Pound of Emissions Saved		
Vessel	**Option**		**NOx**	**DPM**	**CO_2e**
Assist Tug	Existing Diesel	-	-	-	-
	Electric	$10,000,000 – $15,000,000 [a]	$3,500 – $5,200	$105,000 – $157,000	$55 – $88
	Hybrid Electric	$10,000,000 [b]	$5,300	$228,000	$106
Ferry	Existing Diesel	-	-	-	-
	Electric	$1,800,000 [c]	$200	$5,500	$4
	Hybrid Electric	$2,000,000 [d]	$315	$9,700	$8

[a] Cost for the electric tug based on $10 million estimate for ZEETUG and $15 million cost proposal from Crowley.
[b] Cost for the hybrid tug is based on the *Delta Teresa* tug operating in San Francisco Bay.
[c] Cost for the electric ferry is based on *Gee's Bend* operating in Alabama.
[d] Cost for the hybrid ferry based on the *Happiness* ferry based out of Taiwan.

Cost for the electric Crowley is based on the application submitted for its grant award. Cost for the hybrid tug is based on the *Delta Teresa* tug operating in San Francisco Bay. Cost for the electric ferry is based on *Gee's Bend* operating in Alabama. Cost for the hybrid ferry based on the *Happiness* ferry based out of Taiwan. As shown in CHC Table 3, the cost per ton is better for both the electric tug and ferry relative to the hybrid counterparts.

Commercial Availability

As discussed above, some options for electric and hybrid tugs and ferries are mostly still in the prototype stage, options are quickly becoming commercial. Various demonstrations are currently underway worldwide, including one tug replacement at the Port, and manufacturers have expressed commercial availability is expected over the next year or two.

Goals and Objectives

CHC Goal – Reduce emissions from Harbor Craft by advancing emerging zero emission technologies through 2031.

CHC Objective 1: Support ZE Tugboats and Ferries in advance of State regulations, as opportunities become available.

Discussion

Technology for zero emission tugs is still mostly in the proto-type stage. However, the Port and its tenants will explore opportunities to advance this technology as opportunities present themselves.

CHC Objective 2: Advance the State's goals for commercial harbor craft by supporting short-run ferry-operators with implementing ZE ferries ***for all new*** short-runs, and by assisting tug-operators with implementing hybrid/electric technologies ***for all new*** excursion vessels.

Discussion

Choosing to electrify the highest emitters, namely the most active assist tugboat and the most active ferry, would result in substantial emissions savings. A tugboat tenant has already secured a substantial portion of the funding for an electric tug, although charging infrastructure will be needed. For the ferry, given the short runs of the commuter ferries and opportunity for charging during the longer headways during the non-peak time periods, the fully electric version would be useful and unlikely to require substantial operational changes.

Heavy Duty Trucks

Background and Context

According to California's emission inventory model, almost a million heavy-duty vehicles operate on its roads each year. CARB estimates that heavy-duty vehicles contribute 31% of all statewide NOx emissions and approximately 26% of total statewide DPM emissions. In 2015, Governor Brown issued Executive Order B-32-15, which directed State agencies to establish targets to improve freight efficiency, transition to zero emission technologies, and increase the competitiveness of California's freight transport system. This direction culminated into the California Sustainable Freight Action Plan (2016), which acknowledged that the plan's targets are not mandates, but rather aspirational measures of progress toward sustainability for the State to meet and try to exceed. It also noted that:

> "*The [Sustainable Freight] Action Plan is the beginning of a process and signals the State government's interest in collaborating with stakeholders on defining the actions necessary to make the vision for sustainable freight transport system a reality."*

In 2019, Governor Newsom signed Executive Order N-19-19, which among other things, directed the State Transportation Agency to *align the state's climate goals with transportation spending on planning, programming and mitigation to achieve the objectives of the State's Climate Change Scoping Plan, where feasible* and noted that CARB shall:

a. *Develop new criteria for clean vehicle incentive programs to encourage manufacturers to produce clean, affordable cars,*

b. *Propose new strategies to increase demand in the primary and secondary markets for zero emissions vehicles, and*

c. *Consider strengthening existing or adopting new regulations to achieve the necessary greenhouse gas reductions from within the transportation sector.*

Finally, in September 2020, Executive Order N-79-20 established that it shall be the goal of the State that 100% of drayage trucks in the State be zero emission by 2035, and that 100% of medium- and heavy-duty vehicles be zero emission by 2045. These executive orders set the State's long-term vision for sustainable freight transport system, which includes zero emission trucks. They also establish the foundation for regulatory changes that CARB is tasked with executing. Current and forthcoming regulatory requirements pertaining to on-road trucks are discussed in this chapter.

Improving air quality in portside communities by reducing on-road truck emissions remains a high-priority of the District. The AB 617 Portside Community Draft CERP acknowledges that trucks serving the harbor areas and businesses within the community expose Portside Community residents and sensitive receptors to diesel emissions. In the summer of 2020, the AB 617 Steering Committee created the AB 617 Truck Subcommittee, which explored technological and institutional challenges to the electrification of heavy-duty trucks. The AB 617 Truck Subcommittee's activities resulted in several early emission reduction strategies for on-road trucks in the AB 617 Draft CERP. In Fall 2020, the AB 617 MCAS Subcommittee built on this earlier work to further develop and refine strategies that the Port could help advance to accelerate the deployment of ZE/NZE Trucks, in alignment with and/or in advance of Statewide goals.

This chapter provides the necessary background to help identify potential strategies to reduce truck emissions from all heavy-duty trucks that travel to and from TAMT and NCMT, including trucks that move containers, bulk, break-bulk, and Roll-on/Roll-off cargo. It provides an overview of the Port's participation in clean- and ZE/NZE- truck programs, as well as the results from the Port's Truck Survey that was conducted in Spring 2020. It provides a high-level overview of CARB's current and forthcoming requirements pertaining to drayage trucks, which is followed by a discussion of ZE/NZE truck technology and potential applications, with an emphasis on battery electric vehicle (BEV) technology. In conjunction with extensive stakeholder involvement discussed earlier, these data points were used to inform the recommendations included at the end of the chapter, which seek to further accelerate the deployment of ZE/NZE trucks within and around Port tidelands.

The term *drayage truck* is defined by CARB as Class 7 and 8 trucks (trucks with a gross vehicle weight rating of greater than 26,000 pounds) that are used for transporting cargo, such as containerized bulk, or break-bulk goods, that operates (a) on or transgresses through port of intermodal rail yard property for the purpose of loading, unloading or transporting cargo, including transporting empty containers and chassis or (2) off port or intermodal rail yard property transporting cargo or empty containers or chassis that originated from or is destined to a port or intermodal rail yard property.[1] This chapter also addresses other types of trucks that transport cargo to and from TAMT and NCMT and that may be subject to other regulations, such as CARB's Truck and Bus Regulation.

Source Description

The truck source includes drayage trucks that are used to transport port-related cargo between NCMT and TAMT as well as local and regional destinations. To properly account for all emissions associated with truck travel, activity for truck trips is split geographically between the following activities:

- On-Port Moves: These include truck movement and idling within the terminal boundary as trucks move into position to pick up or drop off cargo.
- Near-Port Moves: These include truck movement between the terminal gates and the freeway, or the destination or origin for trips that do not travel on the freeway.
- Off-Port Moves: These include truck movement on the regional freeway network between freeway access and the cargo destination or origin.

At TAMT, trucks mainly consist of refrigerated container trucks, dry bulk and unibody trucks to move dry bulk (e.g., cement, bauxite, and fertilizers), and multi-purpose general cargo (e.g., windmill parts), as well as other miscellaneous deliveries. At NCMT, trucks mainly consist of car carriers, along with some flatbeds and trailers to move general project cargo, and material (parts) deliveries for automobile services. At NCMT, automobile imports arrive by vessel and are off-loaded and driven a short distance to parking areas near the terminal prior to loading onto trucks or rail. At the Cruise Ship Terminal (CST), delivery trucks transport cruise ship cargo and supplies while vessels are berthed.

[1] 13 CCR § 2027(c)(15).

History of Previous Efforts

Truck Retrofit and Replacement Program (2008)

In 2008, the Board of Port Commissioners authorized an MOU with SDAPCD to implement the Port's Truck Retrofit and Replacement Program in an amount not to exceed $1,150,000. Under the terms of the MOU, SDAPCD entered into an agreement with CARB to obtain Goods Movement Emissions Reduction Program (GMERP, or Proposition 1B) funding, and then allocated money (though a cost-sharing agreement) to selected truck owners to either retrofit their trucks with Diesel Particulate Filters (DPF) or replace their trucks, with newer, less polluting models. Under the GMERP, CARB programmed $2.9 million to fund approximately 35 truck retrofits that served the Port of San Diego.

Clean Truck Program (2010)

The Clean Truck Program was adopted by the Port in 2010 as part of the Clean Air Program (precursor to MCAS) to address emissions from on-road, heavy-duty diesel trucks serving the marine terminals. The Clean Truck Program amended the Port's tariff to require trucks entering the Port's marine terminals to reflect CARB's Drayage Truck Regulation ("Drayage Regulation"), which requires ports to report trucks which do not meet emissions standards, but still allows those trucks to do business on the terminals. However, commencing on January 1, 2011, the Port went beyond CARB compliance by prohibiting trucks that did not meet the Drayage Regulation from entering the Port's marine terminals.

San Diego Port Tenant's Association – $5.9 Million All Electric MD/HD Vehicle Grant (2016)

In July 2016, the San Diego Port Tenant's Association (SDPTA) was awarded a $5.9 million grant from the California Energy Commission (CEC) to demonstrate ten freight vehicles (including several pieces of heavy-duty equipment and two drayage trucks), that were outfitted with zero-emission technologies[2]. This award involved the demonstration of two battery electric, on-road Class 8 drayage trucks, as well as to demonstrate Intelligent Transportation Systems (ITS) technologies for freight signal prioritization along Harbor Drive. Information and lessons learned from the SDPTA's ZE MD/HD Demonstration Project was shared with the AB 617 MCAS Subcommittee, to help inform and guide the ZE/NZE truck goals and objectives that are identified at the end of this chapter.

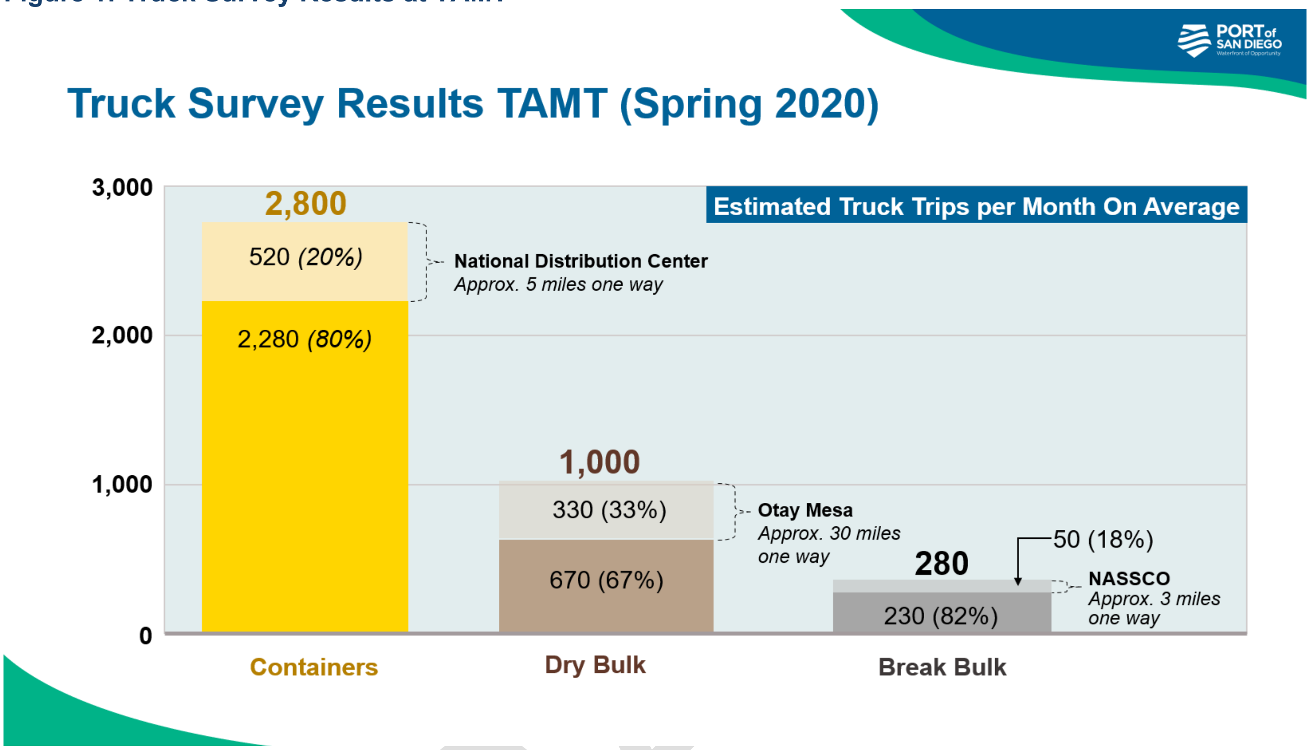
Port of San Diego Truck Survey

To better understand the number of truck trips that transport goods to/from the Port and the distances they travel, Port staff conducted a Truck Survey in the spring of 2020. The primary goal of the survey was to identify if there were any regular, short haul trucking that could potentially be performed with ZE/NZE trucks (e.g., less than 120 miles per day). Port staff conducted the survey, which involved interviewing terminal operators, tenants, trucking companies, and individual truckers that handle refrigerated containers, bulk, and break bulk at TAMT, as well as those who handle roll-on/roll-off cargo (RORO, or vehicles) at NCMT. The survey results were shared with the Board of Port Commissioners at their July 11, 2020 Board meeting, and were used by the AB 617 Truck Subcommittee and MCAS Subcommittee to help develop recommendations for accelerating the advancement of ZE/NZE drayage trucks that transport cargo to and from the Ports marine terminals.

[2] The grant award was matched with $2.3 million in cash and contributions from the SDPTA and its industrial tenant partners, bringing the project total to $8.2 million.

The Port's truck survey results for TAMT are summarized in Figure 1 below and further discussed by cargo type.

Figure 1: Truck Survey Results at TAMT



Refrigerated Containers (TAMT)

Refrigerated containers are one of the three major cargo types that are processed at the TAMT, which results in approximately 700 containers per week. Of the 700 containers, about 130 containers are moved by truck from TAMT to the National Distribution Center (NDC) in National City, approximately five miles south. The remaining containers are transported outside of San Diego, mostly toward Los Angeles. Once at NDC, produce is transferred from the 40-foot refrigerated containers to 53-foot long-haul trailers before being transported out of the Port. The truck survey determined that currently, one company is responsible for the five-mile route to NDC, and it uses both company-owned and contracted vehicles. This route is a potential candidate to test electric truck and charging technologies given that it is relatively short and regular.[3]

Dry Bulk (TAMT)

The primary bulk products passing through TAMT are bauxite, sugar, and fertilizer. Unlike the refrigerated container cargo that has a vessel call every week, none of the bulk carriers arrive on a predictable schedule. The fertilizer has the shortest trip of two to three miles depending on the route; however, the trucking company handling this commodity also does many long hauls in the region. The bauxite goes to Victorville, California (roughly 164 miles one way) and Tucson, Arizona (roughly 408 miles one way). Sugar is hauled to a plant in Otay Mesa, approximately 30 miles away. Staff have

[3] San Diego Unified Port District. July 14, 2020. Presentation and Direction to Staff on Clean Air and Emission Reduction Advancements.

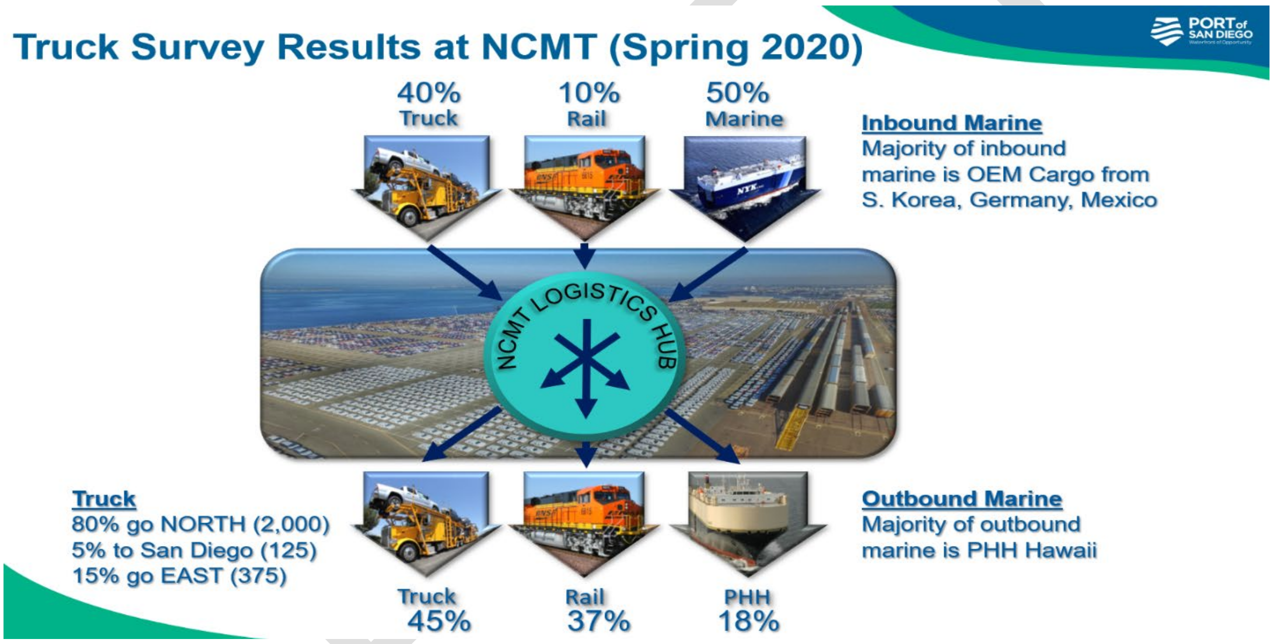
learned that these operations require each truck to drive four or five trips per shift and to change drivers so that two shifts can be performed in one day. This sugar route may be another good candidate for testing electrification.

Break Bulk (TAMT)

Cargo that arrives at TAMT includes steel for shipbuilding, wind turbine blades and tower pieces, military ordnance, and electrical gear. The locations where trucks haul break bulk include the Working Waterfront, which is three miles away; Riverside, approximately 100 miles away; Tehachapi, approximately 235 miles away; and Palm Springs, approximately 140 miles away. There is a current terminal service provider that is located at TAMT with equipment that can move these heavy, break bulk items. The short-haul route along the Working Waterfront may be another potential candidate for electrification.

The Port's truck survey results for NCMT are summarized in Figure 2 below, and is followed by a discussion of how Roll-on / Roll-off cargo is transported and moved at this facility.

Figure 2: Truck Survey Results at NCMT



Roll-on / Roll-off Cargo or Vehicles (NCMT)

Approximately 400,000 vehicles pass through NCMT per year. The site is a confluence of ships, trains, and trucks that import vehicles from both foreign and domestic locations. About 37% of cargo leaves NCMT by train, 18% leave by ship to Hawaii, and 45% leave by truck. Of those that leave by truck, roughly 5% are delivered within San Diego County, 80% go north toward Los Angeles, and 15% go east toward Arizona and Nevada. A high potential candidate for electrification is a route that transports vehicles from NCMT to an offsite storage facility in Otay Mesa, roughly 15 miles away. Currently, the NCMT terminal operator, has three electric class-8 trucks that can haul eight cars at a time on this route. The terminal operator does not currently need another truck for this route, but there may be an opportunity to electrify with trucking companies that visit NCMT.[4]

Legislative and Regulatory Framework

Emissions from heavy-duty trucks are managed by regulations or emission limits implemented at the federal, state, and local levels[5]. In December 2000, the EPA adopted the Heavy-Duty Highway Rule, which reduces emissions from on-road, heavy-duty diesel trucks by establishing a series of increasingly strict emission standards for new engines. Manufacturers were required to produce new diesel vehicles that meet PM and NOx emission standards beginning with model year 2007, with the phase-in period being between 2007 and 2010. The phase-in was based on a percentage-of-sales basis: 50% from 2007 to 2009 and 100% in 2010.

CARB adopted the Drayage Truck Regulation in December 2007 to modernize the Class 8 (Gross Vehicle Weight Rating: more than 33,000 pounds [lbs.]) drayage trucks in use at California's ports. Emergency vehicles and yard trucks (cargo handling equipment) are exempted from this regulation. The regulatory objective was to be achieved in two phases.

1. By December 31, 2009, pre-1994 model year engines were to be retired or replaced with 1994 and newer model year engines. In addition, all drayage trucks with 1994 to 2003 model year engines were required to achieve an 85% particulate matter emission reduction using a CARB-approved, Level 3, verified diesel emission control strategy.
2. By December 31, 2013, all trucks operating at California ports were to comply with the 2007 and newer on-road heavy-duty engine standards.

In December 2010, CARB amended the regulation to include Class 7 drayage trucks with a GVWR between 26,000 and 33,001 pounds. CARB further expanded the definition of drayage trucks to include dray-offs, those non-compliant trucks that may not directly come to the ports to pick up or drop off cargo but that engage in moving cargo destined to or originating from port facilities, and to/from near-port facilities or railyards.

A companion regulation to the Drayage Truck Regulation is CARB's Truck and Bus Regulation. This regulation requires existing heavy-duty trucks to be replaced with those that use the latest NOx and particulate matter Best Available Control Technology (BACT) or be retrofitted to meet required levels. Trucks with a GVWR less than 26,000 pounds, which includes most construction trucks, are required to replace engines with ones that are year 2010 or newer, or equivalent, by January 2023. Trucks with a GVWR greater than 26,000 pounds, which includes most drayage trucks, must meet particulate matter BACT and upgrade to a 2010 or newer model year emissions equivalent engine pursuant to the compliance schedule set forth by the rule. By January 1, 2023, all Class 8 drayage trucks are required to have 2010 model year engines or newer and/or meet the equivalent NOx and particulate matter BACT standards (i.e., EPA 2010 and newer standards).

Various trucks are exempt from the Drayage Truck Regulation. This list includes dedicated use vehicles, such as those with unibody construction – car carriers, refuse trucks, cement mixers, fuel

[4] San Diego Unified Port District. July 14, 2020. Presentation and Direction to Staff on Clean Air and Emission Reduction Advancements.
[5] At the local level, a Memorandum of Understanding (MOU) was signed with CARB in 2014 designating which mobile source inspections the San Diego Air Pollution Control District will enforce, and an updated MOU was signed in 2017 to allow the San Diego Air Pollution Control District to settle certain types of violations.

delivery vehicles, mobile cranes, and dump trucks – as well as emergency equipment and military tactical support trucks. While these trucks are not regulated under the Drayage Truck Regulation, they are subject to the Truck and Bus Regulation.

In addition, CARB adopted an Airborne Toxic Control Measure in 2005 to limit diesel-fueled commercial motor vehicle idling. This regulation states that diesel vehicles with a GVWR greater than 10,000 pounds shall not idle the vehicle's diesel-powered primary or auxiliary power system for more than 5 minutes at any location (13 CCR 1956.8 and 2485). This regulation applies to all trucks that visit the Port.

Advanced Clean Trucks Regulation

In 2020, CARB adopted the Advanced Clean Trucks (ACT) rule, which is the first zero-emission commercial requirement in the U.S. The ACT was approved on June 25, 2020 and has two main components, a manufacturers ZEV sales requirement and a one-time reporting requirement for large entities and fleets. To satisfy the reporting requirement, large employers will need to report information about their shipments and shuttle services, and owners of fleets with fifty or more trucks will have to report on their fleet operations. The sales requirement will require manufacturers to sell an increasing annual percentage of zero-emission trucks beginning in 2024 through 2035, such that by the end of the regulation 75 percent of Class 4 – 8 straight truck sales and 40 percent of truck tractor sales will be zero-emission (Table 1).[6] Sales requirements in the first three years of the rule are relatively conservative in order to provide manufactures sufficient time to establish supply chains and manufacturing capacity. Beginning in 2027, annual sales percentage targets ramp up. The Natural Resources Defense Council estimates that by 2035 approximately 63% of all cumulative truck sales (all truck classes from 2024 through 2035) in California could be zero-emission as a result of the ACT, approximately 319,000 trucks.[7]

Table 1. ACT Truck Sales Requirements

Model Year	Required ZE Class 2b-3 Truck Sales %	Required ZE Class 4 – 8 Straight Truck Sales %	Required ZE Class 7 – 8 Tractor Sales %
2024	5%	9%	5%
2025	7%	11%	7%
2026	10%	13%	10%
2027	15%	20%	15%
2028	20%	30%	20%
2029	25%	40%	25%
2030	30%	50%	30%
2031	35%	55%	35%
2032	40%	60%	40%

[6] CARB. n.d. *Advanced Clean Trucks Fact Sheet*. Available online at: https://ww2.arb.ca.gov/resources/fact-sheets/advanced-clean-trucks-fact-sheet. Accessed January 2021.
[7] Portillo, Patricio. 2020. *California Makes History with Clean Trucks Rule [Expert Blog]*. NRDC. Available online at: https://www.nrdc.org/experts/patricio-portillo/california-makes-history-clean-trucks-rule. Accessed January 2021.

2033	45%	65%	40%
2034	50%	70%	40%
2035	55%	75%	40%

Advanced Clean Fleets Rule (Proposed)

CARB is currently working on the Advanced Clean Fleets rule.[8] This regulation is expected to establish requirements for fleet adoption of zero-emission trucks and buses in certain market segments, and it is meant to complement the Advanced Clean Truck Rule. Early indications suggest that CARB hopes to make progress on developing the proposed regulation and consider it for approval at the end of 2021. CARB's current target is to achieve 100% zero emission drayage trucks by 2035 at California ports.

State of Technology

Throughout the past decade, there has been large focus on developing the technology, supply chains, and marketing strategies to accelerate adoption of light- and medium-duty electric vehicles as the battery electric vehicle market matured. As a result, heavy-duty electric vehicles have been slower to evolve and implement. Recently, however, focus has shifted to electrifying heavy-duty vehicles with a particular emphasis on drayage trucks in the near-term. Drayage may be an attractive near-term application because current electric heavy-duty vehicles are well positioned to handle short-range, regular-duty cycles. Transit buses, school buses, urban delivery vehicles, and yard tractors have all seen success partially due to their regular duty cycles; drayage trucks are also well positioned for future success as the technology for heavy-duty trucks advances.

As noted earlier, transitioning the commercial vehicle market to zero- and near-zero emission technologies is occurring at different stages. CALSTART's Beachhead Strategy[9] projects that ZE/NZE drayage trucks will occur as part of Wave 4 applications and estimates full commercialization in 2023 based on data in the Zero Emission Technology Inventory (ZETI).[10] Commercial availability is defined as when vehicle manufacturers are positioned – through established manufacturing facilities, supply-chain agreements, and logistics – to begin production due to orders placed.

Charging and Infrastructure

Charging infrastructure for heavy-duty electric trucks (ZE HD), which are of the weight-class required to serve as drayage trucks for operations at the Port, requires a higher power output than light-duty and medium-duty electric trucks in order to charge larger batteries in a constrained amount of time. The appropriate power level of a charger depends on vehicle resting time, vehicle operations, and the size of the vehicle's battery. Additionally, charging time for every EV will be impacted by the maximum

[8] CARB. n.d. *Advanced Clean Fleets*. Available online at: https://ww2.arb.ca.gov/our-work/programs/advanced-clean-fleets. Accessed December 2020.
[9] CALSTART: 2020. *The Beachhead Model: Catalyzing Mass-Market Opportunities for Zero-Emission Commercial Vehicles*. Available online at https://globaldrivetozero.org/public/The_Beachhead_Model.docx.
[10] *Drive to Zero's Zero-emission Technology Inventory (ZETI) Tool Version 5.5*. Available online at https://globaldrivetozero.org/tools/zero-emission-technology-inventory/. Accessed December 2020.

power acceptance rate (in KW) for the given EV; the lesser of this versus the charger power level (also in KW) will be the limiting factor that determines charging time.

Critical for enabling heavy-duty charging was the international standard for three-phase charging, which is common at commercial and industrial locations in the U.S. and Canada. The standard, SAE J3068, was instituted in 2018 and was designed specifically for medium-duty and heavy-duty vehicle charging. SAE J3068 was designed to enable the use of three-phase 480 volts (V) (up to 133 kW at 160 amperes), as well as 600 V alternating current (AC) (up to 166 kW at 160A). Additionally, SAE J3105 applies to overhead charging and SAE J2954/2 to HD wireless charging. However, to date overhead and wireless have only been used for electric buses, not for electric trucks.

While plug-in EV charging is expected to serve a sizeable truck population, drayage trucks often idle in queues while loading and unloading, which could make strategically placed opportunity charging using technology such as wireless chargers an option for fleets and Ports to consider in the future.

Beyond technological specifications, the ownership model of certain charging options is important for stakeholders to consider. Charging infrastructure for many trucks is expected to be located at a fleet depot as fleets are expected to charge at the end of their workday. This will be true for fleets that operate predictable routes and have depots that allow their trucks to sit and charge overnight. However, many fleets in California are small and may not have such a facility. Innovative options for delivering electricity to these fleets will need to be developed in the years to come, which will likely include public, shared, and/or limited-access charging sites.

Importantly, entities that deploy charging infrastructure at their facilities (e.g., fleet depots and warehouses) may require facility and grid upgrades to accommodate new power demand, depending on how extensive their deployment plans are. Although the cost of these upgrades can be significant, the State of California and its investor-owned utility companies have implemented ‘make-ready’ programs to help entities deploy this infrastructure at low or zero cost. These utility make-ready programs typically cover the cost infrastructure between the grid interconnection and up to the electric vehicle supply equipment (EVSE, or ‘charger’), taking the burden off fleets and other entities that are installing charging infrastructure.

The Port is evaluating how to support the electrification of vehicles, including by potentially providing locations for the infrastructure necessary for these technologies. The Port is considering strategies to accelerate the advancement of battery electric technology for on-road drayage trucks and cargo handling equipment. For example, chargers have been installed at the NCMT to power drayage trucks as well as electric cars and yard tractors. However, there are several technologies and fuels that produce lower emitting trucks, which the Port will continue to track, including natural gas, renewable natural gas, renewable diesel, hydrogen and others. A more detailed discussion of these technologies are included in Appendix A – ZE/NZE Truck Technology Assessment.

Drayage Truck Market

There are a handful of ZE HD truck models currently available, and many more expected to come in the short- and mid-term. Several traditional truck and engine manufacturers have each developed zero-emission trucks and there are numerous OEMs entering the market.

The commercial availability of ZE heavy duty trucks lags slightly behind other vehicle types which were targeted in earlier markets. Battery electric and fuel cell drayage trucks are currently participating in pilot projects in California and beyond. As these pilot projects continue, vehicle and charger manufacturers are expected to improve their technology as the vehicles approach full commercial availability. California's regulatory environment is also evolving: CARB's Advanced Clean Trucks (ACT) regulation was instituted in 2020, and this will put pressure on manufacturers to achieve increasing ZE heavy duty sales targets over time. CARB is also working on a medium- and heavy-duty ZE/NZE fleet regulation to complement the ACT regulation as it seeks to achieve the State's ZE goals for all truck types by 2045. Given the State's goals for accelerating the adoption of ZE heavy duty trucks, the state of the market is advancing with an increasing list of technology options that are available. Tenants, terminal operators and trucking companies that call to the Port of San Diego will continue to see a rapidly maturing market for on-road ZE heavy duty trucks.

Emission Reduction Estimates

Renewable diesel, renewable natural gas, and battery electric are three options that are presently available to reduce truck emissions. For fleets operating diesel trucks, using renewable natural gas or battery electric technology means truck replacement or repowering. For renewable diesel, however, existing diesel vehicles can be utilized because renewable diesel is a drop-in fuel such that no modifications or vehicle replacements are necessary. Although hydrogen is another viable fuel for Class 8 heavy duty trucks, at this time hydrogen fueling station development is still in its early stages, with approximately 44 stations currently in operation in California.[11] So far these stations are designed for light-duty vehicles, but much can be learned from these developments in preparation for building out hydrogen infrastructure for heavy-duty applications. For more information about hydrogen and fuel cell trucks, please see Appendix A – ZE/NZE Truck Technology Assessment.

Based on the results on of the Port of San Diego's Truck Survey (Spring 2020) and the current state of EV HD technology, staff identified some existing, fixed short haul routes that may be good candidates for ZE Trucks. The table below compares the emission estimates of different fuels and technologies assuming a regular, fixed route of 120 miles day or less, that would target traveling about 20,000 vehicle miles annually. As shown below, diesel trucks produce the highest amounts of emissions for NOx, DPM and CO2e. If renewable diesel fuel was used instead of traditional diesel, the NOx and DPM emissions would be the same, but CO_2e emissions would be reduced from 45 metric tons to 14 metric tons. If trucks were retrofitted to use renewable natural gas, NOx emissions would be reduced from 107 pounds to 11 pounds annually, DPM emissions would be eliminated, and CO_2e emissions would be 21 MT (or slightly less than half of the 45 metric tons produced by a diesel truck). Finally, ZE Trucks would eliminate all NOx and all DPM emissions, and would produce approximately 12 metric tons of CO_2e, (or about a quarter of a diesel truck). Given the emission reduction benefits of ZEV Trucks, the remaining discussion focuses on battery electric trucks.

[11] AFDC. n.d. *Hydrogen Fueling Station Locations*. Available online at: https://afdc.energy.gov/fuels/hydrogen_locations.html#/find/nearest?fuel=HY&hy_nonretail=true&location=california&page=5. Accessed January 2021.

Table 2. Estimated Emissions Associated with Diesel Replacements

Pounds of Emissions Assuming 20,000 Vehicle Miles Annually			
	NOx	DPM	CO_2e MT*
Diesel	107	0.4	45
Renewable Diesel	107	0.4	14
Renewable Natural Gas	11	-	21
ZEV	-	-	12

Note: *CO_2e is measured in metric tons because this is the international standard used to measure greenhouse gases.

Estimated Costs

Currently, the capital costs of electric trucks and charging infrastructure are higher than their diesel counterparts. While a traditional diesel truck is approximately $110,000, electric trucks are approximately $350,000, although that cost is expected to come down to $275,000 in 2023 (See Table 3). Costs associated with charging stations will vary widely based on site specific characteristics, but a $40,000 estimate for a 150 KW charger and $48,000 for installation, which is used in the AFLEET model to estimate an operations and maintenance cost of $4,000 per station for overall maintenance and networking costs.[12]

Table 3. Capital Cost of Diesel Truck Compared to Electric Truck

Input Category	Diesel	Electric	Source
Vehicle Cost	$110,000	$350,000 – 2020 $275,000 – 2023	CalETC report, conversations with OEMs

However, the total cost of ownership (TCO) is another metric that is used when trying to understand the total cost to purchase, operate, and maintain the vehicle over its lifetime. TCO is case specific and depends on a number of assumptions and variables, including the purchase price of the vehicle, fueling and maintenance costs, and incentive amounts that may be available fuel, infrastructure, insurance, taxes, and more (e.g., depreciation cost and resell value for fleets that wish to include these parameters). While TCO is case specific and depends on the variables and assumptions identified above, generally there is potential for electric trucks to have lower lifetime TCO than diesel or natural gas trucks if the conditions are right. The payback period, or breakeven point when the clean fuel vehicle becomes less expensive than the conventionally fueled vehicle, will vary as well. Currently,

[12] Zero Emission Truck Feasibility Study for Mitsubishi Cement Corporation, Port of San Diego, (November 2020), prepared by ICF and CALSTART

the California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP) incentives improve the TCO of Class 8 drayage trucks. However, going forward there is uncertainty to what degree incentive programs will be available.[13]

CARB provided a TCO comparison between diesel, battery-electric, and hydrogen at three different time periods: 2018, 2024, and 2030.[14] The TCO shows that battery electric technology appears to achieve parity with diesel for regional haul truck activity (180 miles a day and 54,000 miles a year over 12 years) by 2024 and becomes even more cost effective by 2030. This is primarily due to the net purchase price of a ZE Truck is projected to decrease and the fuel economy for ZEV trucks is projected to increase. Please note that the TCO analysis shown in Table 3 does not include HVIP incentives, which can further reduce the net purchase price of an electric truck by $150,000. Also, note that the size and weight of the battery in the EV Truck may decrease truck payload capacity for heavier cargo types (such as bulk), thereby increasing the number of trips that would be needed to move the same about of cargo. The TCO analysis below does not account for any increased in trips.

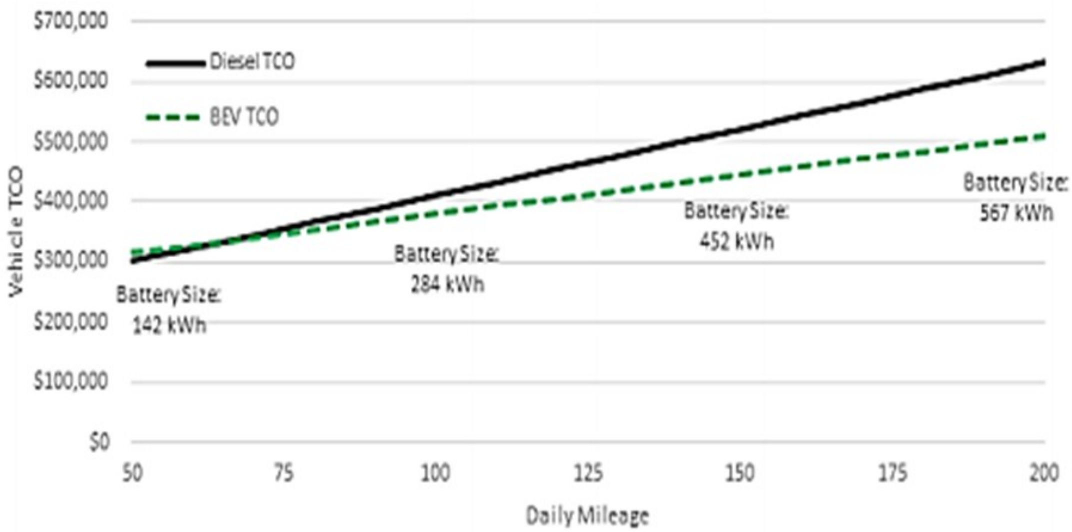
Figure 3 below graphically shows the TCO for battery electric vs. diesel trucks relative to the daily distance traveled. CARB notes that the TCO comparison has a stronger relationship with the duty cycle of a vehicle. ZEV's do better from a TCO perspective, the more they are driven; however, longer daily duty cycles require larger batteries, as noted in Figure 3.

Table 3. CARB TCO Results Assuming 180 miles in Daily Activity Over 12 years (54,000 miles Annually)

Metric	2018 Regional Haul		2024 Regional Haul		2030 Regional Haul	
	Diesel	Electric	Diesel	Electric	Diesel	Electric
Net Purchase Price	$134,000	$474,930	$144,101	$232,155	$146,442	$195,960
Fuel Cost	$296,381	$152,074	$300,308	$145,975	$312,805	$144,375
LCFS Revenue	$0	-$167,778	$0	-$127,348	$0	-$117,637
Other Costs	$141,076	$247,040	$142,768	$165,060	$143,162	$154,685
Total without Infrastructure	$571,456	$706,266	$587,178	$415,841	$602,408	$377,383

[13] ICF. 2019. *Comparison of Medium- and Heavy-Duty Technologies in California*. December.
[14] CARB. Advanced Clean Trucks: Total Cost of Ownership Discussion Document. Available: https://ww2.arb.ca.gov/sites/default/files/2020-06/190225tco_ADA.pdf.

Figure 3. CARB TCO Results Versus Mileage 2024



Goals and Objectives

TRK Goal 1 – To improve the air quality of the Portside Community, accelerate the phase-out of diesel trucks that call to the Port's marine terminals, in alignment with the State's long-term goal to reach 100% ZE Drayage Trucks by 2035.

TRK Objective 1A: Develop a short-haul on-road ZE Truck Shuttle Program comprised of a trucking company and/or independent drivers to displace approximately 20,000 diesel vehicle miles traveled (equal to about 12% of community miles) by 2024 and continuing through 2026.

Discussion

The Port of San Diego's most recent Truck Survey (Spring 2020) identified three potential fixed routes that occur with some regularity and which occur within the 120-mile EV heavy duty truck distance ranges that can be achieved with today's technology. Of these, the five-mile (short-haul) route from the Tenth Avenue Marine Terminal to the National Distribution Center in National City (NDC) may be the most promising for electrification because (1) approximately 130 truck trips occur weekly; (2) there appears to be adequate land at the NDC for EV HD charging infrastructure; and (3) all of the emission reductions would occur along Harbor Drive and would directly benefit the Portside Community. Preliminary estimates suggest that a ZE Truck shuttle program that traveled 20,000 miles could reduce NOx emissions by 107 lbs., DPM emissions by 0.4 lbs., and CO2e emissions by 45 metric tons, annually. These reductions, if operationalized for the 3-year period, would reduce truck-related emissions associated with the Port's terminal activities and would serve to phase out diesel trucks in advance of state regulations.

It's important to note that securing agreements with willing partners (i.e., tenants and truckers), developing the program (i.e., identifying the # of trucks, types of trucks, and/or modifying current business practices), completing the planning, environmental review, and permits to site and install the charging infrastructure, and ordering and purchasing electric trucks to conduct the operations, requires an investment of time and money. Once partnerships are secured and planning funds for a ZE Truck Program is identified, staff estimates that the planning, design, environmental review, and permitting could be completed in an 18- to 24-month timeframe.

To ensure ongoing transparency and accountability to the Board of Port Commissioners and other community stakeholders, Port staff would provide annual updates on the ZEV Truck Program to the Board, AB 617 Steering Committee, Barrio Logan Community Planning Group (BLCPG), and to the National City, City Council. The annual updates may involve tracking the progress of finalizing agreements, securing entitlements, and receiving environmental approvals in relation to the 18- to 24-month timeframe. Once the ZEV Truck Program is operational, Port staff may report the number of ZE HD truck trips that occurred along the corridor annually, as well as the estimated reductions in DPM and NOx emissions. In years 2 and 3 of the program (and thereafter), Port staff may identify how the Port is looking to expand ZEV Truck technologies to other routes and/or more generally.

TRK Objective 1B: Reduce 10% of the 2016 Maritime Air Emissions Inventory's truck emissions (DPM and NOx) by 2023 by working with stakeholders to deploy: a) technologies; or b) fuels; or c) by modifying current business practices and operations.

Discussion

There are multiple strategies that can be applied to help reduce truck related DPM and NOx emissions. This may involve estimating emission reductions associated with existing ZE Trucks that are currently in operation, using of alternative fuels, modifying operations, and/or making operational improvements such as freight signal prioritization along Harbor Drive.

TRK Objective 1C: Use the truck registry system to promote that all fixed, short-haul drayage truck routes are ZE by 2031.

Discussion

At CARB's March 2, 2021, Advanced Clean Fleets Regulation Workshop, CARB staff shared their most recent regulatory proposals for transitioning all Class 7 and 8 drayage trucks operating at California's intermodal seaports or railyards to full zero emission by 2035. To help facilitate this transition, CARB is proposing that after January 1, 2023, only zero-emission trucks would be eligible to be added to the CARB drayage truck registry. To support this effort, staff recommends developing a Port Drayage Truck registry by 2023, or as otherwise required by CARB. This will enable the Port to track the total number drayage trucks and fleet characteristics of the drayage trucks that call to its two marine terminals, and it would also allow the Port to share this data with the nearby residents and other stakeholders.

Working to accelerate the phasing out of diesel trucks terminals remains the overarching goal for the Port. While several stakeholders have urged the Port to establish a 100% ZE Truck goal in advance of the State's 2035 target date, other stakeholders have expressed concern about the feasibility of delivering on a 100% ZE drayage truck commitment before 2035. CARB is arguably the foremost authority on mobile source emissions and air quality issues in the Country.[15] As CARB develops its regulatory schedule to try to meet the State's 100% ZE drayage truck goal by 2035, it will be considering the latest science and technology. However, it will also be looking at manufacturing capabilities, market availability, impacts to local and state employment, as well as implications to the goods movement industry and the State's overall economic competitiveness.

That said, the Port of San Diego is well positioned to help advance the deployment ZE/NZE drayage truck technology by targeting specific, short-haul truck routes that are fixed and that could be accomplished with ZE trucks. By complementing the regulatory efforts being considered by CARB, the Port can reduce truck related emissions while fulfilling its obligations under the Port Act, the California Coastal Act and the Public Trust Doctrine. It allows the Port to be flexible and nimble when identifying ways of increasing the number of ZE/NZE truck trips, which will serve to expand future opportunities, and not limit them.

TRK Objective 1D: Collaborate with community residents, stakeholders, and agencies to identify up to three locations for ZE truck charging with each site capable to serve ten trucks simultaneously by 2023.

Discussion

Recognizing the State's long-term goal is to transition to zero emissions trucks by 2035 and 2045, it is important for the Port work with stakeholders and other local agencies to help plan the charging infrastructure that will be necessary support California's ZE truck fleet. These efforts may build on SANDAG's MD/HD ZEV Infrastructure Blueprint Grant application, that was submitted in November 2020 to identify actions and milestones that are needed to implement MD/HD ZEV trucks and related electric charging and hydrogen refueling within the San Diego region. Several partner agencies supported SANDAG's application, including the Port of San Diego, Metropolitan Transit Service (MTS), North County Transit District (NCTD), Caltrans District 11, and the County of San Diego.

TRK Objective 1E: Work with SDG&E and community stakeholders to develop sites identified in Objective 1D to provide the best available charging technology, and to ensure that the sites are accessible to both fleet and independent truckers and that there is a fair and reasonable rate structure for the customers by 2026.

Discussion

Once these truck charging locations are identified, partner agencies will need to identify how to develop them, including who will be the lead applicant or agency. Partner agencies will also need to identify how to fund the necessary the improvements including costs associated with planning, design, environmental review, permitting, and construction, as well as any costs associated with ongoing operations and maintenance of the facility. This objective also identifies the need to ensure that there is a fair and reasonable rate structure in place for ZE Truck operators and/or owners to pay for e projects along the corridor, including project identification, environmental review and funding opportunities. While SANDAG is likely to be the lead agency for this project, Port staff will remain actively engaged in the ongoing development and refinement of Harbor Drive 2.0.

[15] Since its formation in 1967, CARB has worked with the public, the business sector and local governments to find solutions to California's air quality problems. In 1970, the federal Clean Air Act recognized California's early efforts and authorized the state to set its own separate and stricter-than-federal vehicle emissions regulations to address California's unique circumstances of population, climate and topography, that generated the work air quality in the nation at the time. California established the nation's first tailpipe emissions standards, adopted the nation's first Nitrogen Oxide (NOx) emissions standards for motor vehicles, and led the way to the development of the catalytic converter, which revolutionized the ability to reduce smog-forming emissions from cars.

GOAL 2 – Support the designated truck route to avoid truck impacts to the local community.

TRK Objective 2a: Work with partners to create a connected and flexible freight and transit haul route that provides more efficient freeway access and encourages truck drivers to avoid residential neighborhoods by leveraging technology to support dedicated lanes, signal prioritization and/or geofencing.

Discussion

In December 2019, staff completed the Harbor Drive Multimodal Corridor Study, which included a concept plan entitled Harbor Drive 2.0 – A Greener, Safer, and Healthier Harbor Drive. Harbor Drive 2.0 would create a flexible freight and transit haul road between TAMT, NCMT and the regional freeways by providing a dedicated lane(s) with freight signal prioritization technology. These improvements would result in lower truck emissions by reducing the stop and go movements of trucks along Harbor Drive. By providing a safer and more efficient route to the highways, this improvement would also incentivize truckers use the designated truck route and avoid traveling through residential areas. Harbor Drive 2.0 is identified as an emission reduction strategy in the AB 617 Draft CERP (November 2020), and was identified as high-priority project by the AB 617 Truck Subcommittee, AB 617 Land Use Subcommittee, and the AB 617 MCAS Subcommittee.

Because the majority of Harbor Drive is located outside the Port's jurisdiction, on December 10, 2019 the Board of Port Commissioners directed staff to continue to collaborate with pertinent stakeholder agencies and to work with them to seek federal, state and/or local funding that could be used to further advance the Harbor Drive 2.0 concept. On October 6, 2020, the Port entered into a Memorandum of Understanding (MOU) with the San Diego Association of Governments (SANDAG) and the California Department of Transportation (Caltrans) to further advance the Harbor Drive 2.0 project and other projects along the corridor, including project identification, environmental review and funding opportunities. While SANDAG is likely to be the lead agency for this project, Port staff will remain actively engaged in the ongoing development and refinement of Harbor Drive 2.0.

Port of San Diego Fleet

Introduction

Although not primarily involved in maritime-related operations, the Port's fleet of vehicles, equipment, and vessels are necessary for managing Port Tidelands. The Port's fleet is comprised of many different types of vehicles that run on different fuels. This chapter will summarize the Port's existing fleet, fuels used, and describe opportunities to advance zero emission and lower emitting options in the future. Although there is some cross over between Port Fleet and other Sources, harbor craft and cargo handling equipment in particular, all Port Fleet inventory is addressed exclusively within this source chapter.

Background and Context

Source Description

The Port's fleet is comprised of vehicles, equipment, and vessels. The following overview is reflective of the Port's fleet in calendar year 2019.

Vehicles

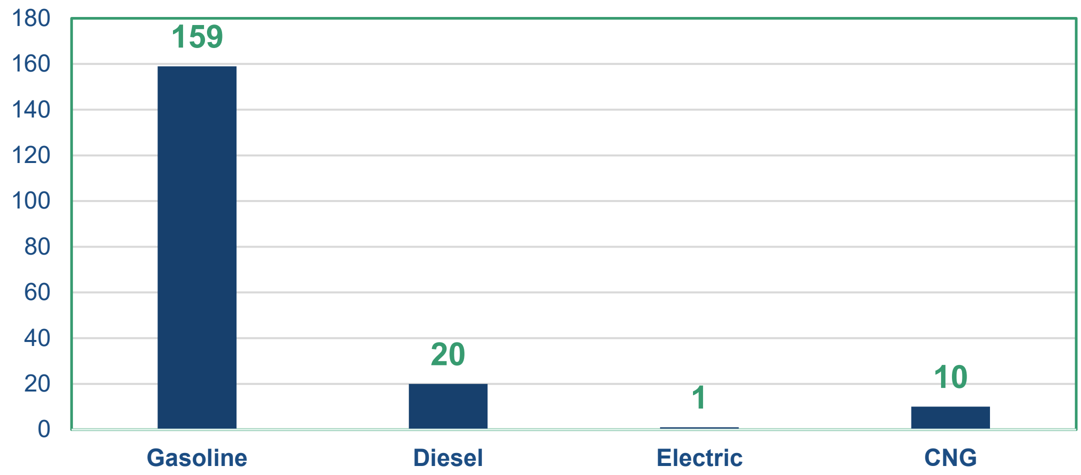
The Port's vehicle fleet includes 190 vehicles of various types. Port vehicles are used by the General Services Department to perform maintenance, Harbor Police and Community Service Officers to ensure public safety, and other Port departments to conduct administrative duties. FLT Table 1 identifies the Port's fleet of vehicles organized by the type of vehicle associated with weight (gross vehicle weight). As shown, most vehicles operated by the Port consist of medium duty vehicles such as SUV's and utility trucks.

FLT Table 1. Port Vehicle Fleet (2019)

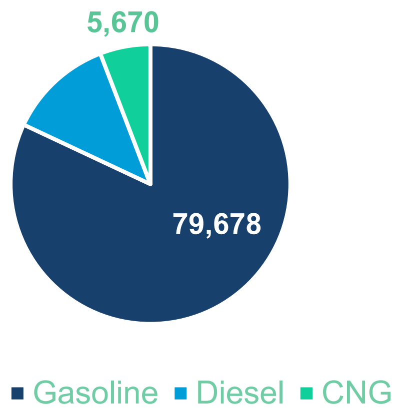
Vehicle Type (GVWR)	Description	Number of Vehicles
Light Duty (<6,000 lbs)	Passenger vehicles, patrol vehicles, and light trucks	53
Medium Duty (6,001-26,000 lbs)	SUV's, vans, and utility trucks	127
Heavy Duty (>26,000)	Refuse and Dump trucks	10
Total		190

FLT Figure 1 showcases the types of fuels used by the Port's fleet. FLT Figure 2 summarizes fuel consumption. Consistent with the number of vehicles, the majority of fuel used by the fleet is gasoline. As the Port's sole electric vehicle consumes electricity, it is not summarized in FLT Figure 2. Diesel consumed by the fleet is renewable diesel, which is a biogenic fuel.

FLT Figure 1. Fuel Type of Port Vehicles



FLT Figure 2. Fuel by Port Vehicles (Gallons)



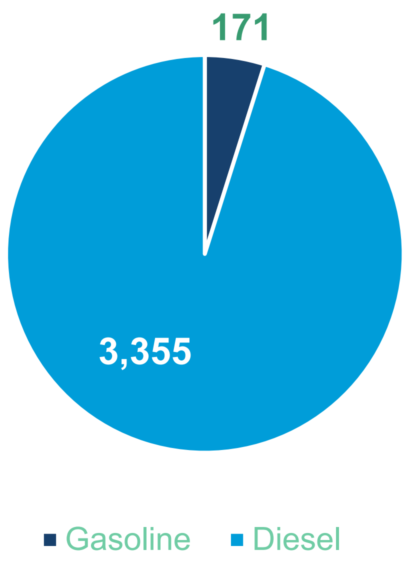
Equipment

The Port's inventory of equipment is diverse. Most of the equipment at the Port is operated by General Services and Maritime Staff for maintenance purposes and backup power. A small amount of the equipment may be used for cargo operations at the Port's marine terminals.   FLT Table 2 summarizes the type of equipment and fuel used by the Port. FLT Figure 3 summarizes fuel use by the Port's equipment. Most equipment uses diesel fuel, followed by gasoline, and propane (limited propane was used in 2019). The Port does not track fuel consumption per each piece of equipment. Electricity use by equipment is not shown in FLT Figure 3.

FLT Table 2. Port Equipment Inventory and Fuel Type

Equipment	Gasoline	Diesel	Propane	Electric	Total Equipment
General (generators, concrete mixers, power washers, etc)	5	9	0	0	14
Forklifts	0	2	2	4	8
Lawn Mowers	0	13	0	0	13
All-Terrain Vehicles	1	2	0	4	7
Lifting Equipment	0	3	0	0	3
Construction Equipment	0	2	0	0	2
Sweepers and Vacuums	0	2	0	0	2
Total Fuel Types	6	33	2	8	49

FLT Figure 3. Fuel Use by Port Equipment (Gallons)



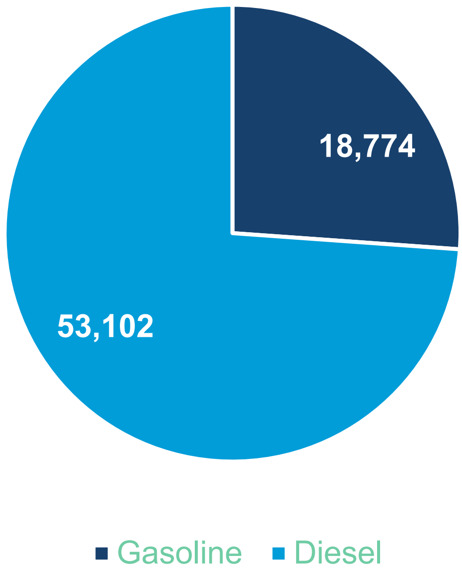
Vessels

The Port operates a variety of marine vessels that are used on San Diego Bay by different departments to perform maintenance, conduct monitoring, and respond to emergencies. FLT Table 3 identifies the different types of vessels operated by the Port organized by fuel type. FLT Figure 2 displays the amount of fuel consumed by the Port's fleet of vessels. As shown, the majority of fuel used is by diesel powered vessels.

FLT Table 3. Port Vessel Fleet and Fuel Type

Vessel Type	Department(s)	Gasoline	Diesel	Total Vessel Type
Fireboat & Patrol Vessels	Harbor Police	5	5	10
Work Vessels	General Services	1	3	4
Environmental	Environmental Conservation and Environmental Protection	1		1
Total Fuel Type		7	8	15

FLT Figure 4. Fuel Use by Vessels (Gallons)



History of Previous Efforts

With the adoption of the Green Port Program in 2008, the Port began introducing alternative fuels to reduce emissions from its fleet. Today, approximately 24% of the vehicle fleet includes alternative fuels or cleaner technology such as a hybrid vehicle. Since the Port's first inventory of GHG emissions from the vehicle fleet, emissions have decreased roughly 19% reflecting a reduction in fuel consumptions and use of low carbon fuels. Below are examples of alternative fuels and cleaner technologies incorporated into the fleet:

- 15 hybrid vehicles including SUVs and police vehicles;
- 10 CNG vehicles across a variety of vehicles types from light-duty passenger vehicles to heavy-duty trucks;
- Diesel particulate filters for heavy-duty vehicles, where necessary;
- One electric light-duty passenger vehicle; and
- Use of renewable diesel beginning in 2018.[1]

While alternative fuels are used in the Port's inventory of equipment including electric and propane forklifts, their use is a small percent of the total. None of the Port's fleet of vessels uses alternative fuels; however, all diesel vessel engines are equipped with Tier 3 engines.

Technology and Strategies

The Port's fleet of vehicles and most types of equipment are well-situated to shift to electric-powered units. However, when shifting to electric power, it's not just the units that need to be replaced, but each unit also needs to be supported by the appropriate electric vehicle service equipment, also known as charging station infrastrucute. Even though electric vehicles and equipment have higher procurement costs compared to traditionally fueled vehicles and equipment, lower total costs of ownership may occur due to incentive programs and the lower cost of electricity and maintenance.

Description of Emission Reduction Technology Options

Vehicles

Zero emission vehicles, including battery-electric, are being developed and already include commercially available options for medium to heavy-duty applications starting at a GVWR 6,000 lbs and greater. This includes battery-electric pickups, SUVs, vans, and platforms for heavier duty vehicles such as refuse and dump trucks. Specialized body configurations for typical municipal work trucks may take longer to come to market but are expected in the next decade. Battery-electric vehicles are a good fit for the Port as average daily mileage of the vehicles is low and the vehicles are domiciled at a central location during off-peak hours for overnight charging.

Emergency Vehicles

Emergency vehicles, such as pursuit-rated police vehicles, also have zero emission and electric hybrid options. Primarily, the shift for emergency vehicles has focused on electric hybrids to ensure confidence in quick fueling and higher mileage. Hybrids help to increase fuel efficiency and decrease idling emissions. As battery-electric technology advances with longer range capability and quick charging, electric vehicles may present a lower cost of ownership compared to hybrids due to a lower cost of electricity and maintenance per mile.

[1] Renewable diesel is a low carbon fuel produced from waste materials and can be used in existing diesel infrastructure. While criteria pollutant emissions associated with the combustion of renewable diesel are not reduced, the release of GHG emissions is not a net increase.

Equipment

The technology to support zero emission equipment used by the Port is at different states of readiness. Electric lawn mowers, forklifts, and all-terrain vehicles are available. Battery electric options for generators are also available to support portable power needs. Specialized scrubbers, vacuums, and sweepers are still largely powered by traditional fuels. Lower carbon fuels such as propane and renewable diesel can be used as bridge fuels until electric options become more readily available.

Vessels

Few options exist for zero emission marine vessel craft at this time. Battery-electric as well as hydrogen fuel cells may be promising solutions to transition vessels to zero emissions; however, research and development for these technologies is needed. In the meantime, best available control technologies to reduce emissions and low carbon fuels can be used.

Infrastructure

Due to the importance of charging infrastructure to support the transition to battery-electric vehicles, California has many programs to incentivize the installation of charging infrastructure. Most importantly, is Senate Bill 350 which requires the State's three investor-owned utilities to invest in transportation electrification. As a result, San Diego Gas & Electric has developed programs to install electric vehicle service equipment and infrastructure at workplaces, public parks and beaches, and for fleets operating medium- and heavy-duty vehicles. Collectively, SDG&E's programs are known as Power Your Drive and represent a critical opportunity to advance the infrastructure to support charging.

Goals and Objectives

FLT Short Term Goal 1: Update Port procurement policies to acquire zero emission vehicles and best available alternative fuels or technologies.

FLT Objective 1a: Update the Port's vehicle procurement policy to identify a hierarchy of procurement considerations which targets zero emission vehicles and then best available alternative fuels to ensure the lowest emitting option available.

FLT Objective 1b: Create a zero emission vehicle transition plan in FY 2022 for the Port's fleet of vehicles and equipment which identifies a long-term acquisition schedule for when current vehicles and equipment will be phased-out and new electric vehicles and equipment is anticipated to be procured.

Discussion

To be a leader in the transition to near-zero and zero emission technologies, the Port can create a foundation set up for success in this venture. The solid foundation includes updating the Port's procurement policy to support these types of investments, identifying equipment and vehicles within the Port's fleet that may be phased out and replaced with electric and alternative fuel technologies, and finally, continuing to create the charging infrastructure to support this transition.

FLT Short Term Goal 2: Procure zero emission vehicles and necessary electric vehicle service equipment beginning in FY 2022.

FLT Objective 2a: Procure at least two battery electric medium- to heavy-duty vehicles in FY 2022.

FLT Objective 2b: Apply to SDG&E's Power Your Drive for Fleets Program in calendar year 2021 which aims to install infrastructure to support power needs and electric vehicle charging located at the General Services facility.

Discussion

Many electric vehicle options are available in the light-duty sector to meet the Port's administrative transportation duties. Advances in electric medium- to heavy-duty vehicles have already taken place and can begin to meet the Port's operational needs in certain instances. In order to demonstrate the Port's commitment to transitioning the electrification, the agency will target procuring at least two electric vehicles and equipment beginning in FY2022.

FLT Long Term Goal 1: Shift to battery-electric vehicles with a target of all light-duty vehicles becoming electric by 2030 and all medium- to heavy-duty vehicles becoming electric by 2035.

FLT Long Term Goal 2: Transition emergency vehicles to alternative fuels including hybrid, electric, and/or low carbon fuels.

FLT Long Term Goal 3: Convert equipment such as forklifts, small powered generators, and lawn maintenance equipment to zero emissions, hybrid technologies, and/or low carbon fuels where feasible and commercially available.

FLT Long Term Goal 4: Seek opportunities to advance lower emitting solutions for marine vessels (few options exist for zero emission vessels).

Discussion

The long-term recommended goals identify objectives for the next 15 years. As electric and alternative fuel technology continues to advance, the Port will continue to upgrade its vehicles and equipment. For details on the Long-Term goals, please refer to FLT Table 4.

FLT Table 4. Recommended Goals for Port Fleet

Fleet Category	Type	Goal	Cost per Piece[1]	Total Cost
Vehicles	Light-Duty (<=6,000 lbs)	100% EV by 2030	$46,550	$1,900,000
	Medium-Duty (6,000 to 26,000 lbs)	100% ZEV by 2035	$127,000	$11,300,000
	Heavy-Duty (>26,000 lbs)	100 % ZEV by 2035	$480,000	$4,800,000
	Emergency and/or Pursuit-Rated Vehicles	100% Alt. Fuels (including hybrid, electric, and/or low carbon fuel) by 2035	$40,770	$2,000,000
Equipment	Lifts, generators, gardening equipment, etc.	100% zero emission, hybrid technology, or low carbon fuel by 2035	$18,000	$1,600,000
Vessels	Patrol, General Services, and Departmental Vessels	Best available low emitting technology by 2035	$400,000 - 1,700,000	$6,750,000 - $25,000,000
Total				**$28 – $47 million**

Note: Vehicle prices were derived from ICF Fleet Transition Tool's EV Model Library. Equipment cost based on internet research. Price for vessels based on repowered hybrid and battery electric options.

To achieve these long-term goals, it is anticipated that the rough order of magnitude costs is approximately $28M to $47M. These costs can be phased over the next 15 years. The costs reflect assumptions in 2021 and may change over time.

Conclusion

As new zero emission vehicle and equipment requirements advance and these technologies continue to enter the marketplace, the Port can begin its preparation for zero emission operations. Because infrastructure is important to make the shift to these new types of technologies, the Port can take advantage of current programs to incentivize the installation of infrastructure to save future expenses. In addition, the Port can continue to track research and development for reducing emissions from marine vessels and seek opportunities to deploy zero emission vessels where appropriate. Meanwhile, low carbon fuels can be utilized to decrease the GHG emissions from these vessel types.

Shipyards (Marine Industrial Uses)

Background and Context

For over a century, the construction and repair of ocean-going vessels have occurred in and around San Diego Bay. In 1915, the first shipyard was the San Diego Marine Construction Company that developed a wharf and facilities for repairing and constructing marine vessels at the foot of Sampson Street. The three shipyards and their suppliers that are in operation today build, repair, and maintain private, commercial, and U.S. Navy vessels. These vessels may be homeported at the Port of San Diego or bound for international ports[1]. These shipyards undertake the following activities: "…maintenance, conversion, overhaul and ship repair that include specialized crafts such as welding, vessel painting, pipefitting, shipfitting, electrical work, abrasive blasting, carpentry and rigging…"[2]. Today the majority of the shipyard work serves the U.S. Navy and associated defense contractors, but the commercial work is significant as well.

The following three shipyards[3] are located along the Working Waterfront, which includes the area west of Harbor Drive between the Tenth Avenue Marine Terminal and the National City Marine Terminal:[4]

- BAE Systems San Diego Ship Repair
- Continental Maritime of San Diego (F/K/A Huntington Ingalls Industries San Diego Shipyard)
- General Dynamics NASSCO

Shipyards Today

The working waterfront is a powerful economic generator for the region. For instance, a Port 2017 economic impact review[5] concluded that the direct economic impact for its industrial maritime sector, which includes shipbuilding, is $2.7 billion. Approximately 46 percent of that total output benefits the San Diego economy. Further, the total number of direct industrial maritime jobs equals approximately 13,300. In 2015, the shipyards alone employed approximately 7,090 workers[6], which is roughly 53 percent of industrial and maritime employment within Port tidelands. The industrial and maritime salaries and benefits per job are approximately $62,205[7]. In addition to the private shipyards, the United States Navy also helps drive economic benefits to the region, particularly with its shipbuilding facilities: in 2019, with the installation of 60 ships in San Diego Bay, the Navy generated a total direct

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[1] https://www.portofsandiego.org/maritime/shipyards

[2] http://sandiegoshiprepair.com/

[3] In addition to the Port's three shipyards, Marine Group Boat Works (MGBW) is a full-service boat construction facility that specializes in refits, repairs, and new construction of boats up to 220 feet long. MGBW has one 5-acre facility in National City and one 15-acre facility Chula Vista. Although MGBW is not a shipyard, they are in contact with Port staff on various emission reduction opportunities.

[4] While it is not within Port's jurisdiction, U.S. Navy Base San Diego is also located within this area and is oftentimes considered part of the region's working waterfront.

[5] *Economic Impacts of the San Diego Unified Port District in 2017 (*published in February 2019*)* (administration/port-of-san-diego-economic-impact-report-2017)

[6] *Barrio Logan Shipyard Parking Study*, San Diego Unified Port District, December 2015

[7] (See Footnote 2, above)

economic impact of $6.8 billion and their shipyards provided approximately 7,600 jobs[8]. Furthermore, a recent report concluded that out of 800 occupations in the Standard Occupational Classification (SOC) system, only 25 occupations were found to be both "recession-resilient" and "pandemic-resilient." Of those 25 occupations, shipbuilding and repair is one of 12 jobs that were classified as a "middle-skill job" that could be trained by a community college program[9]. Thus, the working waterfront remains integral component of our regional economy that is better equipped to keep people employed during challenging economic times.

The working waterfront is an important part of the country's national defense. The United States Maritime Administration has designated the Port as one of 17 commercial strategic ports in the United States[10]. To accommodate rapid military mobilization, these ports provide the infrastructure and resources needed to accomplish such a deployment[11]. Part of the resources offered within Port jurisdiction are the shipbuilding facilities, including wet and dry docks. Further, supporting industries to shipbuilding are located within the Barrio Logan community, east of the BNSF Railroad tracks off Port tidelands.

Source Description

Shipyards and their associated maritime industrial uses are highly regulated by federal, state, and local government agencies due to the nature of their operations. The most common activities that emit air pollutants at the shipyards include welding, vessel painting, abrasive blasting, and carpentry. Additionally, some internal combustion engines are used in load handling and lifting activities that support movement of materials and supplies used in shipbuilding and repair. Welding creates fumes that are oxidized by the reaction between the welding arc and oxygen in the air[12]. Fumes and gases represent the main pollutant sources from welding operations. Fumes create particulate matter such as $PM_{2.5}$ and the gases generated are carbon monoxide, ozone, and nitrous gases[13]. Vessel painting results in the emission of volatile organic compounds (VOC)[14]and other toxic air pollutants. Internal combustion engines used in equipment and vehicles to move parts and materials in shipbuilding and repair emit criteria pollutants and greenhouse gasses (GHG) as part of the processes. Abrasive blasting [15] and carpentry primarily produce particulate matter.

According the U.S. Environmental Protection Agency (EPA), shipyards in the United States produce air emissions such as CAPs, GHGs, and other chemical substances found within the EPA's Toxics Release Inventory (TRI). As noted above, the primary air emissions generated by shipyards originate from vessel painting, welding, and abrasive blasting[16]. The shipyards within Port tidelands emit similar chemicals and hazardous substances as described by the EPA for shipyards nationally. For those activities that produce greenhouse gases, the pollutant generated is carbon dioxide. Shipyard activities that involve combustion of fuel results in direct emissions of GHG (carbon dioxide), while consumption of electricity results in indirect GHG emissions.

[8] *San Diego Military Economic Impact Study* (2019), San Diego Military Advisory Council
[9] https://myworkforceconnection.org/wp-content/uploads/2020/08/Resilient-Jobs_2020-08-27v2.pdf
[10] blankrome.com/publications/strategic-seaports
[11] globalsecurity.org/military/agency
[12] intechopen.com/books/current-air-quality-issues
[13] intechopen.com/books/current-air-quality-issues
[14] https://www.tecamgroup.com/paint-voc-levels/
[15] sdapcd.org/content/sdc/apcd
[16] https://archive.epa.gov/sectors/web/pdf/shipbuilding_bw.pdf

The EPA's TRI tracks several hazardous chemicals that are present in the shipbuilding industrial sector, including manganese, N-Butyl Alcohol, nickel, ethyl benzene, and copper. These TRI listed chemicals are generated from activities such as welding, abrasive blasting, and painting.

Brief Overview of Legislative and Regulatory Framework

Shipyards are subject to a number of Federal, State, and local regulations designed to reduce emissions. In California, the Clean Air Act compliance is a shared responsibility between the EPA, the California Air Resource Board (CARB), and the local air pollution control agency. Under this framework, the San Diego Air Pollution Control District (SDAPCD) is the local agency with authority for issuing air pollution control permits to stationary sources. SDAPCD also regularly inspects shipyards and other facilities holding air pollution control permits to verify compliance with permit conditions, emission limits, and applicable prohibitory rules. In addition to SDAPCD, CARB is responsible for developing statewide programs to reduce the air pollution from mobile sources, including on-road sources such as passenger cars, trucks, busses, and off-road sources such as construction equipment, vessels, forklifts, and load handling equipment; some of these programs are implemented by SDAPCD at the local level.

Since each shipyard may have different activities and equipment, and because they rely on variety of contractors and subcontractors to perform certain work, there is variation in the type of permits and regulations that may apply to each facility. While not exhaustive, the following table summarizes the major regulatory areas applicable to shipyard air emissions (SHP Table 1 – Sample of Existing Regulatory Measures Governing Shipyard Emissions).

SHP Table 1: Sample of Existing Regulatory Measures Governing Shipyard Emissions

Regulation	Description	Originating Agency
Stationary Sources		
Rule 10 - Permit Required	Regulation requiring air pollution control permits for stationary emission units operated in San Diego County	SDAPCD
Rule 52 - Particulate Matter	Regulates emissions of particulate matter (PM)	
Rule 67.17 – Storage of Volatile Organics	Regulates volatile organic material storage and handling practices to minimize emissions	
Rule 67.18 - Marine Coating	Regulates volatile organic emissions from marine painting products and activities	
Rule 69.4.1 – Stationary Reciprocating Internal Combustion Engines	Regulates emissions of oxides of nitrogen, organic compounds, carbon monoxide, and other pollutants from stationary diesel engines	
Rule 71 – Abrasive Blasting	Regulated emissions from abrasive blasting	
Rule 1200 – Toxic Air Contaminants	Regulates toxic air contaminant emissions from new or modified emissions units	
17 CCR 93115 - Airborne Toxic Control Measure from Stationary Compression Ignition Engines	Regulation to reduce diesel particulate and criteria pollutant from stationary diesel engines	CARB
Mobile and Portable Sources		
13 CCR 2025 – Truck and Bus Rule	Regulation to reduce diesel PM and oxides of nitrogen from in-use, diesel fueled, on-road vehicles such as trucks and busses	CARB
13 CCR 2449 – In-Use Off-road Diesel Rule	Regulation to reduce diesel PM and oxides of nitrogen emission from in-use, diesel fueled, off-road vehicles such as forklifts, load handlers, and other construction equipment	
13 CCR 2775 – Large Spark Ignition Rule	Regulation to reduce hydrocarbon and oxides of nitrogen emissions from spark-ignited vehicles such as propane forklifts and sweepers	
17 CCR 93118.5 – Airborne Toxic Control Measure for Commercial Harborcraft	Regulation to reduce diesel PM, oxides of sulfur, and oxides of nitrogen from diesel propulsion and auxiliary engines on harbor craft operating in regulated waters of California	
17 CCR 93116 - Airborne Toxic Control Measure for Portable Diesel Engines	Regulation to reduce diesel PM from portable diesel engines	

History of Previous Efforts

The Port's shipyards have provided the following background on their operations, which identifies several steps they have taken over the past 10 to 15 years to reduce emissions that result from shipbuilding. Measures related to painting, welding, and abrasive blasting activities have helped lower emissions. For example, shipyards use shrouding or temporary enclosures and portable filters to reduce emissions from vessel repair and maintenance activities whenever safe and feasible. Although most ship repair activities occur outdoors, some shipyards have fixed shops or stationary production areas that have been fitted with capture and control devices, such as filtration systems for welding and blasting. However, because many operations can only be conducted on-board or outside vessels, functional or technological barriers or safety concerns may limit the ability to fully capture and control emissions under all circumstances. Because of these constraints, other emission reduction methods may be used to reduce emissions. These techniques include the use of inert gas shielding or lower-emitting welding products or processes, use of hydro-blasting processes, the use of low-VOC paints or solvents, and other work practices designed to reduce emissions when feasible.

General Dynamics NASSCO[17]

NASSCO is a major ship builder for the US Navy and has been designing and building ships in the Portside Community since 1960. In 2000, General Dynamics NASSCO became the first commercial shipyard in the United States to be certified to the ISO 14001 Standard[18]. This framework emphasizes continual improvement in environmental performance, which has led to the following steps that help reduce emissions.

Reduced Diesel Emissions

Since 2004, NASSCO estimates diesel emissions from stationary sources and portable equipment have been reduced by approximately 75% as the result of changes to equipment, infrastructure, and operations. These changes included improving yard air and electrical infrastructure and retiring all owned portable diesel generators, fire pumps, and compressors, as well as installing after-treatment systems (SCR and/or DPF) on nine diesel gantry cranes. Significant investments have also been made to reduce emissions from mobile sources. Since 2009, General Dynamics NASSCO has been on an accelerated program to retire or replace mobile diesel equipment, achieving compliance with CARBs off-road diesel fleet standards six years ahead of the regulatory deadline.

Reduced Welding Emissions

Emissions from welding have been reduced through installation of filtration systems on selected fixed welding locations as well as through implementation of process or material changes that reduce emissions. In 2018, General Dynamics NASSCO commissioned a laser-hybrid thin panel plate line

[17] General Dynamics NASSCO – Presentation to Port Maritime Stakeholder Forum: "Update on Shipyard Environmental Programs," August 2020

[18] The International Organization for Standardization (ISO) 14001 is the international standard that specifies requirements for an effective environmental management system (EMS). It provides a framework that an organization can follow, rather than establishing environmental performance requirements. ISO 14001 is a voluntary standard that organizations can certify to.

into its new vessel construction process. This line uses 30% less weld filler material and is equipped with integrated filtration capability.

Reduced Painting and Blasting Emissions

In 2009, General Dynamics NASSCO added a 66,000 square foot blast and paint facility equipped with capture and control systems that destroy 96% of VOCs from painting and remove more than 99.9% of particulate matter from blasting. Together with the control systems in the automated primer lines used for new vessel construction, it is estimated that these systems destroy 150 tons per year of VOCs. In addition, temporary enclosures are erected to control blasting and painting activities occurring on-board vessels and all paints meet strict federal and local limits on Volatile Organic Compounds (VOCs).

Reduced Greenhouse Gas Emissions

Over the past ten years, several initiatives have helped reduce direct and indirect GHG emissions. These changes included LED lighting upgrades, installation of controlled lighting systems, retirement of gas-fired boilers, and improvement to compressed air control systems. As a result of joining a Strategic Energy Management program in 2018, General Dynamics NASSCO's energy team was able to identify and implement an additional twenty-six new projects that further reduced GHG emissions. Collectively, General Dynamic NASSCO estimates that these efforts have reduced the its GHG emissions by more than 3,300 tons/year, which is equivalent to taking 720 cars off the road.

Reduced Emissions from Employee Transportation

General Dynamics NASSCO also sponsors ongoing programs to reduce emissions from employee transportation. To incentivize the use of transportation alternatives, fuel costs are paid for employees utilizing vanpools and trolley passes are offered at a 20% discount, which can be bought through payroll deduction. Secured bike parking areas and more than 100 bike lockers are available for employees who bike to work. More than 150 electric carts and over 200 bicycles have been provided for transportation in-plant and between shipyards.

BAE Systems San Diego Ship Repair (BAE)[19]

BAE is another major shipyard and provides ship repair services for more than 50 US Navy vessels homeported in San Diego, in addition to the various commercial ships that make port calls in San Diego. At BAE, efforts to reduce potential pollutants associated with its operations include changes to equipment, processes, and industrial products, as well as monitoring of these efforts for continual improvement. The focus of these efforts is the reduction and control of emissions from industrial processes and sources such as diesel engines, welding and preservation operations as follows:

[19] https://www.baesystems.com/en-us/product/san-diego-ship-repair - BAE Systems: *San Diego Ship Repair 2018 Annual Sustainability Booklet*

Reduced Diesel Emissions

Electric equipment, like cranes on both the Pride of California (POCA) dry dock and Pier 4 were installed in 2017, and both propane and electric forklifts are replacing diesel-operated models. During ship movements, the lowest emission generators are utilized whenever possible. All diesel-powered equipment used on-site has a CARB permit, ensuring equipment is approved for operation in California, and subcontractors are required to use the highest Tier certified engines available to operate mobile and portable equipment. The floating barge Heavy Lift Crane and Pier 3 gantry crane were voluntarily upgraded to a cleaner Tier 4 engines in 2013, and the Pride of San Diego drydock is targeted for electrification over the next five years. Further, BAE has operated electric trucks and is currently working with TransPower USA to lease another electric semi-tractor used for transporting equipment between the Yard and nearby warehouses. A current sustainability goal is to add additional electric forklifts to the current fleet by the end of 2021. Over the past several years, the off-road diesel fleet maintained onsite (currently reduced to six vehicles) is being downsized as units are sold or scrapped.

Reduced Welding Emissions

Throughout the yard, controls are in place to reduce emissions associated with industrial activities. Gas shielding and HEPA filtration are used to reduce welding emissions, and as much welding as possible is conducted in a controlled setting in production shops, as opposed to on the vessel. Prohibitions are also in place to prevent the use of certain types of stainless-steel welding and weld rods containing high concentrations of chromium.

Reduced Painting and Blasting Emissions

For marine coating and painting applications, products are reviewed before use for volatile organic compound (VOC) content to ensure compliance with APCD rules and of the lowest VOC available for the work. Many solvents have been replaced with non-VOC or exempt VOC products, and solvent-based part washers have been removed from service or replaced with water-based cleaners. On ships or piers, shrouding is installed to protect air and water quality during spray painting and abrasive blasting operations. Inspections of these spaces occur prior to beginning work, whenever industrial activity in the space changes, and prior to deconstruction of the containment by BAE Environmental staff.

Reduced Greenhouse Gas Emissions

Reductions in GHG emissions are achieved through capital and noncapital energy reduction projects such as the acquisition and installation of the all-electric POCA dry dock, replacing incandescent and fluorescent lighting with LED lights, improvements to HVAC systems, automatic lighting in office spaces, and energy-efficient air compressors and fire pumps.

Reduced Emissions from Employee Transportation

BAE Systems employees utilize Global Electric Motorcars (GEM; “golf carts”) to transit between the yard and Naval Base San Diego and bicycles for transit through the yard, thereby reducing noise and air emissions associated with diesel-power vehicles. Employees are encouraged to participate in SANDAG’s iCommute program through vanpool offerings and use of MTS buses and trolleys. For those who drive a personal vehicle, BAE provides a free shuttle bus between the yard and the Hilton

San Diego Bayfront Hotel downtown parking structure; shuttle buses are also available between the US-MX boarder and the Yard.

Continental Maritime San Diego (F/K/A Huntington Ingalls Industries San Diego Shipyard)

Continental Maritime San Diego is also in the ship building and repair business. In 2008, its facility became ISO 14001 certified. Since receiving the certification, the company has utilized the ISO 14001 as a basis to show its commitment to operate in a more environmentally responsible manner, which includes taking the following actions identified below:

Reduced Diesel Emissions

Since 2012, the company estimates that diesel fuel usage has been reduced from about 30,000 gallons a year to approximately 3,000 gallons per year, for 50 horse-power engines and above. This has been achieved by replacing the upper level engines in two cranes with EPA Certified Tier 4 engines, as well as replacing a crane with one that is Tier 4 compliant in the Off-Road Diesel Fleet. In 2018 the company retrofitted a crane with a PM filter to reduce particulate emissions. By the end of 2020, a diesel forklift was replaced with an electric forklift, the On-Road Diesel Fleet was reduced from five vehicles to four, a sweeper was upgraded to a newer propane model, and a current diesel bus was replaced with a Tier 4 model.

Reduced Welding Emissions

Emissions from welding have been reduced through installation of filters on selected ventilation systems, where feasible, as well as through implementation of material changes that reduce emissions.

Surface Coatings Emissions Reduction

All paints, solvents, and adhesives used are reviewed for VOC content, and whenever feasible, a non-VOC containing product will be used. All products must adhere to local and federal VOC regulations. Painting and blasting conducted inside of the facility is done within a paint and blast booth equipped with a capture and control system to remove particulate matter, and all blasting operations performed on-board vessels is conducted inside temporary enclosures that are constructed on the vessels. In addition, a plural component sprayer was purchased, substantially reducing the amount of paint and solvents used in painting processes.

Reduction of Greenhouse Gas Emissions

Changes have been made in recent years both in the facility and onboard the ships to reduce GHG emissions. Controlled lighting systems have been installed inside of the facility, and in 2020 temporary lighting for the ships was transitioned to more efficient LED lighting. Electric golf carts and bicycles are used for transportation around the facility.

Reduced Emissions from Employee Transportation

Continental Maritime San Diego promotes a carpool incentive program, in which all employees who carpool may enter a raffle daily for the opportunity to win a $100 monthly drawing. The company also utilizes SANDAG's ICommute program to offer employees discounts on Compass Cards.

Technology

Emission Reduction Technology Options

Future emission reduction opportunities within shipbuilding and the shipyards include those that reduce air pollutants and greenhouse gas emissions from transportation, such as the use of electric vehicles, reducing reliance on diesel engines, and increasing employee use of carpools, shuttles, and public transport. Further, ongoing compliance with CARB's on and off-road vehicle standards and airborne toxic control measures will result in decreasing emissions from diesel equipment and vehicles through replacement with clean (Tier 4) or zero emission technology.

The Shipyards and marine industrial uses are highly regulated by SDAPCD and CARB and the Port has limited authority to require adoption of emission reduction technologies; even so, Port staff will continue to stay engaged and support tenants utilization of emerging technologies and comply with SDAPCD's Community Emission Reduction Program (CERP) relevant actions in order to achieve emission reductions from this source.

Emission Reduction Strategies

Portside Environmental Justice CERP

In response to Assembly Bill 617, CARB established the Community Air Protection Program. The program's mission is to reduce pollution exposure in communities based on environmental, health and socioeconomic information. This first-of-its-kind statewide effort requires community air monitoring, community emission reduction plans, and incentive funding to deploy the cleanest technologies in the most impacted areas. The San Diego Portside Communities' Community Emission Reduction Plan (CERP) includes several strategies intended to reduce both air pollution emissions and community exposure to air pollution. The strategies, or actions, account for existing and forthcoming regulations, the operational requirements of the shipyard's facilities and equipment needs, as well as extensive public engagement with local residents and stakeholder agencies through the AB 617 Portside Community Steering Committee. The Port's shipyards have collectively identified the following action items within the CERP to further reduce emissions:

AB 617 Draft CERP Action G5: Reduce DPM and NOx Emissions from Portable Air Compressors and Other Diesel Sources at Shipyards

The shipyards have committed to requiring on site portable air compressors to be powered by either electric or diesel Tier 4 engines, in addition to continuing ongoing actions to reduce emissions from on and off-road diesel equipment, no later than May 1, 2021.

AB 617 Draft CERP Action G6: Promote Best Practices for Reducing Diesel, VOC, and other Emissions from Ship Repair Activities

The shipyards have committed to conduct trainings and events focused on best practices for ship repair contractors to reduce emissions.

AB 617 Draft CERP Action G7: Reduce Emissions from Shipyard Employee Transportation

The shipyards have committed to promoting and increasing participation in alternative transportation.

Conclusion

The shipyards contribute important economic benefits to the Port and the region. This is due to the high dollar values of wages and the direct and indirect economic benefits to the region, as well as the recession-resilient characteristics of the industry. Activities integral to shipyards such as use of mobile equipment, painting, welding, and abrasive blasting generate some air emissions that have the potential to affect public health. In most cases, these activities are subject to a complex framework of Federal, State, and local air pollution control regulations that have already resulted in significant reductions in shipyard emissions. Future rulemaking activities from APCD, CARB, and EPA will continue to drive the conversion to zero and near-zero emission equipment and result in additional reductions to criteria and toxic pollutant emissions. Compliance with these standards and applicable permit conditions continues to be routinely verified though unannounced inspections by APCD and other regulatory agencies, as well as through required reporting and monitoring activities. The Port has worked, and continues to coordinate, with the shipyard tenants, as well as air pollution control agencies to identify additional projects and strategies that can further reduce shipyard air emissions and improve the air quality for the neighboring residents, the Tidelands, and the region.

Ocean-Going Vessels

Ocean-going vessels (OGVs) are used to transport goods and people to and from domestic and international ports. OGVs visit the two cargo terminals and the cruise ship terminal. Tenth Avenue Marine Terminal (TAMT) handles vessels that carry refrigerated containers, break-bulk, and dry bulk cargos. National City Marine Terminal (NCMT) handles vessels with "Roll-on/Roll-off" (RoRo) cargo, primarily motor vehicles. Cruise Ship Terminal (CST) handles passenger (cruise) ships.

The Port has implemented two significant strategies to reduce OGV emissions: Vessel Speed Reduction (VSR) and shore power. The VSR program is a voluntary program that is also employed as required CEQA mitigation at TAMT) and NCMT, where 80% compliance with 12-knot speeds within 20 nautical miles (nm) of Point Loma is required (VSR Zone). Each terminal has specific throughput thresholds above which 90% compliance with 12 knot speeds within 40 nm of Point Loma would be the standard. If these thresholds are not reached by January 1, 2030, the standard will automatically increase to 90% compliance within 40 nm. Shore power is also used at the Port, with a connection available to passenger vessels at the B-Street and Broadway[1] berths at the CST, and a connection at the container terminal at TAMT. This section will discuss these programs in greater detail and how the Port can expand upon these existing strategies to optimize OGV emission-reductions.

Background and Context

Source Description

OGVs are defined as vessels that move cargo and people over the open ocean and have a Category 3 propulsion engine and two or more Category 2 auxiliary engines. Engine categories are defined by the U.S. Environmental Protection Agency (EPA) based upon displacement per cylinder as shown in OGV Table 1. CARB defines OGVs as longer than 400 feet and/or weighing greater than 10,000 Gross Registered Tons. OGVs vary greatly in speed and engine sizes based on ship type. Vessel types have been broken out by the cargo they carry. OGV OGV Table 2 describes the OGV types call at the Port, by terminal.

[1] Although the shore power connection is located at B Street, it is accessible at Broadway by moving the boom over to the other berth.

OGV Table 1. EPA Marine Compression Ignition Engine Categories

Category	Specification	Use
1	Gross Engine Power ≥ 37 kW Displacement < 7 liters per cylinder	Small harbor craft and recreational propulsion
2	Displacement ≥ 7 and < 30 liters per cylinder	OGV auxiliary engines, harbor craft, and smaller OGV propulsion
3	Displacement ≥ 30 liters per cylinder	OGV propulsion

OGV Table 2. Ship Types and Predominant Terminal*

Ship Type	Description	Terminal
Auto Carrier	Self-propelled dry-cargo vessel that carries containerized automobiles	NCMT primarily, TAMT rarely
Bulk Carrier	Self-propelled dry-cargo ship that carries loose cargo	TAMT
Container Ship	Self-propelled dry-cargo vessel that carries containerized cargo	TAMT
General Cargo	Self-propelled cargo vessel that carries a variety of dry cargo	TAMT
Passenger Ship	Self-propelled cruise ship	CST
RoRo	Self-propelled vessels that carry wheeled cargo, such as automobiles, and other cargo, such as containers.	NCMT

*The Port does not own any OGVs.

Emission sources from OGVs include propulsion engines, auxiliary engines, and auxiliary boilers. Propulsion engines are used to propel the ship and are usually either medium-speed diesel (MSD) or slow-speed diesel (SSD). Passenger ships usually have electrically powered propulsion (ED) and all engine power is used to generate electricity. Most passenger ships are MSD-Electric Drive (MSD-ED), but some are Gas Turbine-Electric Drive (GT-ED). Auxiliary engines on non-passenger ships are used to power the ship's electrical needs and are usually Category 2 MSD engines. Auxiliary boilers are used to heat residual oil in the fuel tanks (used outside the 200-nautical-mile North American Emission Control Area [ECA] boundary). Auxiliary boilers also supply heat for engines as well as heat and hot water for crew or passenger needs.

Existing Vessel Summary – 2019 Port OGV Inventory

In Spring 2020, Port staff conducted an OGV Inventory (Inventory) to update the prior iteration from 2016, identify more recent vessel call data, adjust for recent methodological changes recommended by CARB, and to determine the feasibility of upgrades to reduce emissions. The scope of the Inventory includes all OGV calls at the three marine terminals (CST, TAMT, and NCMT) in 2019. This is the fourth Maritime OGV Inventory conducted by the Port, past inventories were conducted in 2006, 2012 and 2016. Emissions were calculated based upon CARB's OGV methodology.[2]

OGV inventory emissions are summarized in Appendix A. Inventory data and emissions inform the analysis below.

Average engine power by ship type for the ships that called on the Port in 2019 are shown in OGV OGV Table 3. As shown, auto carriers are most ships that call on the Port, and passenger ships have the largest engines.

OGV Table 3. Average Engine Power by Ship Type (2019)

Ship Type	Engine Type	Calls	Average by Engine (kW)		
			Propulsion	Auxiliary	Boiler
Auto Carrier	SSD	243	14,161	1,089	316
Bulk Carrier	SSD	8	8,425	262	131
Container Ship*	SSD	52	19,420	811	308
General Cargo	MSD	7	6,843	502	130
	SSD	16	9,260	640	172
Passenger Ship	GT-ED	2	70,977		1,694
	MSD-ED	89	68,792		1,693
	MSD	6	18,513		410
RoRo	SSD	1	14,123	1,087	315
Overall	**-**	**424**	**24,388**	**2,565**	**600**

*Container ships include refrigerated containerized cargo vessels that call on TAMT.

[2] CARB, 2019. *Update to Inventory for Ocean-Going Vessels At Berth: Methodology and Results*. Available at: https://ww3.arb.ca.gov/msei/offroad/pubs/2019_ogv_inventory_writeup_ver_oct_18_2019.pdf.

Vessel activity can be broken out into distinct activity modes. Vessel transit includes movements both outside and within the VSR Zone, entirely outside of the harbor. Maneuvering includes activity within the harbor, between the mouth of the Bay to the berthing areas. Hoteling occurs when vessels are stopped at berth. Anchorage occurs when vessels are stopped outside of a berth, typically outside of the Bay, as the vessel waits for berth capacity. OGV Table 4 summarizes the portion of emissions by pollutant types by activity mode. As shown, most emissions are associated with vessel transit and hoteling. Thus, the focus of this chapter is on vessel transit and hoteling emissions. Emissions associated with maneuvering and anchorage comprise a portion of OGV emissions that are both small and difficult to reduce. Vessels already travel at slow speeds while maneuvering and anchorage occurs when the marine terminals have no berth capacity: both situations are unavoidable. Emissions from transit and hoteling, and the measures to reduce them, are discussed below.

OGV Table 4. Portion of Total OGV Emissions by Mode (2019)

Terminal	NOx	DPM	CO_2e
Transit	37%	33%	24%
Maneuvering	17%	17%	12%
Hoteling	41%	46%	57%
Anchorage	5%	6%	7%

History of Previous Efforts

In 2009, the Port established a voluntary VSR program that encouraged OGVs to lower their speeds within 20 nm from Point Loma and targeted an 80% compliance rate. The program was adopted by Board resolution and a strategy of both the Port's 2009 Clean Air Program and its 2013 Climate Action Plan (CAP). Subsequently, VSR Program has been required mitigation for some tenants through the CEQA process.

In 2010, the Port installed its first shore power plug at CST, which was the first passenger ship system in California, in operation four years prior to the regulation. In 2014, a shore power plug was also installed at TAMT to serve Dole's weekly refrigerated container service.

Legislative and Regulatory Framework

Emissions from OGVs are managed by regulations and emission limits implemented at the international, federal, state, and local levels. The International Maritime Organization (IMO) International Convention for the Prevention of Pollution from Ships (MARPOL) Annex VI, which came into force in May 2005, set new international NO_X emission limits on marine engines over 130 kilowatts installed on new vessels retroactive to the year 2000. In October 2008, IMO adopted amendments to international requirements under MARPOL Annex VI, which introduced NO_X emission standards for new engines and more stringent fuel quality requirements. Annex VI was ratified by the United States in 2008. The waters off North American coasts, which include the Port of San Diego, are considered ECAs, and ships operating in ECAs are required to comply with more stringent fuel sulfur and engine NO_X limits. Applicable requirements at the Port of San Diego include the following:

- Caps on the sulfur content of fuel as a measure to control SO_X emissions and, indirectly, particulate matter emissions. For ECAs, the sulfur limits were capped at 1.0% starting in 2012 and 0.1% starting in 2015.[3] This inventory assumes full compliance with MARPOL Annex VI sulfur limits.
- NO_X engine emission rate limits for new engines. Tier I rate limits, effective in 2000, and Tier II rate limits, effective in 2011, are global limits and apply to all new vessel builds, whereas Tier III limits, effective in 2016, apply only in NO_X ECAs.

To reduce emissions from Category 3 engines (propulsion engines on OGVs), EPA established 2003 Tier 1 NO_X standards for marine diesel engines above 30 liters per cylinder, and large Category 3 marine propulsion engines on U.S. flagged OGVs (40 Code of Federal Regulations [CFR] Parts 9 and 94) (68 *Federal Register* [FR] 9745–9789). The standards went into effect for new engines built in 2004 and later. Tier 1 limits were achieved by engine-based controls, without the need for exhaust gas after-treatment. These standards are similar to IMO MARPOL Annex VI rules which went into effect in 2000.

In December 2009, EPA adopted Tier 2 and Tier 3 emissions standards for newly built Category 3 engines installed on U.S. flagged vessels, as well as marine fuel sulfur limits. The Tier 2 and 3 engine standards and fuel limits are equivalent to the amendments to MARPOL Annex VI. Tier 2 NO_X standards for newly built engines apply beginning in 2011 and require the use of engine-based controls, such as engine timing, engine cooling, and advanced electronic controls. Tier 3 standards apply beginning in 2016 in ECAs and would be met with the use of high-efficiency emission control technology, such as selective catalytic reduction. According to the EPA's Regulatory Announcement, Tier 2 standards are anticipated to result in a 20% NO_X reduction below the Tier 1 levels, while Tier 3 standards are expected to achieve NO_X reductions 80% below the Tier 1 levels. In addition to the Tier 2 and Tier 3 NO_X standards, the final regulation established standards for hydrocarbons and CO (particulate matter is reduced from fuel sulfur requirements).

In addition, existing ships that were built between 1990 and 2000, with marine diesel engines greater than 5,000 kilowatts and a per-cylinder displacement 90 liters or more, are subject to retrofit requirements of the Tier 1 NO_X standard if a remanufactured system (or approved method) has been certified. Of the vessels that called at the Port during 2019, only vessels equipped with specific B&W S-series engine vessels fit in this category and have certified retrofit kits. There were eleven B&W S-series vessels that made up 13 calls during 2019, and the assumption is that each of these had been retrofit by 2019.

[3] The sulfur requirements in ECAs are 1.0% as of July 2010 and 0.1% starting in January 2015. North America was designated as an ECA in August 2012, and the sulfur requirements became applicable at the time of designation.

At the state level, CARB approved the *Regulation for Fuel Sulfur and Other Operational Requirements for Ocean-Going Vessels within California Waters and 24 Nautical Miles of the California Baseline* (13 California Code of Regulations [CCR] 2299.2) in 2008.[4] This regulation requires vessel propulsion engines, auxiliary engines, and auxiliary boilers operating in California waters since July 2009 to either use marine diesel oil with a maximum sulfur content of 0.5% or marine gas oil with a maximum sulfur content of 1.5%. By January 1, 2014, these source activities were required to meet a marine diesel or gas oil sulfur limit of 0.1%, which is now in effect. The analysis herein assumes all vessels comply with the 0.1% sulfur limit.

Additionally, CARB adopted a regulation to reduce emissions from diesel auxiliary engines on OGVs while at berth for container, passenger cruise, and refrigerated cargo vessels: *Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-Going Vessels At-Berth in a California Port* (17 CCR 93118.3). The regulation requires that auxiliary diesel engines on container, reefer and cruise OGVs be shut down for specified percentages of a fleet's visits and also that the fleet's at-berth auxiliary engine power generation be reduced by the same percentages. Applicable vessels can either plug into the electrical grid (i.e., shore power, otherwise known as cold-ironing or alternative maritime power) or use an alternative emission control device. The law sets compliance percentages that phase in over time. By 2014, applicable vessel operators were required to shut down their auxiliary engines at berth for 50% of the fleet's vessel visits and also reduce their onboard auxiliary engine power generation by 50%. The specified percentages increased to 70% in 2017 and 80% in 2020. Applicable vessel operators can also choose an emissions reduction equivalency alternative; the regulation requires a 10% reduction in container, reefer, and cruise OGV hoteling emissions starting in 2010, increasing in stringency to an 80% reduction by 2020.

In August 2020, CARB announced updates to the at-berth regulations that aim to expand public health and environmental benefits by providing additional reductions of particulate matter (PM) and oxides of nitrogen (NOx). The updates include an "Innovative Concepts" (IC) option, where entities are permitted to use other emission-reducing strategies for up to five years as opposed to strategies directly at berth. The regulation also specifies the vessel emissions control strategy connection time of two hours, expands reporting deadlines, and provides greater flexibility with the use of remediation funds. The updates also include an updated implementation schedule to accelerate program benefits. Container, reefer, and cruise vessels are covered by the existing regulation through 2022. The updated implementation schedule expands the regulation to include RoRo vessels by 2025, tanker vessels at the Ports of Los Angeles and Long Beach by 2025, and tanker vessels at ports in Northern California by 2027.[5] Shore power capabilities at the Port currently exist at both B Street Pier at the CST and at berths 10-3/10-4 at TAMT.

[4] This regulation has a sunset clause if/when the US EPA adopts equal or greater requirements.

[5] CARB. 2020. *Control Measure for Ocean-Going Vessels at Berth.* August 26. Available: https://ww2.arb.ca.gov/sites/default/files/2020-08/External%20At-Berth%20Fact%20Sheet%20August%202020%20ADA_0.pdf. Accessed January 2021. Additionally, it should be noted that tanker vessels do not call on Port of San Diego.

While not specific to OGVs, California's Renewables Portfolio Standard helps to further reduce emissions over time for vessels that plug in to shore power. The Renewables Portfolio Standard originally obligated investor-owned utilities, energy service providers, and Community Choice Aggregations to procure an additional 1% of retail sales per year from eligible renewable sources until 20% was reached by 2010. SB100 called the California Renewable Energy Resources Act, obligates all California electricity providers to obtain at least 33% of their energy from renewable resources by 2020. SB 350 requires electricity providers to obtain at least 50% of their energy from renewable resources by 2030 while requiring a doubling of efficiency for existing buildings by 2030. Finally, SB 100 establishes a new RPS target of 50 percent by 2026, increases the RPS target in 2030 from 50 percent to 60 percent, and establishes a goal of 100 percent zero-carbon energy sources by 2045. As of 2018, San Diego Gas and Electric's renewable procurement was at 43%, with 45.2% procured under contract for 2020. OGVs that cold iron while at berth receive additional emissions benefit over time; as the grid becomes increasingly renewable, GHG emissions per unit of electricity consumed from vessels that cold iron will decrease over time.

Research and Analysis

Description of Emission Reduction Technology Options

There are three primary options to reduce emissions from OGVs herein. The first is vessel speed reduction within a designated distance from Port. Generally, for every 10% reduction in OGV speed, emissions are reduced by 19%.[6] Second, shore power can significantly reduce emissions from ships at berth. Shore power refers to vessels plugging into the electrical grid instead of running auxiliary engines while at berth. Because renewable energy (solar, wind, hydro) powers a significant portion of California's electricity, the emissions from plugging in are significantly less than running diesel engines while at berth. Finally, capture and control systems can also reduce emissions while vessels are at berth. Capture and control systems attach to vessels' exhaust stacks to capture emissions and route them to an emissions control unit where they are filtered and treated. Each of these emission reduction options is discussed below in further detail.

Vessel Speed Reduction Program

As discussed above, and summarized in OGV Table 4, in-transit OGV emissions are responsible for measurable criteria pollutant and GHG emissions. A strategy for lowering these in-transit emissions is requiring vessels to reduce speeds when in proximity to the Port. When vessel speeds are reduced, less power is required for propulsion, which results in lower emissions. The Port's existing voluntary vessel speed reduction (VSR) Program targets emissions associated with vessels in transit to and from the Port. At present, starting at 20 nautical miles (nm) from Point Loma, cruise ships are encouraged to reduce speeds to 15 knots and cargo vessels are encouraged to reduce speeds to 12

[6] OGV speed optimization is also important, which is typically 10-30% below operating speed. If an OGV travels at a speed lower than within the optimization range, the OGV may increase emissions by loading injectors. Additionally, there would be an increase in transit time.

knots. Pursuant to a handful of CEQA mitigation measures, some tenants are required to adhere to the VSR program, identifying at least 80% compliance.

While the Port does not require all vessels to adhere to the VSR program, some operators are already choosing to reduce speeds while traveling in and out of the Port. OGV Table 5 summarizes achievement rates within 20 nm and 40 nm of Point Loma by year. Note that VSR compliance is currently evaluated based on a 15-knot speed for cruise ships and a 12-knot speed for all other vessels.

OGV Table 5. VSR Participation Rates

Year	Participation at 20nm	Participation at 40nm
2017	79%	53%
2018	72%	52%
2019	73%	46%
2020	76%	53%

Increasing passenger ship involvement in the VSR program, and further lowering their speed are strategies that would result in further emissions reductions. Passenger/cruise ships are currently only encouraged to reduce their speeds to 15 knots while traveling through the 20-nm VSR zone. Overall, higher compliance from all vessels, and increasing the distance to a 40-nm VSR zone would also result in greater emissions reductions than those currently being realized under the existing 20-nm VSR Program.

Shore Power

As discussed above and summarized in OGV Table 4, OGVs are a source of emissions while at-berth, as auxiliary engines often must remain running to support activities at Port. One strategy to reduce these at-berth emissions is plugging into the electrical grid, also known as "shore power".

The Port installed California's first shore power system for passenger ships at the B Street Cruise Terminal in 2010, four years ahead of CARB's At-berth regulation regulatory requirement. The B Street shore power system is pictured in OGV Figure 1. The shore power upgrades for the CST were funded in part by a $2.4M CARB Carl Moyer Grant.[7]

[7] US EPA. 2017. *Shore Power Technology Assessment at U.S. Ports.* March. Available: https://www.epa.gov/sites/production/files/2017-05/documents/420r17004-2017-update.pdf. Accessed January 2021.

In 2014, the Port installed shore power at TAMT to service refrigerated cargo vessels. The project cost approximately $4.25M and was funded by the Port's Capital Improvement Program.[8] In light of CARB's expanded shore power requirements, the Port is working with the NCMT Terminal Operator (Pasha) to plan a shore power system at the NCMT to accommodate auto carriers, as well as adding a second plug at CST.

OGV Figure 1. B Street Cruise Ship Terminal Shore Power System[9]

Capture and Control Systems

Emission control systems or "capture and control" systems are another strategy available to ports for reducing emissions from vessels at berth. Capture and control systems are exhaust gas scrubbing technologies combined with after-treatment technologies that allow for the capture of auxiliary engine emissions as they exit the vessel's stack (main engines are for propulsion and are off while at berth). An example capture-and-control system in use at the Port of Long Beach is pictured in OGV Figure 2.

With these control systems, a vessel can continue to burn compliant marine gas oil (MGO)[10] or marine diesel oil (MDO)[11] in its auxiliary engines and boilers while berthed. The exhaust from the operating auxiliary engines and boilers is treated to remove criteria pollutants before it is released into the atmosphere. The exhaust cleanup system captures the vessel's exhaust directly from the exhaust stack, using long, flexible ducting to transfer the exhaust back to the barge-based system to be scrubbed/cleaned. However, there is a slight increase in GHG emissions as the barge system runs an auxiliary engine to power the emission control equipment.

[8] Safety 4 Sea. 2014. *Port of San Diego celebrates shore power installation.* February 26. Available: https://safety4sea.com/port-of-san-diego-celebrates-shore-power-installation-2/. Accessed January 2021.
[9] Cochran Marine. 2021. *B Street Cruise Ship Terminal Shore Power System.* Available: https://www.cochranmarine.com/yacht_charters/san-diego/. Accessed January 2021.
[10] Marine gas oil are marine fuels that consist exclusively of distillates.
[11] Marine diesel oil are marine fuels that are composed of various blends of distillates and heavy fuel oil.

OGV Figure 2. Barge-Based Emissions Control System[12]

There are two commercialized barge-based capture-and-control systems currently in use at the Ports of Los Angeles and Long Beach, with other systems under development.[13] Of the two systems originally verified by CARB, one has been issued a “cease and desist” letter because they were not meeting the emission reductions claimed[14].

Emission Reductions and Costs

Three OGV emissions control options are available to the Port including: VSR Program expansion, shore power expansion, and introduction of capture and control systems. The emissions reduction potential and related costs of these strategies is described below.

Expanding VSR

In the absence of formal speed reduction regulations or mitigation measures, OGVs traveling in and out of Port are a significant source of criteria pollutant and GHG emissions. OGV Table 7 summarizes the total annual emissions from vessels traveling at the service speed[15] within 40 nm of Point Loma, using 2019 call data. As shown, under unregulated conditions, in-transit OGVs could emit up to approximately 570 tons of NOx, 11 tons of DPM, and over 24,000 MT CO_2e annually.

[12] Business Wire. 2015. *AEG Receives California Air Resource Board Approval for its Advanced Maritime Emission Control System (“AMECS) Technology.* October 22. Available: https://www.businesswire.com/news/home/20151022005432/en/AEG-Receives-California-Air-Resource-Board-Approval-for-its-Advanced-Maritime-Emission-Control-System-%E2%80%9CAMECS%E2%80%9D-Technology. Accessed January 2021.
[13] San Pedro Ports. 2017. *San Pedro Bay Ports Clean Air Action Plan 2017.* November. Available: https://cleanairactionplan.org/documents/final-2017-clean-air-action-plan-update.pdf/. Accessed January 2021.
[14] https://ww2.arb.ca.gov/berth-regulation-executive-orders
[15] Service speed refers to the average speed a vessel maintains under normal load and weather conditions.

OGV Table 7. Total Annual Emission at Service Speed within 40 nm of Point Loma (tons per year) (2019)

Vessel Type	NOx	DPM	CO_2e *
Auto Carrier	206.0	3.7	7,349
Bulk Carrier	5.0	0.1	188
Container Ship	56.1	1.2	2,194
General Cargo	13.4	0.3	528
Passenger Ship	287.9	5.9	13,841
RoRo	1.0	0.0	31
Total Emissions	*570*	*11*	*24,130*

*CO_2e emissions in metric tonnes.

At present, the VSR program at the Port is voluntary, except for operators bound by specific CEQA mitigation. The program encourages 80% compliance with VSR speeds within 20 nm of Point Loma. To achieve additional emission reductions from OGVs calling to the Port, the current VSR program could be expanded in the following three ways:

- Reducing the compliance *speed* to 12 knots for all OGVs;
- Expanding the *distance* of the VSR zone to 40 nm; and
- Increasing the compliance *rate* to 90%.

The emission reductions and other related benefits of these options are discussed below.

Reducing the Compliance Speed

Currently, passenger ships are encouraged to reduce speeds to 15 knots within the VSR zone, while all other vessels are encouraged to reduce speeds to 12 knots. Additional emission reductions can be achieved by encouraging passenger ships to reduce speeds to 12 knots instead of 15 knots. Emissions and fuel use associated with passenger ships traveling at both 12 and 15 knots is provided in OGV Table 8. Emissions estimates provided assume 90% of vessels will comply with VSR speeds within 40 nm of Point Loma. As shown, reducing the required VSR speed for passenger ships would reduce emissions and fuel from passenger ships between 7 and 8%.

OGV Table 8. Benefit of Reducing VSR Speed for Passenger Vessels (tons per year)

VSR Compliance Speed	NOx	DPM	CO2e[a]	Fuel[a]
15 knots	202	4.1	9,692	3,049
12 knots	185	3.8	8,889	2,796
Total Reduction	17	0.3	803	253
Percent Reduction	8%	7%	8%	8%

[a] CO_2e and fuel in metric tonnes

Expanding Distance of VSR Zone

Presently, VSR speeds are only encouraged (or required for some vessels through mitigation required by CEQA documents) within 20 nm of Point Loma. Expanding the current program to 40 nm from Point Loma as opposed to the previous 20 nm would mean vessels would be slowing their speeds for longer and would effectively double the emissions reductions achieved through the VSR program. OGV Figure 3 shows the current 20-nm and proposed 40-nm VSR zones. The emission reduction potential of expanding the VSR Zone is presented together with increased compliance rates below.

OGV Figure 3. Port of San Diego VSR Zones

Increasing the Compliance Rate

As noted, VSR speeds through the 20 nm VSR zone are currently encouraged or required for some vessels through CEQA mitigation. A third and final strategy to achieving greater emission reductions from OGVs traveling in and out of Port is to increase the achievement rate. To understand the benefit of updating the VSR program, emission reductions from 80% of vessels complying with the VSR program within the 20-nm zone are presented together with the reductions achieved from 90% of vessels complying with the VSR program within the 40-nm zone in OGV Table 9.

Emissions in OGV Table 9 are presented as total annual reductions achieved when vessels go from operating at the service speed within the VSR Zone to meeting the designated VSR compliance and speed through the VSR Zone. Note, these emission estimates also assume that 90% passenger ships would slow to 12 knots as opposed to the current request of 15 knots. As shown, with the proposed program updates, reductions of criteria pollutant and GHG emissions would increase significantly when compared to the current program parameters.

OGV Table 9. Total Annual Emission Reductions under Current and Proposed VSR Program Scenarios (tons per year) (2019)

Vessel Type	NOx	DPM	CO_2e [a]
80% Compliance within the 20-nm VSR Zone			
Auto Carrier	46.5	0.8	1,541
Bulk Carrier	0.6	0.0	22
Container Ship	12.6	0.3	458
General Cargo	2.0	0.0	77
Passenger Ship	38.3	0.8	1,844
RoRo	0.2	0.0	6
Total Reductions	100	2	3,948
90% Compliance within the 40-nm VSR Zone			
Auto Carrier	104.6	1.9	3,466
Bulk Carrier	1.4	0.0	49
Container Ship	28.5	0.6	1,031
General Cargo	4.5	0.1	173
Passenger Ship	103.1	2.1	4,952
RoRo	0.5	0.0	14
Total Reductions	*243*	*5*	*9,685*

[a] CO_2e emissions in metric tonnes.

The costs related to updating the VSR Program are expected to be relatively minimal for the Port since the VSR Program does not require additional equipment or other capital expenditures. The costs associated with updating and implementing the VSR Program would be for annual access to Geographic Information System (GIS) software, administrative efforts in the implementation of the Program, outreach, and consulting costs. These costs are expected to be covered by the Port's annual budget allocations. However, extending the overall travel time of an OGV may have cost implications to the terminal operators in terms of operations, scheduling and/or labor agreements. For example, if a vessel arrives later it may pose problems with scheduling longshoremen to offload the cargo. One way this could be addressed is by scheduling labor when the vessel enters the VSR Zone. In any event, it will be important to work closely with the vessel carriers and terminal operators if an updated VSR Program is pursued.

That said, the updated program could also benefit operators in the form of fuel savings with more vessels (80% to 90% compliance) lowering their speeds for longer distance (20 nm to 40 nm). The fuel savings related to the proposed program updates is presented in OGV Table 10 as total weight, and total cost savings on the purchase of fuel. Fuel cost was obtained from Ship and Bunker Average Bunker Prices and represents cost of fuel in November 2020, which assumes $386 per MT.[16] As fuel prices fluctuate and change over time, so too would the total cost benefit to vessel operators. Operators at the Port would save approximately 1,800 MT of fuel and $700,000 in fuel costs annually with the updates to the VSR program.

OGV Table 10. Annual Fuel Savings under Current and Proposed VSR Program Scenarios (2019)

Vessel Type	Total Fuel Savings (MT)	Total Cost Savings ($ USD)
80% Compliance within the 20-nm VSR Zone		
Auto Carrier	485	$187,059
Bulk Carrier	7	$2,647
Container Ship	144	$55,652
General Cargo	24	$9,331
Passenger Ship	580	$223,860

[16] Ship and Bunker. 2020. *Regional Average Bunker Prices*. Accessed November 17, 2020. Available: https://shipandbunker.com/prices/av/

Vessel Type	Total Fuel Savings (MT)	Total Cost Savings ($ USD)
RoRo	2	$768
Total Savings	***1,242***	***$479,317***
90% Compliance within the 40-nm VSR Zone		
Auto Carrier	1,090	$420,883
Bulk Carrier	324	$5,955
Container Ship	54	$125,216
General Cargo	1,558	$20,996
Passenger Ship	4	$601,234
RoRo	15	$1,728
Total Savings	***3,047***	***$1,176,013***

Shore Power

As discussed above and in OGV Table 6, the Port currently has shore power systems at CST and TAMT, which allowed for 40% of hoteling hours at CST and almost 90% of hoteling hours at TAMT to be powered by the grid as opposed to diesel engines in 2019. Expanding shore power capabilities would expand availability to plug in at other berthing locations, allow for multiple vessels to shore power simultaneously, and would result in greater emissions reductions given that electricity in California is becoming increasingly reliant on renewable energy sources. OGV Table 11 summarizes the annual emission reduction potential of shore power at the Port. The emission estimates presented use 2019 call and hotel duration data and **assume all vessels use shore power** (i.e., 100% of vessel calls are accommodated by shore power minus two hours for each vessel for plugging in and unplugging for each call) versus actual shore power use while at-berth.

OGV Table 11. Total Annual Emission Reductions with Shore Power (tons per year)

Vessel Type	Actual Shore Power (2019)			All Shore Power			Reduction		
	NOx	DPM	CO_2e [a]	NOx	DPM	CO_2e [a]	NOx	DPM	CO_2e [a]
Auto Carrier/RoRo	61.8	1.3	4,270	9.9	0.2	2,507	51.9	1.1	1,764
Bulk Carrier	2.8	0.1	257	0.3	0.0	165	2.4	0.1	92
Container Ship	3.1	0.0	1,551	3.1	0.0	1,551	0.0	0.0	0
General Cargo	12.3	0.3	866	0.9	0.0	465	11.4	0.3	401
Passenger Ship	78.8	1.5	6,526	25.4	0.4	4,872	53.5	1.1	1,654
Total Savings	***158.7***	***3.1***	***13,471***	***39.6***	***0.6***	***9,560***	***119.2***	***2.5***	***3,911***

[a] CO_2e emissions in metric tonnes.

As shown in OGV Table 11, updating terminal infrastructure so that all vessels are accommodated with shore power while at berth could reduce emissions of NOx by 119 tons, DPM by 3 tons, and CO_2e by 2,570 MT annually, which translates to a 75% reduction in NOx, 80% reduction in DPM, and 29% in CO_2e annually from vessel hoteling. **However, it is important to emphasize that in addition to installing the landside shore power system, the vessels also need to be retrofitted for shore power use. The General Cargo and Bulk Carriers that call to TAMT are largely spot calls and CARB does not have any pending or anticipated regulatory mantes that would require these vessel types to become shore power capable.** One option for reducing hoteling emissions with these two vessel types, is a capture and control system, which is discussed in the following section.

New shore power outlets would cost approximately $10M whereas new plugs to existing systems would cost at least $5M per outlet to install at CST, TAMT, and NCMT, with additional costs for planning, design, and engineering. NCMT may require up to four outlets to accommodate overlapping vessel activity and berthing preferences, while TAMT would not require any additional outlets in the next ten years in order to comply with the CARB At-Berth Regulation. However, the Port is targeting to install an additional plug at TAMT by 2031. The CST would also require a second outlet, which would cost approximately $5M to install to comply with the At-Berth Regulation. The total capital cost is approximately $50M to install these outlets (four at NCMT, one at CST, and one at TAMT) in order to increase shore power compliance.

Capture and Control Systems

A Capture and Control System or “bonnet” system is an alternative to shore power that works by placing a filtration system over a vessel’s stack while at berth to capture and treat emissions from its auxiliary engines. As such, it carries the benefit of not requiring a vessel to be retrofitted. A capture and control system can be located on a moveable barge or as a shore-side unit (mobile or stationary). The control element of the system is very similar to control technology in place for many. The capture and control system requires power, either from a stand-alone generator or the electric grid. While this technology is still being demonstrated and piloted, there is one system that has been certified by CARB as meeting the emission reduction standards specified in CARB's At-Berth Regulation. The Port was awarded grant funding for installation of a capture-and-control system to be utilized at TAMT and NCMT. To accommodate the annual vessel load at NCMT, two capture-and-control systems would need to be installed (if no shore power). OGV Table 12 summarizes the annual emission reduction potential of two capture-and-control systems at NCMT and one system at TAMT. The emission estimates presented use 2019 call and hotel duration data and assume all auto carriers and RoRos use the capture-and-control system while at berth versus actual 2019 at-berth activity.

Given that auto carriers and RoRos are similar vessels and all stop at NCMT, their emissions are combined here for ease of analysis. The capture-and-control system at TAMT is assumed to only affect bulk carrier and general cargo ships, as container ships use shore power. For purposes of analysis, it is assumed that capture and control systems will be powered by diesel generators. Use of another fuel (e.g., natural gas, renewable diesel) or electricity would result in emissions lower than assumed herein.

OGV Table 12. Potential Annual Emission Reductions with Capture-and-Control Systems at NCMT and TAMT (tons per year)

Vessel Type	Actual 2019 Emissions			Two Bonnets at NCMT/ One Bonnet at TAMT			Reductions		
	NOx	DPM	CO_2e [a]	NOx	DPM	CO_2e [a]	NOx	DPM	CO_2e
Auto Carrier/ RoRos	61.8	1.3	4,270	51.9	1.1	4,741	9.9	0.2	-471
Bulk Carrier	2.8	0.1	257	2.3	0.1	370	0.5	0.0	-113
Container Ship	3.1	<0.1	1,551	3.1	<0.1	1,551	-	-	-
General Cargo	12.3	0.3	866	10.1	0.2	1,043	2.2	0.0	-177
Passenger Ship	78.8	1.5	6,526	78.8	1.5	6,526	-	-	-
Totals [b]	*159*	*3*	*13,471*	*146*	*3*	*14,231*	*12*	*<0.2*	*-760*

[a] CO_2e emissions in metric tonnes. [b] Totals may not add up due to rounding.

As shown, two bonnet systems installed at NCMT would reduce NOx emissions by approximately 10 tons and DPM emissions by approximately 0.2 tons per year. As mentioned previously, because the barge system utilizes an auxiliary engine to power the control equipment, GHG emissions with the bonnet system would increase. With two bonnet systems accommodating all vessels that call on NCMT, CO_2e emissions would increase by approximately 471 MT annually. Land-based systems are likely to be less expensive, and cost between $2M and $3.6M per installation. Barge-based systems would cost approximately up to $7M, making this option $14M in total.

A single system at TAMT would reduce NOx and DPM emissions but would increase CO_2e 113 MT from bulk carriers and 177 MT from general cargo ships, annually. Emission reductions from as single system at TAMT would result in fewer emission reductions than two systems at NCMT, but reductions would still be substantial.

An alternative at-berth emissions control configuration that would accommodate all vessels at NCMT would be the installation of one shore power system and one capture-and-control system. The emissions benefits of this alternate configuration are provided in OGV Table 13. The emission estimates use 2019 call and hotel duration data and assume all auto carriers and RoRos use either the capture-and-control system or shore power while at berth versus actual 2019 at-berth activity.

OGV Table 13. Potential Annual Emission Reductions with Capture-and-Control and Shore Power System at NCMT (tons per year)

	Actual 2019 Emissions			One Bonnet + One Shore Power at NCMT			Reductions		
Vessel Type	NOx	DPM	CO_2e [a]	NOx	DPM	CO_2e [a]	NOx	DPM	CO_2e
Auto Carrier/ RoRos	61.8	1.3	4,270	30.9	0.6	4,019	30.9	0.6	251

[a] CO_2e emissions in metric tonnes.

[b] Totals may not add up due to rounding.

As shown in OGV Table 13, this alternative configuration would yield greater emissions reductions than the two-bonnet setup (OGV Table 12), with emissions of NOx, DPM, and CO_2e decreasing by 31 tons, 1 ton, and 251 MT annually, as compared to 2019 OGV at-berth emissions. However, it would result in fewer reductions than installing two shore power systems at NCMT (OGV Table 11), which estimates a 51.9 tons reduction in NOx, 1.1 ton reduction in DPM, and 1,764 ton reduction in CO2e. This configuration would cost approximately $17M in total, with the shore power installation at $10M, and bonnet system at $7M. Cost per ton would therefore range from approximately $17M per ton of DPM to approximately $68,000 per MT CO_2e.

Overall Feasibility

A summary of the cost and reduction potential of the available OGV emissions-reducing strategies is provided in OGV Table 14. These strategies include that which addresses in-transit emissions (VSR Program), and those that address emissions at berth (shore power, capture-and-control). A discussion of the feasibility of these strategies is provided in the Recommendation section below.

OGV Table 14. Summary of OGV Emissions-Reducing Strategies

Option	NOx	DPM	CO_2e[a]	Estimated Costs[b]
In-Transit Strategy				
Expand VSR Program	243	5	9,685	*minimal*
At-Berth Strategies				
Shore Power				
Shore power for all vessels	119	3	3,911	$50M
Shore Power at NCMT (4 plugs)	52	1	1,764	$40M
Additional Shore Power at CST	53	1	1,654	$5M
Additional Shore Power at TAMT	14	<1	493	$5M
Capture-and-Control Systems				
Two barge-based capture-and-control systems installed at NCMT and one at TAMT	12	<1	(760)	$14M
One barge-based capture-and-control and one shore power system installed at NCMT	31	1	251	$17M

[a] CO_2e emissions in metric tonnes.

[B] Approximate capital costs only. Does not include other costs, such as planning, design, and engineering and therefore these costs are based on predesign and are subject to change based on actual design.

Goals and Objectives

OGV In-Transit Goal 1 – Reduce OGV in-transit annual emissions by 243 tons for NOx, 5 tons for DPM and 9,685 metric tonnes for CO_2e.

OGV Objective 1A: Implement an expanded VSR Program that achieves upwards of 90% compliance.

Discussion

An expanded VSR Program would encourage 90% of vessels instead of 80% to comply within a 40-nm zone instead of a 20-nm zone. It would also assume that 90% passenger ships would slow to 12 knots as opposed to the current request of 15 knots.

As shown in OGV Table 14, expansion of the current VSR program yields the greatest emissions reductions and would have negligible operational costs to the Port. It may result in a net cost benefit given the fuel savings that result from reducing vessel speed, but there may be increased costs operational and/or labor costs associated with extending the vessels travel time. In addition to the high emission reduction potential and negligible costs to the Port, the VSR Program may be one of the more feasible of the strategies considered. The VSR Program only requires a reduction of vessel speed, which is technically feasible as no additional equipment needs to be installed on the vessel or at the Port to achieve the reduced speeds. In addition, the Port already has an AIS receiver in operation to obtain real-time vessel data. No additional evaluations of technological feasibility are required. Note that because vessel transit emissions occur outside of the Bay, emission reductions may not result in community health benefits as significant as other more localized strategies sited closer to the community. However, VSR would contribute reductions in emissions associated with regional air quality violations (i.e., NOx and ozone) and would reduce GHG emissions to assist both the Port, regional, and state agencies in meeting GHG emission reduction goals.

As noted above, one issue that arises with implementation of the VSR Program is longer transit times that will result from requesting vessels to slowdown in the VSR Zone. Under current procedures for making dock-side labor assignments based on the time a ship arrives at the dock, this would impact vessels that require land-based labor. One option to address this issue is working with labor groups to provide gang assignments based on the estimated time when the ship would enter in the VSR Zone region, rather than when the vessel docks at the Port. This would ensure that participating vessels retain the same access to labor as those that choose not to participate. The implementation of the expanded VSR Program would require a limited amount of effort from Port staff. The expanded VSR Program is not expected to compromise safety in any way.

OGV At-Berth Goal 2 – Reduce OGV At-Berth emissions by expanding existing and/or developing new shore power systems and/or equivalent technologies at the Port's marine terminals.

OGV Objective 2A: At CST, add additional plug to existing shore power system by 2023.

OGV Near Term Objective 2B: At NCMT, add new shore power system with at least two plugs by 2025.

OGV Mid Term Objective 2C: At TAMT, add additional plug to existing shore power system by 2031.

Discussion

Shore power for all vessels hoteling at the Port would also provide significant emissions reductions but would be the costliest option of those considered. In addition to infrastructure upgrades at the Port, individual vessels would also require retrofitting to participate in shore power at berth. Per CARB, average vessel retrofit costs are approximately $1.6M for each cruise ship, $880K for each container vessel, and $3.2M for each RoRo/auto carrier. The cost range for RoRo/auto carriers is quite large, though, and has been cited as low as $900K, and as high as $4.8M.[17] While OGV Near Term Objective 2 identifies installing shore power at NCMT by 2025, the Port anticipates commencing testing by 2024 in order to train vessel crews and land-based labor how to operate the technology and incorporate it into their operations.

An alternative to shore power is the capture-and-control system is not as costly as shore power installation, and unlike shore power, capture-and-control systems do not require vessel retrofit. However, reduction benefits are not as high as those achieved with shore power, and at present, the capture-and-control strategy has poor feasibility given the status of CARB-approved technologies and operational expenses. As discussed previously, given that capture and control systems may operate with small generator-type engines that run on a fossil fuel (e.g., diesel), the system results in a slight increase in GHG emissions, as opposed to shore power and VSR Program expansion which decrease GHG emissions. Additionally, in November 2020, CARB officially issued a cease-and-desist letter to Advanced Environmental Group (AEG), which is the manufacturer of the barge-based capture-and-control systems. CARB removed their verification letter on AEG's system after finding it was not meeting the emission reductions it claimed. With this letter, all operation of the AMECS as a control technology under the At-Berth Regulation was ordered to stop.[18] Given these issues, barge-based capture-and-control is not recommended as a long-term OGV emissions-reducing strategy for the Port, however it could be used as a bridge technology while the Port gathers enough funding to install shore power infrastructure and carriers retrofit their ships to plug in while at berth.

[17] CARB. 2019. *Control Measure for Ocean-Going Vessels At Berth Cost Analysis Inputs and Assumptions for Standardized Regulatory Impact Assessment.* May 10. Available: https://ww2.arb.ca.gov/sites/default/files/2020-04/costassumptions_may19_ADA.pdf. Accessed February 2021.

[18] CARB. 2020. *CARB AEG Cease and Desist Letter*. November 5. Available: https://ww2.arb.ca.gov/sites/default/files/2020-12/AEG-AMECS%20Immediate%20Cease%20and%20Desist%20Letter.pdf. Accessed January 2021.

Freight Rail

Background and Context

Source Description

Rail locomotives carry freight cargo between the Port's maritime cargo terminals and anywhere from regional destinations to farther locations in the western United States. Freight rail service at the Port is provided exclusively by Burlington Northern Santa Fe (BNSF) Railway which has direct access onto both Tenth Avenue Marine Terminal (TAMT) and National City Marine Terminal (NCMT) along the north-south BNSF right-of-way. The railroad also has switch yards adjacent to the terminals where rail cars can be decoupled to be added to other trains, which is located adjacent to the Portside Community. Auto cargo from NCMT often travels to Dallas, Memphis, Kansas City, St. Louis, and Chicago. Dry bulk and breakbulk cargos from TAMT often travel to Arizona, Nevada, and the California desert.

At NCMT, rail tracks used for auto train cars are on the terminal grounds. About 10% of the vehicles arrive at NCMT via rail (from the Midwest) and about one-third of the cars leave via rail. To accommodate this movement there is an 8-track switch yard on the terminal and many long stretches of track as well. Adjacent to the Port's NDC warehouse is another yard that serves Cal Portland cement and can also hold numerous cars. The tracks also serve Dixieline lumber yard at the east side of the terminal.

At TAMT, there are limited tracks on the terminal for loading and unloading; however, upgrades are planned to make the use of rail more efficient. Cargo that can be moved from TAMT by rail includes dry bulk and military ordnance. Adjacent to TAMT to the east is a large 20-track switch yard that is in constant use. It is not on Port property but sits between the terminal and Barrio Logan.

Brief Overview of Regulations

CARB recognizes three categories of locomotive, categories by horsepower (hp) and type of operation:

- Interstate line haul – (>4,000 hp);
- Medium horsepower – (2,301 to 3,999 hp); and
- Switch (yard) or switcher – (1,006 to 2,300 hp).

Emissions from locomotives are managed by regulations and emission limits implemented at the federal, state, and local levels.[1] At the federal level, the EPA has established a series of increasingly strict emission standards for new or remanufactured locomotive engines (63 FR 18997-19084). Tier 0 standards, effective as of 2000, applied to engines manufactured or remanufactured from 1973 to 2001. Tier 1 standards applied to engines manufactured/remanufactured from 2002 to 2004. Tier 2 standards applied to engines manufactured/remanufactured after 2004. In 2008, EPA strengthened the Tier 0 through 2 standards to apply to existing locomotives and introduced more stringent Tier 3 and 4 emission requirements (73 FR 88 25098-25352). Tier 3 standards, met by engine design methods,

[1] Freight rail is regulated at the federal level, commuter rail is regulated at the federal, state, and local level.

were phased in between 2011 and 2014. Tier 4 standards, which are expected to require exhaust gas after-treatment technologies, became effective starting in 2015.

At the state level, CARB has two agreements with Class 1 railroads that affect emissions from locomotives in Southern California. In 1998, CARB, Class I freight railroads operating in the South Coast Air Basin (Burlington Northern Santa Fe [BNSF] and Union Pacific Railroad [UPRR]), and EPA signed the 1998 Memorandum of Understanding (MOU), agreeing to a locomotive fleet average emissions program. The 1998 MOU required that, by 2010, the Class I freight railroad fleet of locomotives in the South Coast Air Basin achieve average emissions equivalent to the NOX emission standard established by EPA for Tier 2 locomotives (5.5 grams per brake horsepower-hour). BNSF and UPRR must continue to comply with the Tier 2 locomotive fleet average from 2010 to 2030. This MOU also provides emission reductions at the Port of San Diego because all freight trains either arrive from or depart to the South Coast Air Basin. BNSF's NOX emission level is 5.1 grams per brake horsepower-hour as of its most recent reporting.

In 2005, the same parties signed another MOU agreeing to several program elements intended to reduce the emission impacts of railyard operations on local communities. The 2005 MOU includes a locomotive idling-reduction program, early introduction of lower-sulfur diesel fuel in interstate locomotives, and a visible emission reduction and repair program. The 2005 agreement also required a number of efforts to gather information and assess advanced technologies to further reduce locomotive and railyard emissions in the future, including the preparation of emission inventories and health risk assessments at the 17 major railyards in the state (including San Diego Railyard), community and air district involvement, evaluation and development of measures to further reduce impacts on local communities, and ongoing efforts to evaluate and assess advanced control technologies.

In April 2017, CARB petitioned the EPA to update its standards to take effect for remanufactured locomotives in 2023 and for newly built locomotives in 2025. The new emission standards would provide critical further NOx and PM emissions from locomotives as well as provide the first emission standards for rail GHGs. To date, there has been no regulatory action at the federal level,[2]

In March 2018, CARB staff provided an informational update on potential concepts for minimizing community health impacts from large freight facilities including seaports, rail yards, warehouses, and distribution centers. The concepts for rail included: (1) evaluation and potential development of a regulation to reduce idling emissions from all rail yard sources and emissions from other stationary locomotive operations; and (2) evaluation and potential development of regulation to reduce emissions from locomotives not preempted under the Clean Air Act. Neither concept has formally been brought to CARB for consideration.[3]

History of Previous Efforts at the Port

In December 2016, the Board of Port Commissioners certified the TAMT Redevelopment Plan and Demolition and Initial Rail Component Environmental Impact Report (TAMT EIR). The project

[2] CARB. 2020. *Draft 2020 Mobile Source Strategy*. Available: https://ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy. November 24.
[3] CARB. 2019. *California Air Resources Board Staff: Update on Concepts to Minimize the Community Health Impacts from Large Freight Facilities*. Available: https://ww2.arb.ca.gov/sites/default/files/2020-07/Revised%20Advance%20Materials%20-%2010-10-2019%20ADA%20Final.pdf.

description includes “on-terminal rail upgrades that include a rail lubricator and compressed air system for air brake testing”. One of the objectives for the proposed project is to establish “an expanded on-dock rail facility to broaden certain cargo customer access to rail in the long term”. The existing Tier 0 locomotive switcher that moves cargo between the marine terminals and the BNSF yard was not assumed to be replaced over the life of the plan (through 2035). However, the proposed rail upgrades would allow for BNSF line-haul locomotives, which are much cleaner than the existing switcher, to bypass the yard and access the existing on-dock rail facility at the southeastern portion of the project site and the proposed expanded on-dock rail. Shifting work from the switcher to the line-haul locomotive and removing the stop at the yard would help to reduce emissions beyond what was contemplated in the EIR.

Technology and Strategies

Switcher

Tier 4 Single Engine Switcher

Switcher locomotives are often Tier 0 and pre-Tier 0 units that have been retired from a line-haul operation or diesel-electric switcher units. The vast majority (75%) of switchers statewide are Tier 0.[4] Railyard emissions can be reduced by replacing these high emission locomotives with Tier 4 switcher locomotives that rely on clean engines and exhaust after-treatment to meet the most stringent EPA standards.[5] Single engine Tier 4 switchers have been adopted in other ports across California. For instance, in 2018 the Sacramento Metropolitan Air Quality Management District and the Bay Area Air Quality Management District acquired grants totaling $15 million to facilitate repurposing 10 diesel-electric switchers into Tier-4 single engine switchers in conjunction with Union Pacific. Funding for this initiative was made possible through California’s Proposition 1B: Goods Movement Emission Reduction Program, a partnership between CARB and local air districts. Reporting suggests that the Tier 4 switchers reduced PM and NOx emissions by more than 90 percent. Tier 4 single engine technology tends to be more reliable and easier to repair than genset models.[6]

Gen-Set Switcher

A gen-set switcher locomotive is powered by one or more nonroad (off-road) engines (typically three) of less than 1,006 horsepower (750 kilowatt), instead of one large diesel fuel-powered locomotive engine. EPA regulates nonroad engine emissions use a tier structure more stringent than locomotive engine standards. Gen-set switchers are presently built up to 2,100 horsepower utilizing three nonroad 700 horsepower engines. Nearly every action that a conventional (diesel only) switcher makes (including idling and low-load movements) requires for the main engine to be powered up resulting in large inefficiencies while going through daily operations. In comparison, a gen-set switcher can use as many or as few engines as the action requires, resulting in higher efficiencies. As a result, gen-set switchers can reduce diesel fuel consumption, as compared to older switch locomotives, by 20 to 40

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[4] CARB. 2020. *2020 Locomotive Emissions Inventory*. Available: https://ww2.arb.ca.gov/sites/default/files/2020-09/CARBlocoinvwebinar2020.pdf. September 3.
[5] CARB. 2016. *Technology Assessment: Freight Locomotives*. Available: https://ww2.arb.ca.gov/resources/documents/technology-assessment-freight-locomotives. November.
[6] Union Pacific. 2018. *New California Locomotives Designed to Reduce Emissions*. Available: https://www.up.com/aboutup/community/inside_track/repowered-switchers-11-16-2018.htm.

percent. Recently, various ports have chosen gen-set switchers over hybrid-electric models due to the greater gen-set operational capabilities and flexibility. However, many ports have found that as the number of engines has increased so has the maintenance issues encountered by the switchers lowering their popularity.[7]

As noted in the paragraph above there is a tier structure in which nonroad engines are classified according to their emission levels. As you go up in tier the cleaner the engine performs with tier 4 being the highest level that can be obtained. EPA's 2005 ruling on nonroad engines introduced tier 4 nonroad engine standards that phased into effect between 2011 and 2015. Manufacturers met Tier 4 standards by introducing exhaust treatment controls such as DPF and SCR. While new nonroad engines must meet Tier 4 PM standards, the Tier 4 NOx requirements were implemented in phases from 2011 to 2014. By 2015, new-model gen-sets were mandated to be fully compliant with Tier 4 nonroad engine standards. Through this process, new gen-set switchers are Tier 4 and bring all the associated efficiencies.

Battery Electric Hybrid Switch Locomotive

A typical locomotive is referred to as diesel-electric: a diesel engine drives an electrical generator or alternator; the generator provides electricity to the traction motors, which in turn drive the locomotive wheels.

While battery-electric hybrid switchers use a design that incorporates small diesel-powered generators combined with large banks of recyclable, long-life batteries. This design allows for the hybrids to run at a higher efficiency.[8] The energy stored in the batteries (lead acid in original and most recent models) of the hybrids can be used to produce the equivalent of 1,000 to 2,000 tractive horsepower for switch locomotive operations, primarily within a railyard. Additionally, hybrid locomotives can cut NOx and diesel particulate matter (DPM) by 80-90%, while achieving fuel savings in the order of 50-80%, when compared to conventional yard locomotives in the 1,000-2,000-horsepower range.[9] However, several factors have caused some ports and yards to turn away from battery-electric hybrid switchers. For instance, battery-electric switchers are limited to light-duty applications due to the relatively quick drawdown of battery stored power under heavier workloads, and the time needed to recharge the lead-acid batteries. Additionally, a number of the battery-electric hybrid switchers caught fire when in operation due to their batteries. Finally, this form of switcher is not currently being produced by any manufacturers and therefore should not be considered as a replacement option at this time.

Full Battery Electric

Full battery electric freight line haul locomotives operate in other parts of the world (e.g., Europe, China, and Russia) and can cost up to two times more than current U.S. diesel-electric freight locomotives. These locomotives are typically built for greater speeds, to reduce slowdowns for high-speed

[7] CARB. 2009. *Technical Options to Achieve Additional Emissions and Risk Reductions from California Locomotives and Railyards*. Available: https://www.ci.benicia.ca.us/vertical/sites/%7BF991A639-AAED-4E1A-9735-86EA195E2C8D%7D/uploads/CARB_2009.pdf

[8] *Development of a hybrid switcher locomotive the Railpower Green Goat*. Available: https://ieeexplore.ieee.org/document/1634954

[9] *RailPower announces 'Green Goat Plus' development*. Available: https://www.ble-t.org/pr/news/headline.asp?id=7736

passenger trains that share the same rail electrification system (CARB 2016). No all-electric freight line haul locomotives are active in the US.

However, CARB notes that with the all-battery power system, there may be potential to utilize all electric technologies for switching operations. In 2018, the San Pedro Bay Ports partnered with VeRail Technologies, Inc. to build and demonstrate a zero-emission switcher locomotive. The project started as a low emission CNG switcher, but after receiving $3 million in grants, the project transitioned to the construction and demonstration of a full battery-electric model. This 2,100 horsepower six-axle switcher locomotive was being designed to operate throughout the on-terminal rail network that services the Ports of Los Angeles and Long Beach, and was anticipated to be capable of working a full 12-hour shift before needing to charge.[10] However, recent conversations with CARB revealed that the project was canceled on request of the Port, citing logistical issues. After the Port of Los Angeles requested cancellation of the project, CARB redirected the project funds (through legislation) to CARB's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP). CARB noted that it is possible for similar projects to move forward as there is continued interest in demonstrating a zero-emission switcher locomotive in California.

In July of 2020, Progress Rail, a Caterpillar company, announced they are in the process of developing a lithium ion battery, zero-emission, zero-idle and low noise switcher with Brazilian mining company Vale. The switcher includes battery capacity of 1.9 megawatt hours and could reach up to 2.4 megawatt hours with additional options. The switcher has nominal power up to 3,000 horsepower (2,230 kilowatt), and a run time of up to 24 hours, depending upon charging and utilization. The new switcher will go into a pilot phase late 2020, with full service anticipated for Vale thereafter. Progress Rail anticipates global availability of the new switcher locomotive in 2021.[11]

Hydrogen Fuel Switcher

Test Runs were completed in 2008 and 2009 by BNSF in Los Angeles. In 2009 an operational unit was then shown at another BNSF facility in 2009 and then sent to Colorado for further testing in 2010. Following this, no updates were posted. It does not appear that any additional research interest has been garnered by hydrogen switchers in the year following these initial test phases.[12,13]

100% Natural Gas Switcher

The railroad companies are also interested in natural gas as a locomotive fuel because of its potentially favorable economics as compared with diesel fuel. The benefit natural gas is DPM emissions are completely eliminated relative to diesel. However, from an operational standpoint, the most significant difference between natural gas (both liquified and compressed) and diesel is energy density (the amount of energy produced per unit volume of fuel). According to the 2016 CARB freight study,

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[10] CARB. N.d. *Zero-Emission Track-Miles Locomotive Project*. Available: https://ww3.arb.ca.gov/msprog/lct/pdfs/zelocomotive.pdf
[11] Progress Rail. 2020. *Progress Rail Signs Contract with PT KAI for GT Series Locomotives*. Available: https://www.progressrail.com/en/Company/newsandevents/corporatepressreleases/ProgressRailSignsContractwithPTKAIforGTSeriesLocomotives1.html
[12] BNSF Railway and Vehicle Projects Demonstrate Experimental Hydrogen-Fuel-Cell Switch Locomotive. Available: http://www.3plnews.com/rail-freight/bnsf-railway-and-vehicle-projects-demonstrate-experimental-hydrogen-fuel-cell-switch-locomotive.html
[13] Fuel cell-Hybrid Shunt Locomotive. Available: http://www.fuelcellpropulsion.org/projects.html

compressed natural gas (CNG) has approximately 25 percent of the energy density of diesel fuel and liquified natural gas (LNG) has about approximately 60 percent of the energy density of diesel fuel. Because of this difference in energy density, more fuel is required to move the same ton-mile of cargo. Given the fact that its energy density is higher than that of CNG, LNG will likely be the form of natural gas used by interstate line haul locomotives.

CARB discusses a few 100% natural gas locomotive projects and applications. The Napa Valley Wine Train used Carl Moyer Program funding to retrofit a diesel locomotive. This has been running on 100% CNG since May 2003. Most of the CNG usage, particularly for freight applications, have favored dual-fuel applications, as discussed below. At this time, there is no commercially available natural gas freight interstate line haul locomotive.[14]

Dual engine (Natural Gas/Diesel)

A dual fuel engine is characterized as one that operates on a variably adjusted ratio of diesel and natural gas supplied to a compression ignition engine. The diesel fuel is mixed with the vaporized natural gas in the engine combustion chamber to provide full rated horsepower of the engine while allowing up to 80% natural gas substitution at various loads, thus gaining the dual benefits of reducing exhaust emissions and allowing the use of a lower cost fuel. Typical usage ratios run 70%/30% natural gas to diesel, with the ratio of natural gas increasing with the throttle notch.

Converting a diesel locomotive to a dual-fuel model involves either installing a conversion kit on an existing locomotive engine or utilizing a commercially available dual fuel engine. In each case, the technologies work with either LNG or CNG.

In 2016, Indiana Harbor Beltway (IHB) released a request to convert up to 21 EMD SW1500 switcher locomotives to dual-fuel technologies. IHB's goal was to convert 70 percent of IHB's fleet to CNG as the primary fuel source by the end of 2020. The locomotives feature a 1,500-hp twin-engine configuration using two 750-hp engines. These engines support single-engine or multiple-engine locomotive configurations and different modular onboard CNG storage sizes. The first two engines were sent in 2017 and are currently in use.[15] Each CNG conversion was expected to cost approximately $1.7 million.

Emission Reductions and Costs

A summary of emissions for each technology is presented in RL Table 1. A summary of technology capital cost and cost per emissions saved is presented in RL Table 2. Note that the analysis below does not include hydrogen or 100% natural gas switcher options because those are not viable at this time, as explained in the preceding section.

As shown, NOx, PM, and DPM emissions decrease with use of Tier 4 diesel. GHGs do not change because there are no fuel consumption benefits associated with Tier 4 relative to the existing switcher. For full battery electric, all emission at the tailpipe are eliminated, and GHGs associated with upstream

[14] CARB Technology Assessment: Freight Locomotives. https://ww2.arb.ca.gov/sites/default/files/2020-06/final_rail_tech_assessment_11282016%20-%20ADA%2020200117.pdf

[15] IHB Going CNG: https://www.cmap.illinois.gov/documents/10180/614534/05.01.17_IHB+going+CNG_RAILWAYAGE.pdf/bc4d87af-23e4-4ed4-91c7-925ec801fb3e

electricity consumption are significantly reduced related to the diesel option. The dual engine (CNG/diesel) reduces NOx, DPM, and GHGs, but PM10 and PM2.5 increase substantially since natural gas PM is not DPM by definition. Natural gas has a lower carbon content, but the calculations herein do not account for the potential decrease in fuel efficiency relative to diesel.

RL Table 1. Summary of Emissions for Each Technology Option

Equipment Type	Pounds Per Year			Emission Reductions Per Year		
	NOx	DPM	CO_2e	NOx	DPM	CO_2e
Pre-Tier 0 Diesel (Current Piece)	82.6	1.2	5,281	-	-	-
Tier 4 Diesel	9.9	0.1	5,281	72.7	1.2	-
Full Battery Electric	-	-	817	82.6	1.2	4,464
Dual Engine (CNG/Diesel)	7.8	0.04	4,602	74.8	1.2	679

RL Table 2. Summary of Cost

Equipment Type	Technology Cost	Cost per Pounds of Emissions Saved		
		NOx	DPM	CO_2e
Pre-Tier 0 Diesel (Current Piece)		-	-	-
Tier 4 Diesel	$2 million	$27,500	$1,690,000	-
Full Battery Electric	$3.8 million	$46,000	$3,050,000	$851
Dual Engine (CNG/Diesel)	$1.7 million	$22,700	$1,400,000	$2,500

Tier 4 Single Engine

Cost

As mentioned in the technology description above, the Sacramento Metropolitan Air Quality Management District and the Bay Area Air Quality Management District acquired grants totaling $15 million, which were used to aid in repurposing/repowering 10 diesel-electric switchers into tier-4 single-engine switchers in conjunction with the rail company Union Pacific. This was stated to have covered approximately 75% of costs. This is in line with a briefing put out by the Utah Department of Environmental Quality, which reported a $1.5 million unit cost plus an additional $400,000 - $500,000 in installation expenses. Thus, cost to repower a switcher to Tier 4 is approximately $2 million per switcher.

Emissions reductions

Based on the EPA Port Strategy Assessment, Tier 4 results in a 95% reduction in PM emissions and 88% reduction in NOx relative to the current switcher. There is no change in GHGs with engine tiers. Emissions associated with a Tier 4 diesel switcher are summarized in RL Table 1, above. Cost per pound of emission saved is higher than both the other replacement options. Note that the emissions estimate for the Tier 4 switcher assumes the same activity is the current switcher.

Full Battery Electric

Cost

The cost of the switchers under development by Progress Rail has yet to be released, but the proposed costs of the full battery electric switcher pilot locomotive that was slated to be constructed at the San Pedro Bay Ports was $3,833,150. Most (70%) of this funding was set to be financed by a CARB grant, with the remainder of the cost being split between the City of Los Angeles Harbor Department, Pacific Harbor Line Inc., SCAQMD, and VeRail Technologies.[16] In the 2016 technology assessment, CARB stated since an all-battery powered switch locomotive would reduce diesel fuel consumption to zero, at about 33,000 gallons annually and $3 per gallon, the annual diesel fuel cost savings could be up to $100,000. However, this project only reached the initial phases of research before being called off by the port who cited logistical issues. Fuel savings at Port of San Diego would likely be not significant given the switcher activity is fairly limited at this point.

Emissions reductions

The battery-electric switcher was slated to have zero tailpipe emissions. However, there are upstream (electrical grid) emissions associated with charging the battery from the grid. Emissions associated with upstream (grid-related GHG emissions) are summarized in RL Table 1. Cost per pound of emission saved ($851 per pound of GHG, zero for other pollutants) is much lower for the battery-electric switcher than other technologies given the fact that there are no tailpipe emissions. Note that the emissions estimate for the battery-electric switcher assumes the same activity is the current switcher.

Dual engine (Compressed Natural Gas/Diesel)

Cost

The exact cost of the dual engine systems was not given by the Indiana Harbor Belt Railroad Co. in its discussed plans to convert 31 of their 46 diesel-powered locomotives to CNG/diesel. However, it did state that it had obtained a $34.25 million grant from the Chicago Metropolitan Agency for Planning in late 2013 to cover 65% of the conversion's costs. This would mean that the full cost to convert the 31 switchers was approximately $52 million in total, resulting in an approximate cost of $1.7 million to convert one switcher to a dual engine unit.

Emissions reductions

As noted above, Tier 4 diesel engines decrease NOx and PM 88% and 95%, respectively, relative to a pre-tier 0 engine. CNG combustion results in much higher PM than a Tier 4 diesel engine but note that none of this PM is in the form of DPM. CO_2 from CNG is assumed to be about 24% lower than diesel, while NOx is assumed to be the same. Emissions associated with a dual fuel switcher are summarized in RL Table 1. Cost per pound of emission saved is similar to Tier 4 diesel for NOx but actually in the negative for PM10 and PM2.5 because PM10 and PM2.5 emissions are much higher than the current switcher. However, none of this PM is in the form of DPM, and cost per DPM pound saved is better than the Tier 4 diesel. Note that the emissions estimate for the Tier 4 switcher assumes the same activity is the current switcher assuming 70% of fuel consumption is from CNG and 30% is from diesel.

[16] SCAQMD. 2018. *Develop and Demonstrate Zero Emissions Battery-Operated Switcher Locomotive*. Available: http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2018/2018-oct5-005.pdf?sfvrsn=2

Overall Feasibility

Emissions associated with the existing pre-controlled switcher that operates between the BNSF yard and TAMT are low in comparison to other sources. However, the switcher does operate near residential uses. The simplest replacement would be a Tier 4 diesel upgrade. From a cost per ton perspective, the full battery electric option would provide the cheapest method to reduce GHG emissions from the Port's current switching operations but is likely to have the highest initial cost. Also note this cost does not take into account the cost to install electrical infrastructure.

On the cost side, there are funding opportunities available through CARB, CEC, EPA, and other agencies. However, due to the complexity of replacements and the low usage of the switcher, Port staff would not recommend prioritizing the immediate replacement of switchers to reduce criteria pollutant, DPM, and GHG emissions due to the high associated costs and relatively low contribution to maritime related emissions. If the switcher is used more in the future, the emissions benefit and cost per emissions saved would increase along with activity.

Goals and Objectives

RL Goal 1 – Implement Rail Upgrades identified in TAMT EIR.

RL Objective: Complete TAMT rail upgrades including a rail lubricator and compressed air system for air brake testing.

Discussion

The rail upgrades identified in the TAMT EIR would allow for BNSF line-haul locomotives, which are much cleaner than the existing Tier 0 switcher, to bypass the yard and access the existing on-dock rail facility at the southeastern portion of the project site and the proposed expanded on-dock rail. Shifting work from the switcher to the line-haul locomotive and removing the stop at the yard would help to reduce emissions beyond what was contemplated in the EIR since the Tier 0 switcher could be bypassed.

RL Goal 2 – Promote the use of Single Engine Tier 4 Switcher if applicable to operations at TAMT and NCMT

RL Objective: Tenants that rely on rail operations to move cargo shall be encouraged to use cleaner switchers.

Discussion

Local switcher locomotives are often Tier 0 and pre-Tier 0 units. Port related rail emissions can be reduced by replacing these high emission locomotives with a Tier 4 single fuel switcher locomotives. Single engine Tier 4 switchers rely on clean engines and exhaust after-treatment to meet the most stringent EPA standards and have been adopted in other ports across California. Reporting suggests that the Tier 4 switchers reduced PM and NOx emissions by more than 90 percent. Tier 4 single engine technology tends to be more reliable and easier to repair than genset models. Upgrading switcher technology at NCMT and TAMT (prior to completion of rail upgrades) would reduce Port related rail emissions.

Funding Opportunities and Financing

Advancing the projects, programs, and initiatives identified in the MCAS will require significant financial resources. The MCAS establishes a broad framework to assist with determining how public and private sector funding opportunities can be leveraged over time with the Port's resources, to maximize emission reductions in a complementary and cost-effective manner.

While some emission reduction strategies are relatively simple and straightforward (e.g., purchase of an electric forklift), other strategies will require coordination with multiple entities and involve detailed planning and design, subsequent environmental review and approval, issuance of discretionary permits, and construction (e.g., installation of shore power). Successful implementation of several strategies will, therefore, require dedicated funding over several years.

It is important to acknowledge that external funding will be essential for investments in zero-emissions and hybrid technologies, equipment, fuels, and infrastructure, as well as for planning and workforce development. Strategies that are dependent on external funding and/or forthcoming technological advancements may proceed incrementally as funding and resources (e.g., internal account balances, grants, and loans) become available and/or the cost of deploying new zero-emissions or hybrid equipment approaches parity with diesel-fueled equipment.

Background and Context

In recent years, the Port and its tenants have implemented emission reduction projects and thereby improved air quality within and around Port tidelands. For example, in 2010 the Port installed California's first shore power system for passenger ships, four years ahead of when CARB's At-berth Regulation went into effect and installed another shore power system at the Tenth Avenue Marine Terminal in 2014 to service refrigerated cargo vessels. In 2017, the Port Tenant's Association (PTA) received a $5.9 million grant from the California Energy Commission (CEC) to demonstrate ten battery-electric yard tractors, drayage trucks and forklifts. More recently, the Board of Port Commissioners (Board) allocated $461,000 from the Port's Maritime Impact Industrial Fund (MIIF) in January 2020 to purchase and install an enhanced air filtration system at Perkins Elements in Barrio Logan. These projects were funded by a variety of different programs, which includes both internal and external funding sources.

While these projects have helped improve air quality, they have been identified and implemented on a project by project basis. The MCAS provides the Port, its tenants, and other community stakeholders with an opportunity to evaluate a range of emission reduction projects in a comprehensive and holistic manner, so that funding and resources may be allocated to reach the near-term and longer-term goals and objectives identified in the MCAS.

The purpose of this chapter is to: (1) summarize the Port's budgetary process for developing and implementing projects; (2) review existing internal and external sources of funding that have been used to implement emission reduction projects in the past; and (3) identify recommendations to involve tenants and others in the selection of emission reduction projects, as well as recommendations to help fund and/or incentivize emission reductions within and around Port Tidelands.

Port of San Diego Annual Budget Process

The Port is self-funded, relying primarily on revenues from maritime operations and lease agreements to fund priority projects and initiatives. The Port reinvests the revenues into the Tidelands and into public services such as public safety, as well as public amenities, including roads, sidewalks, parks, promenades, public piers, and public art. The Port also participates in public-public and public-private partnerships to bring funding and potential reinvestment to Tidelands for the benefit of present and future generations.

The Port prepares a budget every fiscal year (July 1st through June 30th) to fund personnel and non-personnel expenses. The budget document establishes a one-year financial plan to fulfill the Port's statutory mission, support the Port's role as trustee of State Tidelands, and achieve its strategic goals. The budget is also a disclosure document providing transparency on Port operations. According to Section 4 of the Port Act, the Port is responsible for the development, operation, maintenance, control, regulation, and management of Tidelands and for the promotion of commerce, the environment, fisheries, navigation, and recreation. Without financial sustainability, the Port would not be able to accomplish these mandates.

As mentioned earlier, revenues generated on Tidelands are reinvested to support public services and amenities. Some of these revenues may be used to fund air quality improvement projects and other environmental initiatives. The Port has a variety of funding mechanisms, each of which has specific requirements and is ultimately subject to Board discretion.

Sources of Funding

Internal Funding

In conjunction with the budget process outlined above, the Port has several tools to reinvest its revenues into public benefit projects, which includes investments that result in improved air quality. However, plans, studies, and other entitlement work oftentimes is needed in advance of executing a project. This section provides a high-level overview of the project development process, and highlights some of the key funding mechanisms the Port has used to fund air quality-related projects and studies.

Funds for project planning, business case development, engineering, and permitting to develop shovel-ready projects requires complete plans for locations of utilities or charging infrastructure, complete environmental review, a robust business case analysis, and partnerships with the organizations that will purchase, test and operate equipment purchased with the grant funds. Developing these plans and partnerships requires funding prior to purchasing, installing, and/or constructing the project. In many instances, the planning, design, and environmental review requires significant funding of its own, and may take a year or more to complete. Often times it is necessary to pay for the planning, design, environmental analysis, and/or permitting one or two years in advance of a grant solicitation, so the project can be "shovel ready" and the Port's grant application can be competitive[1]. Some of the current programs that the Port has at its disposal to fund clean air initiatives are summarized below.

[1] While most grant programs are for project deployment and/or infrastructure upgrades, there are some programs that provide money for planning and entitlements. For example, in November 2020, SANDAG partnered with the Port of San Diego, the Metropolitan Transit System (MTS), North County Transit District (NCTD) and the County of San Diego to apply for a $200,000 Medium / Heavy Duty ZEV Infrastructure Blueprint Planning Grant.

Environmental Funds (BPC Policy No. 730)

The Board created the Environmental Advisory Committee (EAC) and the Environmental Fund to provide the funding and decision-making guidance necessary to select and execute projects aimed at improving the bay and surrounding tidelands. A key component of the EAC and the Environmental Fund is to support a variety of projects that ensure the protection and improvement of the environmental conditions of the Bay and surrounding tidelands and supports the Port's goal of "A Port with a healthy and sustainable Bay and its environment." Environmental Fund projects address air, water and sediment quality, sustainability and climate action planning, natural resources and endangered species management, habitat creation, restoration or protection, reclaiming natural shoreline conditions, environmental education, research and monitoring, and/or other issues in the Bay and/or tidelands. In accordance with BPC Policy No. 730, one-half of one percent (1/2 of 1%) of the Port's projected gross revenues is set aside as part of the Environmental Fund.

In recent years, the Environmental Fund has helped provide funding for a variety of clean air initiatives including electric vehicle charging stations in public parks, the Port's participation in the Green Marine Program, as well as partial funding for the MCAS.

Maritime Industrial Impact Fund (BPC No. 773)

In July 2010, the Board established a Marine Industrial Impact Fund (MIIF) to invest in projects that will help offset the negative maritime industrial impacts on neighboring communities. The Board established an initial set-aside of $500k with additional funds to be set aside annually starting in FY 2011. In June 2015, BPC Policy No. 773 was revised to change the way the annual set-aside is calculated to include revenues from maritime industrial tenants between the two terminals. The annual set-aside is currently calculated at one-half of one percent (1/2 of 1%) of the actual gross revenues earned from TAMT and NCMT, as well as revenues from maritime industrial tenants located along the working waterfront between the two terminals.

Funding from the MIIF was used to purchase and install an enhanced air filtration system at Perkins Element School in Barrio Logan, fund the Barrio Logan Nighttime Noise Study, as well as to purchase hotel vouchers for community residents that needed to evacuate as a result of the USS Bonhomme Richard Navy Fire in the Summer of 2020.

Five-year Capital Improvement Program (BPC No. 120)

The Port's five-year Capital Improvement Program is the primary mechanism the Port uses to construct large projects and/or infrastructure improvements that span multiple years. The Port's Renewable Energy Microgrid Project[2] at the Tenth Avenue Marine Terminal and shore power installation at the Cruise Ship Terminal are two air quality related projects that are programmed as part of the Port's FY 2019-2023 CIP. Annual fiscal year expenditures are included in the Port's annual budget.

[2] Please note that while the Renewable Energy Microgrid Project is fully funded by a California Energy Commission (CEC) Grant, the project is programmed within the Port's 5-year Capital Improvement Program (CIP) because construction will span multiple years.

Major Maintenance Program (BPC Policy No. 130)

In addition to the Capital Improvement Program, the Port must also set aside funds for ongoing operations and maintenance. The Port's Major Maintenance Program is governed by BPC Policy No. 130, and several of these types of projects may span multiple years and budget cycles. Electrical charging connections for electric forklifts operating at the Port's B Street Cruise Ship Terminal is an example of an air-quality related project that would be considered major maintenance.

Low Carbon Fuel Standards Credits

The Low Carbon Fuel Standard (LCFS) is a relatively new source of funding that allows the Port to generate credits by facilitating or implementing low-carbon transportation changes that can be monetized and reinvested in furthering the electrification of transportation and infrastructure.[3] In January 2019, CARB included shore power as an eligible resource, and the Port registered as an opt-in entity in June 2019 and started monetizing eligible credits in Q2 of 2019. LCFS expenditures for the Port could include shore power additions, charging stations, and new electric vehicles.

The credit represents the difference between the carbon intensity of the electricity versus the carbon intensity of the fossil fuel. Algorithms developed by CARB determine the number of credits created based on the alternative energy and equipment used. This program could become a significant source of funding to help advance the electrification of the transportation sector, particularly as more energy is used from shore power and/or an EV Truck Shuttle at TAMT and/or NCMT.

External Funding - Grants

Several state and federal grant programs exist to fund projects to reduce air emissions through the construction of new infrastructure or purchase of new equipment. These programs are often very competitive, and securing these funds requires that funds have already been spent for project planning, business case development, engineering and permitting. While there are some grant programs for project development[4], most of State and federal grant programs are for project deployment and/or infrastructure improvements and require projects to be shovel-ready and/or to have environmental review completed to qualify for funding. Projects with completed plans and compelling benefits will be more competitive for winning these grant funds.

Many of the San Diego Air Pollution Control District (SDAPCD) programs that are used to fund equipment prioritize applications on cost-effectiveness calculations and/or utilization rates. The parameters of these various programs have posed challenges for the Port and its tenants to receive enough funding to offset the higher cost of ZE / NZE equipment in recent years, particularly for equipment with relatively lower utilization rates. The Port's application for a grant for a BYD 6R electric garbage truck helps illustrate this point. In 2020, the Port requested a $320,000 grant from SDAPCD to offset the cost of replacing a 2005 diesel GMC T7500 garbage truck with a the $400,000 all-electric,

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[3] CARB notes that electric vehicles, trucks, electric transit systems (fixed guideway, buses), electric forklifts, electric cargo-handling equipment, electric transportation refrigeration units, and shore power to ocean-going vessels at-berth are eligible to generate credits. See: https://ww2.arb.ca.gov/sites/default/files/2020-09/basics-notes.pdf

[4] For example, in November 2020, SANDAG partnered with the Port of San Diego, the Metropolitan Transit System (MTS), North County Transit District (NCTD) and the County of San Diego to apply for a $200,000 Medium / Heavy Duty ZEV Infrastructure Blueprint Planning Grant

BYD 6R garbage truck. During the application process, the SDAPCD's cost effectiveness calculations determined that the Port could qualify for a $10,922 award because the Port's existing 2005 garbage truck was fairly new and had a relatively low utilization rate. Another recent example, in Fall 2020, Port staff consulted with SDAPCD staff about what type of grant award could be anticipated to replace four pieces of high-emitting diesel CHE at TAMT at an estimated upgrade cost of $6.1 million; the preliminary cost-effectiveness analysis identified the maximum award potential as $306,671, or about 5% of the estimated upgrade cost (See FND Table 1 below). The use of this equipment ranged from a low of 200 hours to a high of 710 hours annually Additionally, SDAPCD-administered programs, such as Carl Moyer, presently require an existing piece of diesel equipment to be destroyed in exchange for grant funding, which deters equipment owners from pursuing lower-emitting alternatives, particularly if the diesel piece is only a few years old and/or still within its useful life and regulatorily compliant.

FND Table 1: Preliminary CHE Cost Estimates and Estimated Grant Awards (November 2020)

Type	# of Pieces	Description	MY	HP	Fuel	Annual Hours	Tons per Year			Estimated Costs	San Diego Clean Air Grant (October 2020) Estimated Award Amounts
							NOx	DPM	CO_2e MT		
Top Handler	1	Taylor TEC950L Cummins C260	1999	280	Diesel	241	1.79	0.007	136	$1,850,000	$104,249 or 6%
Reach Stacker	1	Taylor RS9968 OSM11-C	2010	330	Diesel	710	0.38	0.018	51	$1,850,000	$131,401 max or 7%
Top Handler	1	Taylor TEC-9501	2005	280	Diesel	405	0.33	0.009	25	$1,850,000	$35,835 max or 2%
Front End Loader	1	CAT 928 G	199	125	Diesel	200	0.11	0.006	9	$550,000	$35,186 max or 6.3%
Total Pieces	**4**					**Total**	**2.61**	**0.040**	**221**	**$6.1 million**	**$306,671 or 5%**

Despite these obstacles, SDAPCD's **Clean Air for All Grant Program**, which combines the **Carl Moyer Program, FARMER,** and the **Community Air Protection Program**, will continue to be one way that the Port and its tenants can help offset the cost of new ZE/NZE on-road vehicle projects.

Another important program is **Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP)**. California HVIP is a first-come first serve voucher incentive program for ZE/NZE ***on-road*** medium- and heavy-duty vehicles that can help offset the price of these vehicles. The vouchers are applied at point-of-sale, effectively creating a discount on the purchase prices of new and eligible vehicles. Incentive amounts are broken down by gross vehicle weight and ranched from $25,000 to $165,000 within a disadvantaged community (See Appendix B – HVIP Incentive Amounts).

The **California Clean Off-Road Equipment Incentive Voucher Incentive Program (CORE)** is a similar program that offers point-of-sale vouchers that are applied to the purchase of eligible off-road equipment. CORE provides funding for on- and off-road terminal tractors, TRUs, forklifts, container handling equipment, airport cargo loaders, aircraft tugs, railcar movers, mobile power units, ground power units, and mobile shore power cable management systems[2]. The CORE Program also offers funding for charging infrastructure and/or hydrogen fueling for certain types of equipment, and it provides a 10% enhancement from the given equipment's base voucher amount if it is deployed in disadvantaged or low-income communities. (See Appendix B – CORE Voucher Amounts)

Innovative Financing Options

Once a project is designed and has a business case in place, Port staff works with the Port's Chief Financial Officer and the Finance Department to develop a financial strategy for the project. These strategies can include direct payments by the Port, grant funds, borrowing, and public-private partnerships (P3s).

While this document is not meant to provide a comprehensive listing of borrowing options, it is notable that there are several advantageous financing options available for eligible infrastructure projects and equipment. These include loans from the California Infrastructure and Economic Development Bank[5], the Transportation Infrastructure Finance and Innovation Act (TIFIA) Loan Program[6], and some special bonds such as Private Activity Bonds.[7]

For the purpose of this document, P3s refer to contractual agreements formed between a public agency and private sector entity that allow for greater transfer of risk and responsibility to the private sector for the delivery and operation of projects. Traditionally, private sector participation has been limited to separate planning, design or construction contracts on a fee for service basis – based on the public agency's specifications. Expanding the private sector role allows the public agencies to tap private sector technical, management and financial resources in new ways to achieve certain public agency objectives, such as greater cost and schedule certainty, supplementing in-house staff, innovative technology applications, specialized expertise, or access to private capital. An in-depth discussion of P3s as an innovate financing mechanism is included in the Port Planning and Investment Toolkit.[8]

Recommendations

In addition to developing the emission reduction goals, objectives and strategies in the MCAS, discussions with neighboring community residents, tenants, and other stakeholder agencies have yielded several ideas and concepts to help finance and implement emission reduction initiatives. These ideas have been synthesized into the following recommendations listed below:

FND Goal 1 – Establish a Process that Allows Stakeholders and the Public to Provide Input in the Selection, Deployment and On-going Monitoring of Emission Reduction Projects

To help ensure that emissions reduction strategies are evaluated year-over-year in conjunction with available funding, and that they are evaluated in a holistic, publicly transparent and comprehensive manner, staff recommends establishing a process whereby staff works closely interested stakeholders and the public every fall (either September, October, November) to (1) Evaluate and report on the previous year's clean air accomplishments; and (2) Recommend new clean air projects, programs and initiatives for funding.

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[5] https://ibank.ca.gov/

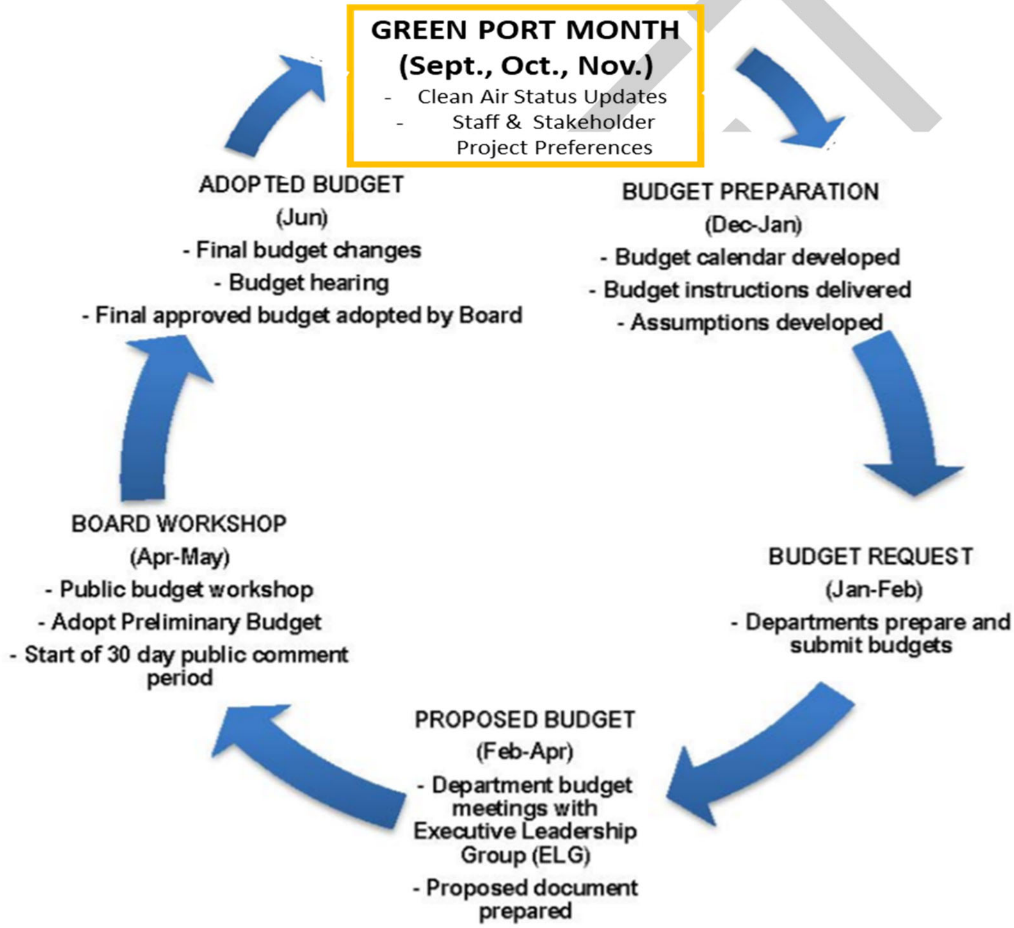
[6] https://www.transportation.gov/buildamerica/financing/tifia

[7] https://www.transportation.gov/buildamerica/financing/private-activity-bonds-pabs/private-activity-bonds

[8] https://www.aapa-ports.org/empowering/content.aspx?ItemNumber=21263

Based on the Port's annual budget process, staff could begin working with stakeholders at the beginning of the fiscal year (July and August) to identify near- and mid-term emission reduction strategies they would like to see advanced the following year. Port staff would work closely with its Clean Air partners and stakeholder agencies to identify recent accomplishments and to provide status updates on technological advancements, regulatory changes, and emissions data from the Portside AB 617 community monitoring program. This information could be presented to the Board annually in September (e.g., part of the Port's Green Port month), and then be used to help inform the projects, programs and initiatives that stakeholders would like to the Port to advance when the department heads begin budget preparations in December / January (See FND Figure 2 below).

The ongoing involvement of tenants, public agencies and community stakeholders will help staff prioritize long-term emission reduction projects, so that the planning, design and environmental work can be funded prior to pursuing external funding for construction, purchase and/or implementation.



FND Figure 2 – Suggested MCAS Update to Board

FND Goal 2 – Create a Clean Air Clearinghouse Program to Holistically Support Deployment, Operation and Maintenance of Large Emission Reducing Projects, with Clean Air Benefits

The Port's current process to fund large infrastructure projects that span multiple years is the five-year Capital Improvement Program (CIP). However, the CIP does not address the systematic purchase of Port-owned equipment, nor does it address potential support for tenants or terminal operators to upgrade and/or replace equipment. A Clean Air Clearinghouse Program (or Clean Air Project Improvement Program), would enable the Port to support funding pathways and track infrastructure improvements and/or equipment purchases that align with the Port's emission reduction goals and objectives.

This planning effort should include a full lifecycle analysis that quantifies the project's full cost by including the planning, design, construction, operation, and ongoing maintenance costs. For Port projects, this could include a green procurement policy that allots additional points to submittals that incorporate emission reduction components or strategies. Adequately addressing the planning gap in Port-led projects will increase the likelihood of successful grant applications in the future.

FND Goal 3 – Enter into a Memorandum of Understanding (MOU) with the San Diego Air Pollution Control District (SDAPCD) to Administer CARB Funding to Help Fund ZE/NZE Trucks and/or Cargo Handling Equipment

In 2008, the BPC authorized an MOU with SDAPCD to implement the Port's Truck Retrofit and Replacement Program in an amount not to exceed $1,150,000. Under the terms of the MOU, APCD entered into an agreement with CARB to obtain Goods Movement Emissions Reduction Program (GMERP, or Proposition 1B) funding, and then solicited truck owners to participate in the cost sharing agreement to either retrofit their trucks with Diesel Particulate Filters (DPF) or replace trucks, with newer, less polluting models. Under the GMERP, CARB programmed 2.9 million to fund emission reductions for trucks serving the Port of San Diego.

Similar to the MOU executed in 2008, the Port could work with CARB to set aside a pre-determined amount of money for ZE/NZE trucks and equipment that serve the Port of San Diego and enter into an MOU with SDAPCD to implement the program. Given the low grant amounts that the Port and its tenants have been awarded under SDAPCD's Carl Moyer, FARMER and the Community Air Protection Program in recent years, there is precedence to set aside a fixed amount of money for ZE/NZE trucks and equipment that serve the Port of San Diego.

FND Goal 4 – Establish an Emission Reductions Incentive Program

To support the goals and help reach the objectives identified in the Port's MCAS, the Port could provide monetary and/or non-monetary incentives to tenants and terminal operators that encourages them to invest in emission reduction projects and/or lower emitting alternatives. Monetary Incentives could include reduced dockage fees and/or lower Tariff rates. Non-monetary incentives could include public recognition awards, positive marketing, and/or promotional materials.

FND Goal 5 – Prepare a market study / feasibility analysis for the Board that explores a range of potential fees that can support zero and near-zero emission reduction projects, as well as any implications that the fee may have on the Port's revenue and maritime business opportunities.

The Port of Los Angeles and Port of Long Beach, collectively referred to as the San Pedro Bay Port Complex, recently approved a joint resolution that authorized a $10 fee per loaded TEU for containers hauled by trucks that enter or exit port terminals that included an exemption for loads hauled by Zero Emission Trucks or by a low NOx truck from rate initiation through the end of 2031. This fee supports its 2017 Clean Air Action Plan (CAAP) Goal of 100% Zero Emission Trucks by 2035 and was set after the San Pedro Bay Port Complex conducted a Truck Feasibility Assessment in 2018 and an Economic Study for the Clean Truck Fund Rate in February 2020. The San Pedro Bay Port Complex is the busiest container port in North America, handles almost 17 million TEU's a year, and has 18,421 trucks in the Port Drayage Registry.

To better understand the implications of establishing a similar type of fee at the Port of San Diego, and if appropriate, to determine what the rate should be, the Port should prepare a market study / feasibility analysis that explores the range of potential fees that could be levied to support zero and near-zero emission reduction projects. The study should determine the price elasticity for transportation of the cargoes through TAMT and NCMT to help forecast the impacts of any fees on current or future cargo volumes. However, as of this writing, San Pedro ports have experienced record-breaking high cargo volumes during 2020, while primarily recreational, ports such as San Diego and San Francisco have experienced the severest revenue shortfalls in history. The disparate impacts among California's ports have been extreme, with San Diego's projected $98 million shortfall striking a profound contrast with the surging economic activity of other ports. For that reason, a state fee on container and roll-on/roll-off carrier vessels - split between local/regional remediation fund for infrastructure, efficiencies, supply chain improvements, and environmental justice programs would be an equitable way to distribute benefits from across California's economic spectrum without exposing San Diego's unique market to greater competitive disadvantages. Additionally, parity among federal funding programs must be advocated to reestablish an even playing field among ports like San Diego who compete for business among ports in other states, such as Texas and Georgia, that have less robust environmental regulations. The Biden administration may be able to help address the inequity in federal grant awards, so that that business is not diverted from California Port to out-of-state competitors.

Conclusion

Projects, Programs, and Strategies identified in the MCAS will be funded from a multitude of sources, internal and external. Port staff will work within the parameters of the existing Port budget cycle and programs, as well as look into creating new Port programs and opportunities with stakeholders. Most importantly, Port staff will continue to keep community members and interested parties informed as MCAS funding processes are developed.

2019 MCAS Emissions Inventory

As part of the Maritime Clean Air Strategy (MCAS), Port staff conducted a Maritime Air Emissions Inventory to update the prior iteration from 2016 for several emission sectors, identify the higher-emitting equipment that are in use, and to determine the feasibility of cleaner upgrades to reduce emissions.

The equipment and emissions inventory was developed for three sectors: Ocean Going Vessels (OGVs), Commercial Harbor Craft (CHC), and Cargo Handling Equipment (CHE). Emissions from rail and trucks were not updated from 2016. The emissions inventory update includes OGV, CHC, and CHE sources throughout the bay and at the three marine terminals: Cruise Ship Terminal (CST), Tenth Avenue Marine Terminal (TAMT), and National City Marine Terminal (NCMT).

The inventory covers the same pollutants covered in previous maritime inventories: reactive organic gases (ROGs), nitrogen oxides (NO_X), carbon monoxide (CO), particulate matter 10 microns or less in diameter (PM10), particulate matter 2.5 microns or less in diameter (PM2.5), diesel particulate matter (DPM), sulfur dioxide (SO_2), and carbon dioxide equivalent (CO_2e).

Emissions Summary

A summary of maritime emissions is provided in INV Table 1. Note that estimates for some emission sectors increased relative to 2016 due to increased visitation of some large CHC research vessel and work boats that remained in the bay for a substantial amount of time, revised methodological guidance from the California Air Resources Board (CARB) for estimating emissions OGVs, a slight increase in vessel calls (from 420 to 424), and more complete data provided by the tenants.

Emission estimation methods follow the same methods, formulas, and emission factors presented in the 2016 Maritime Air Emissions Inventory (2016 Inventory) except for some updates to address CARB's revised methods.[1] Changes since 2016 include revised CHC load factors for some ship types as well as OGV auxiliary engine and auxiliary boiler loads and low load adjustment factors. These changes are discussed at a high level below.

[1] *Port of San Diego 2016 Maritime Air Emissions Inventory*. Available: https://pantheonstorage.blob.core.windows.net/environment/2016-Maritime-Air-Emissions-Inventory.pdf

INV Table 1. Summary of 2019 Maritime Air Emission Inventory (tons)

Type	ROG	CO	NOx	PM10	PM2.5	DPM	SO2	CO2e (tons)	CO2e (MT)
Ocean-Going Vessels	17.5	33.4	378.3	7.5	6.9	6.7	15.8	25,770	23,378
Harbor Craft	33.9	200.0	283.6	9.1	8.9	9.1	0.4	25,495	23,128
Cargo Handling Equipment	1.0	22.6	8.4	0.1	0.1	0.1	0.0	2,439	2,213
Freight Rail	1.9	7.5	30.3	1.2	1.2	1.2	0.5	2,916	2,646
On-Road Vehicles	3.1	12.3	51.4	0.3	0.3	0.3	0.1	16,095	14,601
Total Emissions	***57.5***	***275.9***	***752.0***	***18.3***	***17.4***	***17.4***	***16.7***	***72,715***	***65,966***

Ocean Going Vessels

The OGV emissions inventory was updated based on 2019 conditions. Data sources used for this analysis include vessel call data from the Port, Automatic Identification System (AIS) data, and Lloyd's data. The scope of the Inventory includes all OGV calls at the three marine terminals (CST, TAMT, and NCMT) in 2019. This is the fourth OGV Inventory conducted by the Port, past inventories were conducted in 2006, 2012 and 2016. Emissions were calculated based upon CARB's OGV methodology.

Average propulsion and auxiliary power by ship type is shown in INV Table 2. OGV emission estimates by ship type are shown in INV Table 3. Emissions by activity mode are shown in INV Table 4. INV Figure 1 portrays the relative contribution of each pollutant by geographic area: outside of bay, maneuvering in-harbor, and hoteling at-berth. Note that emissions outside of the bay includes transit, VSR, and anchorage emissions.

INV Table 2. Average Propulsion and Auxiliary Power by Ship Type 2019

Ship Type	Engine Type	Calls	Average Power (kW)		
			Propulsion	Auxiliary	Boiler
Auto Carrier	SSD	243	14,161	1,089	316
Bulk Carrier	SSD	8	8,425	262	131
Container Ship	SSD	52	19,420	811	308
General Cargo	MSD	7	6,843	502	130
	SSD	16	9,260	640	172
Passenger Ship	GT-ED	2	70,977		1,694
	MSD-ED	89	68,792		1,693
	MSD	6	18,513		410
RoRo	SSD	1	14,123	1,087	315
Total	-	424	24,388	2,565	600

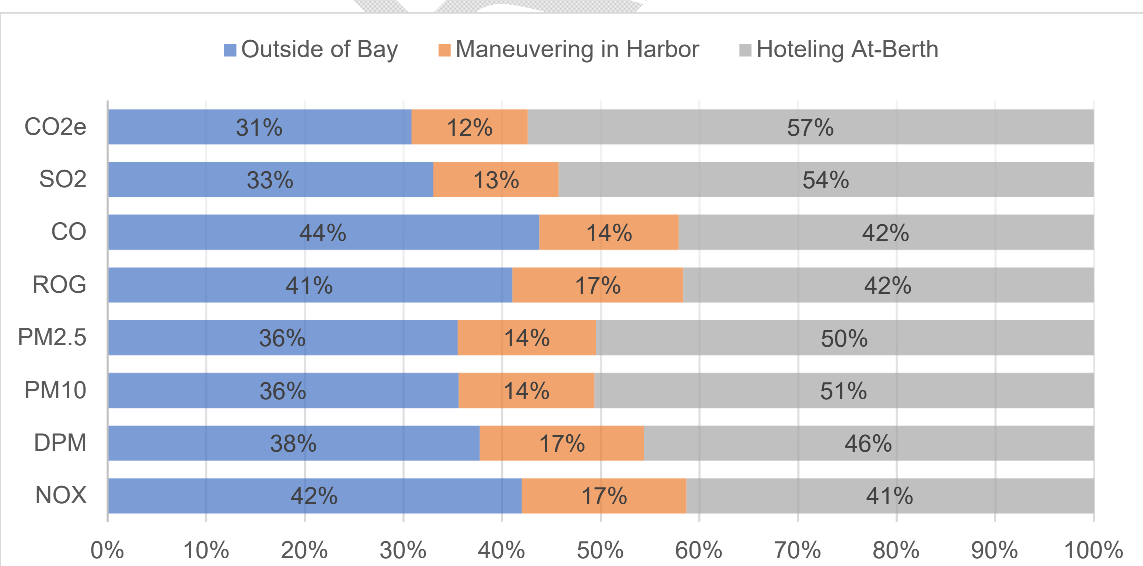
INV Table 3. Emissions from OGVs by Type (tons)

Ship Type	NOX	DPM	PM10	PM2.5	ROG	CO	SO2	CO2e (tons)	CO2e (MT)
Auto Carrier	180.5	2.9	3.2	3.0	8.0	16.4	7.2	10,383	9,420
Bulk Carrier	4.5	0.1	0.1	0.1	0.2	0.5	0.2	349	316
Container Ship	17.7	0.2	0.4	0.3	0.8	1.2	1.2	2,386	2,164
General Cargo	19.3	0.4	0.4	0.4	0.8	1.9	0.9	1,371	1,243
Passenger Ship	154.3	3.0	3.3	3.1	7.6	13.3	6.2	11,157	10,122
RoRo	1.9	0.0	0.0	0.0	0.1	0.2	0.1	123	112
Total	*378.3*	*6.7*	*7.5*	*6.9*	*17.5*	*33.4*	*15.8*	*25,769*	*23,378*

INV Table 4. Emissions from OGVs by Mode in 2019 (tons)

Ship Type	NOX	DPM	PM10	PM2.5	ROG	CO	SO2	CO2e (tons)	CO2e (MT)
Transit	29.7	0.4	0.5	0.4	1.3	3.1	0.8	1,282	1,163
VSR	109.5	1.7	1.7	1.6	5.0	9.8	3.2	4,936	4,478
Maneuver	63.2	1.1	1.0	1.0	3.0	4.7	2.0	3,039	2,757
Hotel	156.1	3.1	3.8	3.5	7.3	14.1	8.5	14,784	13,412
Anchor	19.8	0.4	0.5	0.5	0.8	1.8	1.2	1,728	1,568
Total	*378.3*	*6.8*	*7.5*	*6.9*	*17.5*	*33.4*	*15.8*	*25,769*	*23,378*

INV Figure 1. Portion of OGV Emissions Inside and Outside of the Bay in 2019



Harbor Craft

The CHC emissions inventory was updated based on 2019 conditions for all harbor craft except for the commercial and sport/charter fishing fleet. Information on the number, vessel types, location, operating radius, engine size, model year, and general operating activity of CHC was obtained from tenants through a Port-issued survey. The scope of the Inventory includes all CHC operating in the Bay, including those that not only visited the three marine terminals (CST, TAMT, and NCMT), but also those that visited the various boatyard and other tenants in 2019. This is the fourth CHC Inventory conducted by the Port, past inventories were conducted in 2006, 2012 and 2016. Emissions were calculated based upon CARB's CHC methodology.

Port Table 5 summarizes the activity metrics for the various types of vessels considered, including the equipment counts, average engine model year, horsepower by engine type, and annual hours both within the Bay and outside the Bay (but within 24 nautical miles). As shown, there were 94 harbor craft vessels included the fleet, not including commercial and sport fishing. All harbor craft are diesel powered.

CHC emissions for all 2019 activity (regardless of location) are summarized in INV Table 6 by vessel type.

The contribution of each pollutant both within and outside the Bay by pollutant type is shown in INV Figure 2. The majority (62-71%) of CHC emissions are emitted within the Bay. INV Figure 3 summarizes DPM emissions by vessel type in bay versus outside the Bay. As shown, the majority of DPM emissions from ferries, excursion vessels, and assist tugs occur within the Bay.

INV Table 5. Characteristics of Commercial Harbor Craft at the Port in 2019

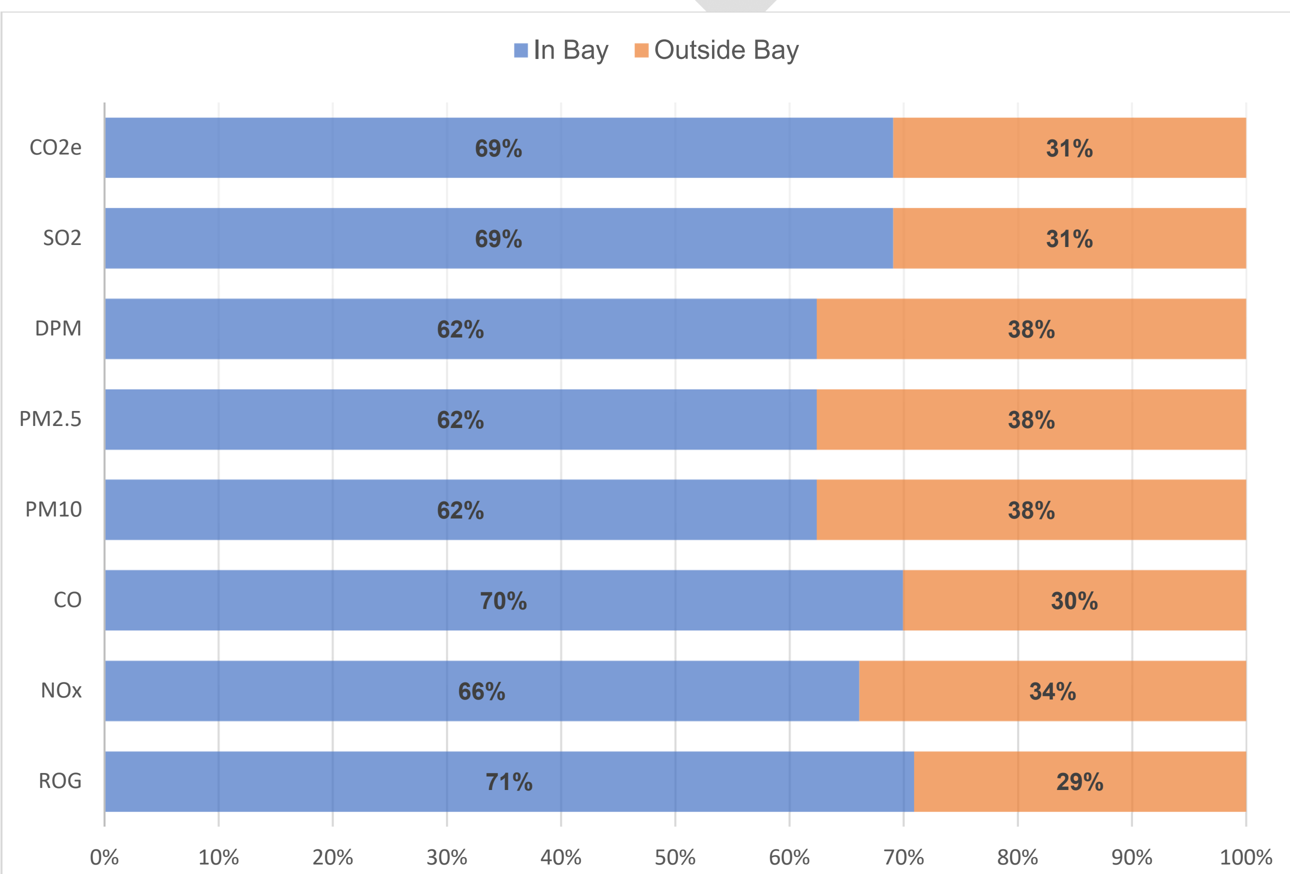
Vessel Type	No. of Vessels	Model Year	Average Engine Power (HP)		In Port Hours		Outside Port Hours	
			Propulsion	Auxiliary	Propulsion	Auxiliary	Propulsion	Auxiliary
Crew Supply	9	1994	1690	165	64	1824	84	225
Dredge	2	1996	3475	1700	5	26	20	47
Escort/Ship Assist Tug	6	2003	1508	79	337	2559	11	12
Excursion	24	2000	779	456	389	1601	71	73
Ferry	2	1976	368	74	2343	5093	0	0
Bunker Barge	1	2010	-	201	1	171	11	11
Pilot Boat	2	2010	625	220	285	1757	223	226
Push Tow Tug	26	1994	1035	86	120	852	126	139
Research Boat	10	1993	1565	602	14	636	100	114
Work Boat	12	2009	1236	535	53	308	151	321
Total [a]	**94**	**1998**	**1163**	**338**	**224**	**1237**	**97**	**138**

[a] Total vessels; all other values are averages, weighted by number of vessels of each type.

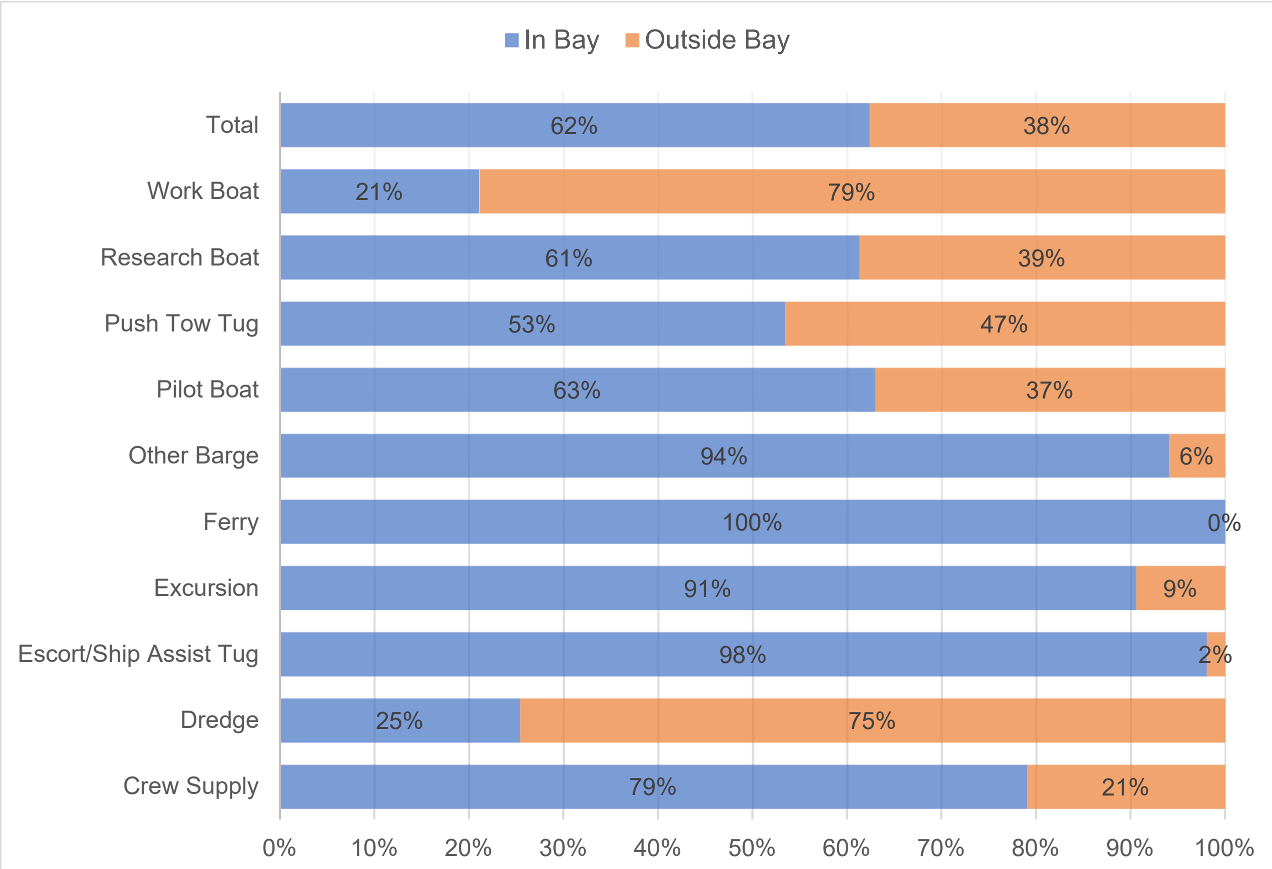
INV Table 6. Summary of Commercial Harbor Craft Emissions in 2019 (tons)

Type	ROG	NOx	CO	PM10	PM2.5	DPM	SO2	CO2e (tons)	CO2e (MT)
Crew Supply	4.21	28.38	25.96	0.66	0.64	0.66	0.04	3,202	2,905
Dredge	0.28	2.07	1.85	0.07	0.06	0.07	0.00	227	206
Escort/Ship Assist Tug	1.32	9.32	8.31	0.24	0.23	0.24	0.01	1,043	946
Excursion	6.08	44.82	36.56	1.29	1.26	1.29	0.05	4,259	3,864
Ferry	1.10	8.15	6.31	0.26	0.26	0.26	0.01	728	661
Other Barge	0.02	0.16	0.12	0.00	0.00	0.00	0.00	13	12
Pilot Boat	0.38	3.34	2.60	0.09	0.09	0.09	0.00	310	281
Push Tow Tug	4.41	39.87	23.40	1.72	1.67	1.72	0.03	3,161	2,867
Research Boat	4.09	51.00	23.30	1.63	1.59	1.63	0.03	2,618	2,375
Work Boat	3.69	34.97	24.41	1.12	1.09	1.12	0.03	3,004	2,725
Total	**25.57**	**222.07**	**152.81**	**7.11**	**6.89**	**7.11**	**0.21**	**18,565**	**16,842**

INV Figure 2. Portion of Commercial Harbor Craft Emissions Inside and Outside of the Bay in 2019



INV Figure 3. Portion of Commercial Harbor Craft Diesel Particulate Matter Emissions Inside and Outside of the Bay by Vessel Type in 2019



Cargo Handling Equipment

The scope of the Inventory includes all CHE utilized by the Port and participating tenants at the three marine terminals (CST, TAMT, and NCMT) in 2019. This is the fourth Maritime Cargo Handling Equipment Inventory conducted by the Port, past inventories were conducted in 2006, 2012 and 2016. Emissions were calculated based upon CARB's CHE methodology.

This inventory includes all equipment at all terminals, even if not part of MCAS or unrelated to cargo handling.

A summary of CHE specifications by equipment type is shown in INV Table 7. A summary of CHE emission by equipment type and fuel for existing pieces is shown in INV Table 8. A summary of CHE emissions by terminal is shown in INV Table 9.

The contribution of each pollutant by terminal is shown in INV Figure 4. The majority of CHE emissions for all by CO occurs at TAMT, which has the largest and most active diesel CHE pieces.

INV Table 7. Summary of Cargo Handling Equipment Activity in 2019

Equipment	Fuel	Count	Power (hp)			Model Year			Annual Activity Hours		
			Min	Max	Avg	Min	Max	Avg	Min	Max	Avg
ATV	G	18	13	32	17	2007	2017	2013	479	479	479
Cart	E	11	10	40	21	2005	2012	2008	479	479	479
	G	1	9	9	9	2007	2007	2007	10	10	10
Crane	D	1	1030	1030	1030	2002	2002	2002	245	245	245
Compressor	E	7	5	15	9	2003	2003	2003	566	566	566
	G	1	13	13	13	2003	2003	2003	566	566	566
Forklift	D	27	67	250	187	2007	2016	2010	25	925	314
	E	21	28	149	133	2004	2019	2011	25	1409	529
	G	1	23	23	23	2015	2015	2015	400	400	400
	P	10	60	149	92	2000	2014	2007	48	520	229
Stationary Lift	E	21	2	2	2	2003	2017	2008	375	375	375
Loader	D	1	125	125	125	1999	1999	1999	200	200	200
	G	3	138	138	138	2002	2002	2002	63	63	63
Reach Stacker	D	4	315	400	344	2008	2016	2011	150	710	328
	E	1	354	354	354	2010	2010	2010	1300	1300	1300
Segway	E	2	2	2	2	0	0	0	375	375	375
Signal Board	S	6	0	0	0	2004	2008	2005	0	0	0
Sweeper	G	1	83	83	83	1998	1998	1998	479	479	479
Top Handler	D	2	280	280	280	1999	2005	2002	405	1300	853
Yard Tractor	D	27	164	238	201	2007	2015	2011	176	1487	578
	E	3	241	241	241	2017	2017	2017	102	715	308
Other	E	12	1	6	2	2003	2003	2003	375	375	375
Lighting	D	3	14	14	14	2019	2019	2019	10	10	10

Notes: D = Diesel, E = Electric, G = Gas, P = Propane, S = Solar

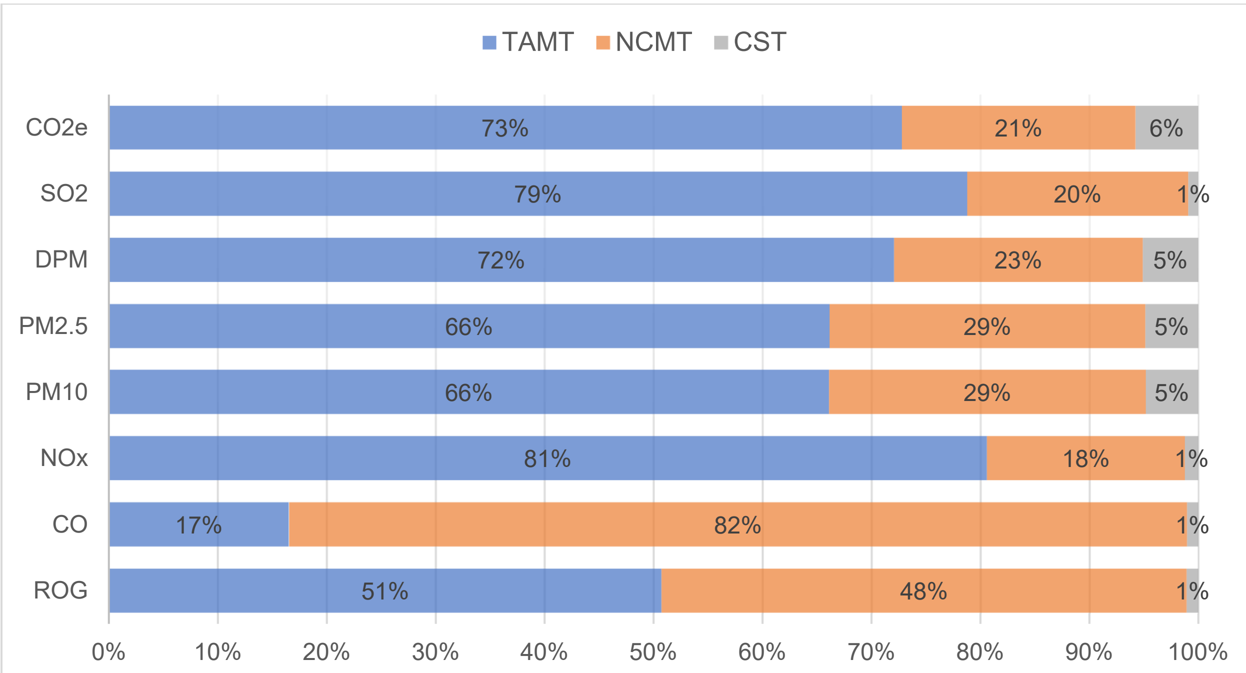
INV Table 8. Summary of Cargo Handling Equipment Emissions by Fuel and Equipment Type in 2019 (tons)

Fuel	Type	ROG	CO	NOx	PM10	PM2.5	DPM	SO2	CO2e (tons)	CO2e (MT)
Diesel	Crane	0.01	0.11	0.48	0.01	0.01	0.01	0.00	68	62
	Forklift	0.05	0.79	0.93	0.04	0.04	0.04	0.00	207	188
	Loader	0.01	0.05	0.11	0.01	0.01	0.01	0.00	9	8
	Reach Stacker	0.03	0.24	0.57	0.02	0.02	0.02	0.00	163	148
	Top Handler	0.04	0.16	2.12	0.02	0.01	0.02	0.00	178	162
	Yard Tractor	0.44	3.13	3.40	0.04	0.03	0.04	0.02	1,399	1269
	Lighting	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
Electric	Cart	-	-	-	-	-	-	-	16	15
	Forklift	-	-	-	-	-	-	-	124	112
	Reach Stacker	-	-	-	-	-	-	-	72	65
	Segway	-	-	-	-	-	-	-	0	0
	Yard Tractor	-	-	-	-	-	-	-	23	21
	Other	-	-	-	-	-	-	-	2	1
	Compressor	-	-	-	-	-	-	-	5	5
	Lift	-	-	-	-	-	-	-	2	2
Gasoline	ATV	0.13	10.92	0.25	0.01	0.01	0.00	0.00	90	82
	Cart	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0
	Forklift	0.00	0.21	0.01	0.00	0.00	0.00	0.00	2	2
	Loader	0.02	0.34	0.12	0.00	0.00	0.00	0.00	12	11
	Sweeper	0.25	4.33	0.26	0.00	0.00	0.00	0.00	24	21
	Compressor	0.03	1.18	0.04	0.00	0.00	0.00	0.00	4	3
Propane	Forklift	0.02	1.17	0.13	0.00	0.00	0.00	0.00	38	35
Solar	Signal Board	-	-	-	-	-	-	-	0	0
Grand Total		1.03	22.64	8.41	0.15	0.13	0.13	0.02	2,439	2,213

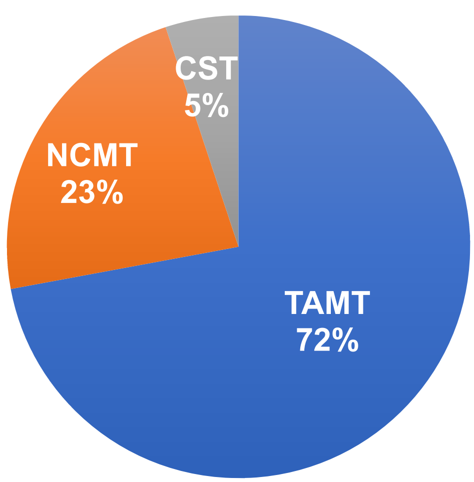
INV Table 9. Summary of Cargo Handling Equipment Emissions by Terminal in 2019 (tons)

Terminal	ROG	CO	NOx	PM10	PM2.5	DPM	SO2	CO2e (tons)	CO2e (MT)
TAMT	0.52	3.74	6.78	0.10	0.09	0.10	0.02	1,776	1,611
NCMT	0.50	18.66	1.53	0.04	0.04	0.03	0.00	523	474
CST	0.01	0.23	0.10	0.01	0.01	0.01	0.00	141	128

INV Figure 4. Portion of Cargo Handling Equipment Emissions by Terminal in 2019



INV Figure 5. Portion of Cargo Handling Equipment Diesel Particulate Matter by Terminal in 2019



Rail

Freight rail emissions were not updated for 2019 conditions. Summary of emissions below is based on the 2016 Inventory. Rail emissions by activity mode (regional line haul and near-terminal switching) is shown in INV Table 10. Rail emissions by terminal is shown in INV Table 11.

INV Table 10. Summary of Freight Rail Emissions by Activity Mode in 2016 (tons)

Activity Mode	ROG	CO	NOx	PM10	PM2.5	DPM	SO2	CO2e (tons)	CO2e (MT)
Line Haul	1.46	5.7	23.0	0.94	0.91	0.94	0.40	2,215	2,009
Switching	0.46	1.8	7.3	0.30	0.29	0.30	0.13	702	637

INV Table 11. Summary of Freight Rail Emissions by Terminal in 2016 (tons)

Terminal	ROG	CO	NOx	PM10	PM2.5	DPM	SO2	CO2e (tons)	CO2e (MT)
TAMT	0.03	0.1	0.5	0.02	0.02	0.02	0.01	42	39
NCMT	1.89	7.4	29.8	1.22	1.18	1.22	0.52	2,874	2,607

Trucks

Heavy Duty drayage truck and other onroad emissions were not updated for 2019 conditions. Summary of emissions below is based on the 2016 Inventory. Truck and other onroad emissions by location (on-terminal, near-port, and regionally) and by terminal is shown in INV Table 12.

INV Table 12. Summary of On-Road Emissions by Mode by Terminal in 2016 (tons)

Type	Location	ROG	CO	NOx	PM10	PM2.5	DPM	SO2	CO2e (tons)	CO2e (MT)
TAMT Trucks	On-Terminal	0.1	0.6	1.6	<0.1	<0.1	<0.1	<0.1	291	264
	Near-Port	<0.1	0.1	1.1	<0.1	<0.1	<0.1	<0.1	346	314
	Regional	1.8	5.5	35.7	0.2	0.2	0.2	0.1	11,025	10,002
NCMT Trucks	On-Terminal	0.1	0.5	1.4	<0.1	<0.1	<0.1	<0.1	217	197
	Near-Port	<0.1	<0.1	0.1	<0.1	<0.1	<0.1	<0.1	39	35
	Regional	0.6	1.7	11.1	0.1	0.1	0.1	<0.1	3,436	3,117
NCMT Cars Offloading		*0.6*	*2.7*	*0.1*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*437*	*397*
CST Passengers		*<0.1*	*1.0*	*0.2*	*<0.1*	*<0.1*	*<0.1*	*<0.1*	*304*	*276*
Total		**3.1**	**12.3**	**51.4**	**0.3**	**0.3**	**0.3**	**0.1**	**16,095**	**14,601**

APPENDIX - B

Zero Emission and Near Zero Emission Truck Technology Assessment

March 2021

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Zero and Near Zero Truck Technology Assessment

On-road vehicles at the Port of San Diego (Port) include heavy-duty trucks that are used to transport port-related cargo between National City Marine Terminal (NCMT) and Tenth Avenue Marine Terminal (TAMT) and local and regional destinations, as well as vehicle on-loading and off-loading at NCMT. For purpose of this report, heavy-duty trucks are defined as Class 7 and Class 8 trucks (with a gross vehicle weight rating (GVWR) greater than 26,000 pounds). This report provides additional background information that helped inform the discussion in the Heavy Duty Trucks chapter, which addresses emissions from all heavy-duty trucks that travel to and from TAMT and NCMT, including trucks that move containers, bulk, break-bulk, and Roll-on/Roll-off cargo.

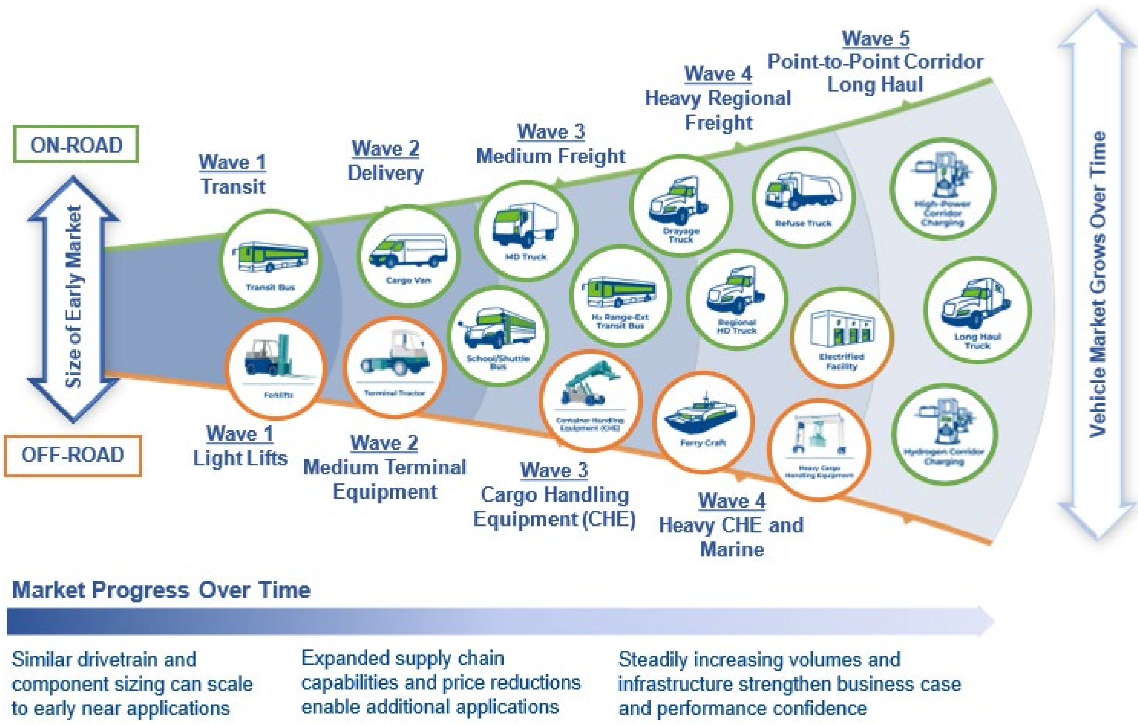
Conventional port drayage trucks are considered to be those that have less than 100 daily vehicle miles traveled (VMT) with multiple stops at the Port, and a significant number of them are domiciled at a regular depot overnight. This makes them prime candidates for electrification with currently available Class 8 electric truck technology. Many fleets operating drayage trucks in California, however, are small fleets that may not have a depot. As will be discussed later in the chapter, this presents a challenge to typical overnight charging setups. It should also be noted that as transload and freight facilities are being located farther from the ports, the typical daily VMT for these trucks may increase going forward.

Transitioning the commercial heavy-duty truck market to zero- and near-zero (ZE/NZE) emission technologies is occurring at different stages. CALSTART's Beachhead Strategy[1] estimates how ZNZ technologies for on- and off-road vehicles will progress through different applications overtime. The first vehicle market segments to successfully transition are operated in largely urban applications where vehicles travel along established routes and over relatively short distances, and importantly, can recharge overnight at depots. Going forward, ZE/NZE emission technologies will advance from first-success beachhead applications (as shown in TRK-B **Error! Reference source not found.**) and expand to larger-volume, longer-distance, and more demanding applications which still make use of core zero-emission commercial vehicle (ZECV) powertrain components and supply chains. For zero-emission freight vehicles, (including heavy-duty trucks), the Beachhead Strategy diagram shows that commercialization will start with smaller and lower-range vehicles, cargo vans and yard tractors, as first-success applications in receptive markets around the world. The components and supply chains for these vehicles is then leveraged and scaled-up so that ZE/NZE freight vehicle technology can advance into applications that meet longer-range, and more rigorous duty cycles in heavier vehicles. This progression is shown in TRK-B TRK-B Figure 1.

[1] CALSTART: 2020. *The Beachhead Model: Catalyzing Mass-Market Opportunities for Zero-Emission Commercial Vehicles*. Available online at https://globaldrivetozero.org/public/The_Beachhead_Model.docx.

Technologies and Strategies

TRK-B Figure 1. "Beachhead Pathways" for Zero-Emission Vehicle Commercialization[2]



Based on the Beachhead Strategy, the zero-emission vehicle market is approaching the end of Wave 3. It is projected that Wave 4 applications, including drayage trucks, will be commercially available in 2023 based on data in the Zero Emission Technology Inventory (ZETI)[3], as discussed below.

Related to the Beachhead Strategy is CARB's Long-Term Heavy-Duty Investment Strategy[4], within which CARB created high-level technology readiness assessments for heavy-duty vehicles. A simple scoring methodology for technology readiness level (TRL) is used from 1 through 9 to identify the maturity and commercial readiness of the technology. Technologies with TRL scores from 1-4 are considered to be in their earliest stage of commercialization, where the technology is assessed for its feasibility. Technologies with TRL scores from 5-6 are undergoing early demonstrations for research, design, and development. Technologies with TRL scores from 7-8 are in the precommercial stage, where pilot projects happen. Lastly, technologies with TRL scores of 9 are either early market entries accelerated through financial incentives, or at market scale accelerated by fleet turnover incentives. More information about TRLs and how they relate to the trucks operating at the Port is covered in the Commercial Availability section.

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[2] CALSTART: 2020. *The Beachhead Model: Catalyzing Mass-Market Opportunities for Zero-Emission Commercial Vehicles*. Available online at https://globaldrivetozero.org/public/The_Beachhead_Model.docx.

[3] *Drive to Zero's Zero-emission Technology Inventory (ZETI) Tool Version 5.5*. Available online at https://globaldrivetozero.org/tools/zero-emission-technology-inventory/. Accessed December 2020.

[4] CARB. 2020. *Appendix D: Long-Term Heavy-Duty Investment Strategy*. Available online at: https://ww2.arb.ca.gov/sites/default/files/2020-11/appd_hd_invest_strat.pdf. Accessed January 2021.

Emission Reduction Technology Options

Drayage trucks have a very specific use case, which is to transport containerized, bulk, and break-bulk cargo from ports and railyards to their next location. The term *drayage truck* is defined by CARB as Class 7 and 8 trucks (trucks with a gross vehicle weight rating of greater than 26,000 pounds) that are used for transporting cargo, such as containerized bulk, or break-bulk goods, that operates (a) on or transgresses through port of intermodal rail yard property for the purpose of loading, unloading or transporting cargo, including transporting empty containers and chassis or (2) off port or intermodal rail yard property transporting cargo or empty containers or chassis that originated from or is destined to a port or intermodal rail yard property.[5]

Currently, there exist multiple emission reduction technologies for Class 8 drayage and non-drayage trucks that are at different levels of commercialization. While some are fully commercialized, others are in research and development phases and are being tested through demonstrations and pilots. This section describes the different emission reduction technologies that are available. The Costs and Emissions Reductions section will include information about the emissions associated with each technology, and the Commercial Availability section will include more information on how developed each technology is and where it stands in the market.

Natural Gas

Heavy-duty natural gas vehicles (NGV) operate similarly to that of their diesel or gasoline counterparts, depending on the type of NG used. Natural gas is stored in tanks, and it is produced in two forms: compressed natural gas (CNG) and liquefied natural gas (LNG). In CNG trucks, high-pressure gas travels via fuel lines to a pressure regulator which adjusts the pressure of the gas to a suitable level for the engine fuel injection system. The gas is then mixed with air, compressed and ignited by a spark plug.[6] LNG fuel systems store the liquidized fuel in large tanks. LNG has a greater energy density and thus a longer range compared to CNG, but due to its higher cost CNG remains the more commonly used natural gas type.

Low-NOx natural gas engines have been a major technological innovation as it reduces both particulate matter and NOx emissions. Low-NOx NGVs produce roughly similar levels of NOx emissions as battery-electric trucks. However, natural gas produces the second highest lifecycle GHG emissions on a grams per mile basis, slightly less than conventional diesel.[7] It should be noted that heavy-duty low NOx standards in the state of California means natural gas used in trucks operating in the state is considered to be low NOx.

Renewable Natural Gas

Renewable Natural Gas (RNG) is derived from organic waste material, which can come from many sources including manure, food waste, landfill gas, wastewater treatment sludge, forest and agricultural residues, and organic municipal solid waste.[8] Anaerobic digestion of these materials produces a variety of gases including carbon dioxide and biomethane. Once separated from the carbon dioxide, the remaining biomethane and trace gases, known simply

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[5] 13 CCR § 2027(c)(15).

[6] Alternative Fuels Data Center. n.d. *How Do Natural Gas Class 8 Trucks work?* Available online at: https://afdc.energy.gov/vehicles/how-do-natural-gas-class-8-trucks-work. Accessed January 2021.

[7] ICF. 2019. *Comparison of Medium- and Heavy-Duty Technologies in California*. Available online at: https://caletc.com/comparison-of-medium-and-heavy-duty-technologies-in-california/

[8] Jaffe, AM and Dominguiz-Faus, Rosa. 2016. *The Feasibility of Renewable Natural Gas as a Large-Scale, Low Carbon Substitute Contract No. 13-307. UC Davis ITS. Available online at: https://ww2.arb.ca.gov/sites/default/files/classic//research/apr/past/13-307.pdf.*

as "RNG", can be blended with fossil natural gas or substituted entirely. RNG meets existing required fossil natural gas pipeline and vehicle specifications, meaning RNG and fossil natural gas are interchangeable in NGV applications.[9]

While RNG emits comparable levels of GHGs as fossil fuels, the differences in upstream processes, such as methane capture, result in an overall reduction of lifecycle GHG emissions with its use. Some CARB-certified RNG pathways are even considered carbon-negative.[10] Overall, Low NOx RNG has been found to reduce GHG emissions by more than 60 percent, and criteria air pollutant emissions by 90 percent in Class 8 vehicles when compared to conventional diesel.[11]

In 2019, Californians consumed approximately 162 million gasoline gallon equivalents of RNG, accounting for approximately 77 percent of the total NGV demand, and 7 percent of the total alternative fuel demand in California.[12] According to a UC Davis study, California has enough organic waste material to increase the state's production of RNG to at least 94.6 billion cubic feet (Bcf) per year.[13] As of June 2020, the Proposition 1B: Goods Movement Emission Reduction Program has resulted in 561 natural gas drayage truck replacements and 891 retrofits statewide.[14]

A recent demonstration of 20 RNG-fueled Class 8 trucks, funded by CARB, CEC, and South Coast Air Quality Management District (SCAQMD), confirmed that RNG can be a feasible option for port drayage and regional trucking. Seven trucking companies operating at the Ports of Los Angeles and Long Beach were outfitted with Cummins ISX12N engines and fueled with RNG. The ISX12N engine is certified by CARB to reduce NOx emissions by 90 percent compared to the current engine standard. By the end of 2019 over 100 trucks were outfitted with the ISX12N engine and operating at the Ports of Los Angeles and Long Beach.[15]

Battery Electric

As the battery electric vehicle market matured through the past decade, there was a large focus on developing the technology, supply chains, and marketing strategies to accelerate adoption of light- and medium-duty electric vehicles. As a result, heavy-duty electric vehicles have been slower to evolve and implement, however, recent focus has shifted to electrifying heavy-duty vehicles with a particular emphasis on drayage trucks in the near-term. Drayage may be an attractive near-term application because current electric heavy-duty vehicles are well positioned to handle short range, regular duty cycles. Transit buses, school buses, urban delivery vehicles, and yard tractors have all seen success partially due to their regular duty cycles; drayage trucks are well positioned for future success as the technology for heavy-duty trucks advances.

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[9] UC Davis ITS. 2017. *Policy Brief—Renewable Natural Gas Provides Viable Commercial Pathway for Sustainable Freight*. Available online at: https://steps.ucdavis.edu/wp-content/uploads/2017/10/RNG-policy-brief-FINAL-WITH-ABSTRACT-Sep2017.pdf.

[10] California Air Resources Board. 2020. *LCFS Pathway Certified Carbon Intensities*. Available online at: https://ww2.arb.ca.gov/resources/documents/lcfs-pathway-certified-carbon-intensities.

[11] ICF. 2019. *Comparison of Medium- and Heavy-Duty Technologies in California*. Available online at: https://caletc.com/comparison-of-medium-and-heavy-duty-technologies-in-california/.

[12] CARB. n.d. *Data Dashboard: 2011-2019 Performance of the Low Carbon Fuel Standard*. Available online at: https://ww3.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm. Accessed August 2020.

[13] Jaffe, M, A. 2016. *The Feasibility of Renewable Natural Gas as a Large-Scale, Low Carbon Substitute*. Available online at: https://ww2.arb.ca.gov/sites/default/files/classic/research/apr/past/13-307.pdf.

[14] CARB. 2020. *Proposition 1B: Goods Movement Emission Reduction Program June 220 Semi Annual Status Report.* June 30. Available online at: https://ww2.arb.ca.gov/sites/default/files/2020-06/Proposition%201B%20-%20Goods%20Movement%20June%202020%20Semi-Annual%20Report_0.pdf. Accessed September 2020.

[15] San Pedro Bay Ports. 2018. *San Pedro Bay Ports – Clean Air Action Plan.* Available online at: https://cleanairactionplan.org/documents/final-drayage-truck-feasibility-assessment.pdf/. Accessed September 2020.

Battery electric technology is in development for multiple applications, including heavy duty drayage and non-drayage trucks. Electric trucks use a battery for propulsion and refuel with electricity generated from the grid or by distributed energy resources (DERs) such as solar power. Battery electric technologies therefore do not produce any air pollutant or GHG emissions at the tailpipe, so any related emissions are from upstream processes. Although even when considering the upstream emissions associated with electricity generation, the energy efficiency of electric batteries and the emissions profile of the San Diego region's electric grid, result in lower emissions than comparable fossil fuel alternatives. According to the California Energy Commission, San Diego Gas & Electric generated 43% of its 2018 electricity sales from renewable generation, 29% from natural gas generation, and 27% from unspecified power sources.[16] Further, since the state is required to meet a goal of 100% carbon-free retail electricity sales by 2045, the upstream emissions profile associated with electric vehicles in California is expected to continue to decline.[17] At present, electric drayage truck technology is able to achieve 80 to 100 percent reduction in GHG emissions when compared to conventional diesel.[18]

Battery electric technologies are significantly more energy efficient than conventional diesel vehicles for different weight classes, vehicle types, and duty cycles. Battery electric vehicles have energy efficiency ratios approximately 3.5-7 times greater than conventional diesel engines depending on vehicle speed, with greater efficiency improvements at lower speeds due to losses during idling and coasting with conventional engines.[19]

In 2019, Californians consumed approximately 114 million gasoline gallon equivalents of electricity for transportation, accounting for approximately 5 percent of the total alternative fuel demand in California.[20] While vehicle electrification for heavy-duty vehicles has been slower to evolve than light- and medium-duty applications, several technology demonstrations for Class 7-8 trucks have been deployed across the country, and at ports within the state specifically.

The Port is working to prepare itself to support the electrification of vehicles by providing the infrastructure necessary for these technologies. For example, chargers have been installed at the National City Marine Terminal to power drayage trucks as well as electric cars and yard tractors. Working with agency partners such as San Diego Gas and Electric, the Port is piloting additional EV Charging for medium- and heavy-duty freight equipment.

Hydrogen

Another viable alternative fuel for Class 8 heavy duty trucks is hydrogen. Fuel-cell electric trucks operate similarly to battery electric trucks where an electric motor is responsible for propulsion. The main difference between the two is that in a fuel cell electric truck on-board hydrogen is processed through a fuel cell to produce electricity, which is then stored in a battery and used to power an electric motor. While it is still too early to say whether battery electric trucks or hydrogen fuel cell trucks will capture greater market share, fuel cell trucks may be well-

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[16] *SDG&E 2018 Power Content Label. Available online at:* https://www.energy.ca.gov/sites/default/files/2020-01/2018_PCL_San_Diego_Gas_and_Electric.pdf. Accessed January 2021.
[17] California Energy Commission. n.d. *Senate Bill 100 Joint Agency Report*. Available online at: https://www.energy.ca.gov/sb100
[18] ICF. 2019. *Comparison of Medium- and Heavy-Duty Technologies in California*. December.
[19] CARB. 2018. *Battery Electric Truck and Bus Energy Efficiency Compared to Conventional Diesel Vehicles*. May. Available online at: https://ww2.arb.ca.gov/resources/documents/battery-electric-truck-and-bus-energy-efficiency-compared-conventional-diesel Accessed August 2020.
[20] CARB. n.d. *Data Dashboard: 2011-2019 Performance of the Low Carbon Fuel Standard*. Available online at: https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm. Accessed August 2020.

positioned for long-haul operations due to longer range and quicker refueling compared to battery electric trucks.

Hydrogen is currently mainly produced from natural gas through a process called natural gas reforming, or gasification. The process works by reacting natural gas with high-temperature steam and it produces three end products: hydrogen, carbon monoxide, and carbon dioxide. There are a handful of other production techniques including electrolysis, renewable liquid reforming, and fermentation (e.g., landfill methane). As it stands, gasification is the least expensive and efficient of the current production techniques.[21] However, hydrogen fuel cell vehicle emissions will vary depending on the hydrogen production process used. Hydrogen from natural gas has the highest amount of emissions compared to electrolysis and fermentation. Electrolysis, which is the splitting of water into hydrogen and oxygen, using electricity will have lower emissions when renewable energy (e.g., solar or wind electricity) is used compared to non-renewable generated electricity.[22]

There are less heavy-duty hydrogen fuel cell vehicle pilots to point to compared to battery electric projects, but more are expected. One existing pilot project is taking place at the Ports of Los Angeles and Long Beach and is assessing the feasibility of the technology. This project tested Two Kenworth T680 Class 8 trucks utilizing Toyota fuel cell electric drivetrains in 2020, with an additional 8 trucks coming in 2021.[23] The Port of Houston started to launch a fuel-cell electric hybrid demonstration project in 2017 and 2018 with the intention of using Navistar International drayage trucks, however the project fell apart due to the lack fleet partner.[24] The joint CARB and CEC Zero-Emission Drayage Truck and Infrastructure Pilot Project described in previous sections of this chapter is open to both battery and fuel cell electric trucks.

Renewable Diesel

Renewable diesel is an alternative fuel made of agricultural waste products including natural fats, vegetable oils, and greases. Renewable diesel is not a fossil fuel, but is chemically similar, and effectively identical in performance characteristics to conventional petroleum diesel.[25] For these reasons, renewable diesel can be used in conventional diesel engines, pipelines, and storage tanks with no need for blending.

When compared to conventional diesel, Class 8 vehicles operating with renewable diesel can achieve GHG emission reductions of 50 to 70 percent. Relative to conventional diesel, renewable diesel used in California resulted in a reduction of 5.8 and 9.4 tons of NOx per day in 2018 and 2019, respectively.[26]

In 2019, Californians consumed approximately 692 million gasoline gallon equivalents of renewable diesel for transportation, accounting for approximately 30 percent of the total

[21] Alternative Fuels Data Center. n.d. *Hydrogen Production and Distribution*. Available online at: https://afdc.energy.gov/fuels/hydrogen_production.html. Accessed January 2021.
[22] UCS. 2014. *How Clean Are Hydrogen Fuel Cell Electric Vehicles*. Available online at: https://www.ucsusa.org/sites/default/files/attach/2014/10/How-Clean-Are-Hydrogen-Fuel-Cells-Fact-Sheet.pdf. Accessed January 2021.
[23] Toyota. 2020. *First Heavy Duty Fuel Cell Electric Trucks Set for Delivery to Pilot Program Customers at Ports of L.A. and Long Beach*. December 10. Available online at: https://pressroom.toyota.com/first-heavy-duty-fuel-cell-electric-trucks-set-for-delivery-to-pilot-program-customers-at-ports-of-l-a-and-long-beach/. Accessed January 2021.
[24] Houston-Galveston Area Council. 2018. *Hydrogen Fuel Cell Electric Hybrid Truck Demonstration – Final Technical Report.* November 2018. Available online at: https://www.osti.gov/servlets/purl/1496037. Accessed January 2021.
[25] CARB. 2018. *Renewable diesel is increasingly used to meet California's Low Carbon Fuel Standard*. November 13. Available online at: https://www.eia.gov/todayinenergy/detail.php?id=37472#. Accessed August 2020.
[26] CARB. 2020. *Public Hearing to Consider the Proposed Amendments to the Regulation on the Commercialization of Alternative Diesel Fuels.* January 7. Available online at: https://ww3.arb.ca.gov/regact/2020/adf2020/isor.pdf. Accessed September 2020.

alternative fuel demand in California.[27] According to the U.S. Energy Information Administration (U.S. EIA), California is the greatest consumer of both U.S. produced and imported renewable diesel due to the economic benefits of the State's Low Carbon Fuel Standard (LCFS). The import of renewable diesel to California is currently limited mainly to the Neste and Diamond Green companies. Neste Oil is a Finnish company that supplies renewable diesel to California from a refinery in Singapore. Since 2010 when operations began, production capacity of the Singapore refinery has increased from 800,000 to 1.3 million tons annually.28 There are currently eight cardlock fueling stations offering Neste renewable diesel in Northern and Central California.29 Diamond Alternative Energy is a U.S. based company and subsidiary of the Valero Energy corporation. Diamond Green Diesel is a joint venture, which operates a renewable diesel plant in Norco, Louisiana.[30] The plant is the largest of its kind in North America, and at capacity produces approximately 275 million gallons of renewable diesel annually. There are significant investments occurring in both of these dedicated renewable diesel plants and co-processing plants. By 2021, Diamond Green Diesel is expected to expand production to 675 million gallons of renewable diesel annually, and process approximately 20% of the animal fats and used cooking oil generated in the U.S.31 Neste has also announced plans to more than double the output of their refinery in Singapore to meet the global demand for renewable energy.32 Interest in policies similar to the California LCFS may present competition from other states for renewable diesel in the foreseeable future.

Vehicles

There are a handful of zero-emission, heavy-duty truck models currently available, and many more expected to come in the short- and mid-term. Several traditional truck and engine manufacturers have each developed zero-emission trucks and there are numerous OEMs entering the market.

The Port used ZETI, a public database of commercially available or announced zero-emission, medium- and heavy-duty vehicles, to identify Class 8 battery electric and fuel cell electric trucks available and announced.[33] Commercial availability is defined as when vehicle manufacturers are positioned – through established manufacturing facilities, supply-chain agreements, and logistics – to begin production due to orders placed. Of these trucks, 6 were expected to be commercially available by the end of 2020 and another 6 were expected to be commercially available by the end of 2021, while the rest should become available over the next 2–3 years. As reported in the ZETI tool, as of March 2021, five trucks – the Meritor Tractor, BYD 8TT, BYD Day Cab, Volvo VNR, and the Lion 8T – are available. Each has a range of over 100 miles, which is enough to complete the average drayage truck duty cycle of less than 100 miles on a

[27] CARB. n.d. Data Dashboard: 2011-2019 Performance of the Low Carbon Fuel Standard. https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm. Accessed August 2020.
[28] Neste. 2020. *Production: Singapore*. Available online at: https://www.neste.com/about-neste/who-we-are/production/singapore. Accessed September 2020.
[29] Biodiesel Magazine. 2020. *Neste Opens 4 New Renewable Diesel Fueling Stations in California.* July. Available online at: http://www.biodieselmagazine.com/articles/2517085/neste-opens-4-new-renewable-diesel-fueling-stations-in-california. Accessed September 2020.
[30] Diamond Green Diesel. 2019. *About Diamond Alternative.* Available online at: https://www.diamondgreendiesel.com/about-diamond-alternative. Accessed September 2020.
[31] DAR PRO Bio Energy. 2020. *Diamond Green Diesel.* Available online at: https://www.darpro-bioenergy.com/solutions/diamond-green-diesel. Accessed September 2020.
[32] Jaganathan and Samanta. 2019. *Finland's Neste expands Singapore refinery as it taps renewable growth.* July 30. Available online at: https://www.reuters.com/article/us-singapore-neste-interview/finlands-neste-expands-singapore-refinery-as-it-taps-renewable-growth-idUSKCN1UQ0OW. Accessed September 2020.
[33] *Drive to Zero's Zero-emission Technology Inventory (ZETI) Tool Version 5.5.* Available online at https://globaldrivetozero.org/tools/zero-emission-technology-inventory/.

single charge. As will be discussed later in the chapter, several demonstrations and pilots are underway or being planned, and those projects will increase the industry's understanding of the in-use range capabilities of these trucks.

Table TRK-B Table 1 shows what battery electric and fuel cell trucks are currently available and under development. The availability dates listed are reported in ZETI and based on manufacturer announcements; vehicles could potentially be offered in limited quantities and actual product availability may change depending on how OEMs progress with vehicle development.

TRK-B Table 1. Current Available and Future Available Battery Electric Trucks for Class 8 Applications

Manufacturer	Model	Energy Storage (EV: kWh, H2: kg H2)	Estimated Range (miles)	Availability or Expected Availability
Electric				
BYD	8TT	435	150	2020*
Peterbilt	579EV	396	150	2020*
Volvo	VNR Electric	300/560	75–175	2020*
Lion	Lion8T	588 kWh	210	2021*
Kenworth	T680E	396	150	2021
Mercedes-Benz	EActros (U.S.)	240	124	2021
Navistar	Navistar Class 8	107–321	250	2021
Freightliner/ Daimler	eCascadia	550	250	2022
Tesla	Semi	NA	300/500	TBD
Nikola	Tre EV/ Two EV	720	250	TBD
XOS	ET-One	NA	300	TBD
Fuel Cell				
Hyundai	Xcient	32	249	2020
Toyota	Beta	40 kg	300	2020
Kenworth	T680 FCEV	NA	350	2021
Nikola	One FC	NA	650	2023
Hyundai	HDC-6 Neptune	NA	600-800	2023

Source: Compiled from ZETI tool, March 2021.
* these are available for order or pre-order

Vehicle ranges for heavy-duty trucks operating on longer routes are expected to increase as manufacturers develop higher energy density, longer-range truck batteries. For example, the Tesla Semi is projected to exceed 500 miles near the 2023 timeframe. Also, fuel cell electric vehicles are likely to play a role in long-haul applications where the high capital cost of the vehicle and the cost of the fuel could make a better business case given higher vehicle utilization. In addition, fuel cell electric trucks may be positioned to serve operations that demand refueling which is quicker than current electric vehicle chargers are able to provide.

Charging and Fueling Infrastructure

Charging

Charging infrastructure for heavy-duty electric trucks requires a higher power output than light-duty and medium-duty EVs in order to charge larger batteries in a constrained amount of time. The appropriate power level of a charger depends on vehicle resting time, vehicle operations, and the size of the vehicle's battery. For example, a vehicle with a depleted battery pack of 250 kilowatt hours (kWh) can charge up to 80% in approximately 90 minutes at 150 kW or in 4–5 hour at 50 kW. TRK-B TRK-B Figure 2 and TRK-B TRK-B Figure 3 show examples of vehicle chargers capable of charging medium- and heavy-duty vehicles. Some real world examples of charging stations include the ABB HVC (TRK-B TRK-B Figure 2), which has a power range of 100–150 kW with a voltage range from 150–850 V DC and sequential charging with up to three outlets with 100 kW and 150 kW per vehicle; and the ChargePoint Express Plus (TRK-B TRK-B Figure 3) has a modular and scalable architecture that allows for up to four Power Blocks to serve each station and send up to 500 kW to a single vehicle. While there is currently no standard for appropriate battery size. Battery sizes will vary, but it is likely that battery sizes will increase as a response to reductions in battery costs.

TRK-B Figure 2. ABB HVC 150 kW

TRK-B Figure 3. ChargePoint Express Plus

The figures above represent only a couple examples of charging infrastructure available for medium- and heavy-duty vehicles. Other models exist and more are being developed. Research is also ongoing to develop innovative charging solutions that address an increasing number of functional requirements as a result of a growing set of charging use cases. In addition to plug-in chargers, wireless (inductive) and overhead chargers have been used for medium- and heavy-duty EVs in some existing markets, including transit buses and urban delivery vans. For example, Oak Ridge National Laboratory (ORNL) released results from a demonstration project with UPS that deployed a 20-kW bi-directional wireless charging system for a medium-duty electric parcel delivery van. ORNL found that power transfer from the wireless charging pad to the truck was greater than 92 percent efficient.[34] It is expected that this technology will continue to improve in its power capacity, which will be necessary to charge heavy duty drayage and non-drayage trucks in a reasonable timeframe.

[34] Edelstein, Stephen. 2020. *Wireless Charging Demo for Trucks: 20 kW Across 11 inches, 92% Efficiency*. Available online at: https://www.greencarreports.com/news/1127954_wireless-charging-demo-for-trucks-20-kw-across-11-inches-92-efficiency. Accessed January 2021.

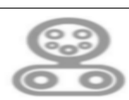
While plug-in EV charging is expected to serve a sizeable truck population, drayage trucks often idle in queues and while loading and unloading, which could make strategically placed opportunity charging using technology such as wireless chargers an option for fleets and the Port to consider.

Critical for enabling heavy-duty charging was the international standard for three-phase charging, which is common at commercial and industrial locations in the U.S. and Canada. The standard, SAE J3068, was instituted in 2018 and was designed specifically for medium-duty and heavy-duty vehicle charging. SAE J3068 is similar to the European IEC 62196 (aka Type 2 or CCS Combo). SAE J3068 was designed to enable the use of three-phase 480 volts (V) (up to 133 kW at 160 amperes), as well as 600 V alternating current (AC) (up to 166 kW at 160A). Additionally, SAE J3105 applies to overhead charging and SAE J2954/2 to HD wireless charging. However, to date overhead and wireless have been used for electric buses but not for electric trucks.

CCS1 connectors are expected to be used widely in North America. However, CCS2 connectors have been used in some electric truck pilot projects. The need for higher power charging has created a shift toward direct current (DC) charging as well. It also shifts some costs away from vehicles toward infrastructure because higher charging power rates are typically more expensive, and vehicles charging solely by DC fast charging will not bear the added costs of on-board AC-to-DC inverters.

TRK-B Table 2 lists the most common types of charging connectors, with added details including charger level categories and power levels. Proprietary stations and connector types, such as those for Tesla, are not included.

TRK-B Table 2. Examples of Different Chargers and Charging Stations[35]

Charging Station Level (Electric Current Type)	U.S. Connector Type	Power	Fill Time for a 100kWh Battery (80% Fill)	Voltage	Best Commercial Use Case Example
Level 2 (Alternative Current (AC) 1-phase)	 **SAE J1772**	> 3.7 kW ≤ 22kW	7 kW = 12.5 hours 22kW = 4 hours	208/240V	Medium- and heavy-duty vehicles that sit parked for 5+ hours at a time
Level 3 (Direct Current (DC) Fast Charging)	 **CHAdeMO**	> 22 kW ≤ 43.5 kW	2+ hours	277/480V	Medium- and heavy-duty vehicles with shorter routes/smaller battery packs that have a natural pause in their duty cycle of around 2 hour or more; medium- and heavy-duty vehicles with a longer route / larger battery packs that can charge over several hours
Level 3 Combo (AC, DC Fast Charging) Note: Combined Charging System (CCS1) Combo 1 Connector is currently used in North America, but the CCS2 combo 2 may be used in North American MD/HD applications.	 **J1772 CCS1**  **J3068 CCS2**	Today, <450 kW, projected up to 1 MW	15+ minutes (future) 40+ minutes (today)	Industrial voltage levels (speak with your utility)	Medium- and heavy-duty vehicles that have a natural pause in their duty cycles (e.g. while waiting at a loading dock) that is less than 2 hours
Inductive Charging (DC)		Inductive charging equipment uses an electromagnetic field to transfer electricity to a plug-in electric vehicle without a cord. In HD applications, inductive charging is often used for in-route charging on bus routes with 150-300 kW charging capability.			

[35] CALSTART. 2020. *Chicago Commercial Electric Vehicle Readiness Guidelines*. Available online at https://www.chicago.gov/content/dam/city/progs/env/MDHDCommercialEVReadiness.pdf.

The energy capacity of electric truck batteries is expected to increase; therefore, a concurrent need for higher power charging can be expected. Current standards allow for charging up to 350-kW, but research on very high-power charging is underway. CharIN and the High-Power Commercial Vehicle Charging Task Force are currently developing a charging standard for chargers rated at one to three megawatts of power.[36] Similarly, Tesla trucks are expected to charge at 500 kW with their proprietary charging system.

Beyond technological specifications, the ownership model of certain charging options is important for stakeholders to consider. Charging infrastructure for many trucks is expected to be located at a fleet depot as fleets are expected to charge at the end of their workday. This will be true for fleets that operate predictable routes, can allow their trucks to sit overnight, and have depots. However, many fleets in California are small and that may not have such a facility. Innovative options for delivering electricity to these fleets will need to be developed, such as public, shared, or limited-access charging sites.

Importantly, entities that deploy charging infrastructure at their facilities (e.g., fleet depots, warehouses, Port properties) may require facility and grid upgrades to accommodate new power demand, depending on how extensive their deployment plans are. Although the cost of these upgrades can be significant, the State of California and its investor-owned utility companies have implemented 'make-ready' programs to help entities deploy this infrastructure at low or zero cost. In make-ready programs, like **San Diego Gas & Electric (SDG&E):** *Power Your Drive for Fleets*, utilities cover the make-ready costs of charging infrastructure development, which generally includes infrastructure between the grid interconnection and the charger. Other costs covered by available make-ready programs vary somewhat by utility. Through the programs, utilities help fleets and infrastructure site hosts with infrastructure planning, design, construction, and maintenance. SDG&E has set a goal to service 3,000 medium- and heavy-duty vehicles (on- and off-road) at 300 sites in their service area.

In addition to the make-ready programs, utilities are also developing special commercial electricity rates that are aimed to incentivize electric vehicle adoption. SDG&E will make a specific rate available for heavy-duty electric vehicle charging applications. The High-Power Electric Vehicle Rate (EV-HP) will give flexibility and transparency to customers to determine the amount of power necessary to charge their fleet and pay this in the form of a subscription fee each month. Notably, customers in the EV-HP plan will not pay demand charges.[37]

As stated above, public charging may be required in some situations. Public charging for heavy-duty electric trucks is currently not available. However, individual stations and corridor electrification for MD and HD electric trucks are in the planning stage. One public charging station for electric trucks is planned at a Loves station in Southern California as part of the Volvo LIGHTS project and should be installed in 2021.[38] Other locations are being planned along and around important corridors. US West Coast utilities recently completed a study to map out optimal charging infrastructure locations along the Interstate (I-) 5 corridor.[39] The study proposes installing charging infrastructure at 27 sites to serve both MD and HD truck in a first phase. In the second phase, about half of these sites are proposed to be expanded to accommodate higher power charging for HD electric trucks.

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[36] CharIN. 2019. *CharIN Steering Committee paves the way for the development of a CCS compliant plug for commercial vehicles with >2MW.* Available online at: https://www.charinev.org/news/news-detail-2018/news/charin-steering-committee-paves-the-way-for-the-development-of-a-ccs-compliant-plug-for-commercial-v/.

[37] *SDGE Power Your Drive for Fleets.* Available online at: http://semprasdande.prod.acquia-sites.com/sites/default/files/sdge.pydff_-_rate_waiver_fact_sheet.pdf.

[38] Volvo Lights. n.d. Available online at: https://www.lightsproject.com/project-map/. Accessed January 2021.

[39] *West Coast Clean Transit Corridor Initiative, 2020.* Available online at: https://www.westcoastcleantransit.com/.

Hydrogen Fueling

As part of Assembly Bill 8, California set a goal to build a network of 100 light-duty hydrogen fueling stations across the state. At this time, hydrogen fueling station development is still in its early stages, with approximately 44 stations currently in operation in California.[40] So far these stations are designed for light-duty vehicles, but much can be learned from these developments in preparation for building out hydrogen infrastructure for heavy-duty applications.

There are three different hydrogen delivery system options available: delivered gaseous hydrogen, delivered liquid hydrogen, and on-site hydrogen generation via electrolysis. In the delivered gaseous hydrogen system, hydrogen is produced at central steam reforming production facilities, and is then transported to the station within high-pressure tube trailers before it is stored in pressurized underground storage vessels. Delivered liquid hydrogen systems are similar to gaseous systems. Hydrogen gas is generated from natural gas at a central steam reforming plant, and is then it is chilled until it takes liquid form before it is pumped into a pressurized and temperature-controlled trailer. The trailer is then transported to the station and pumped into an on-site tank where it is stored until use. Finally, electrolysis is the process of generating hydrogen from water and electricity. Water molecules are split with an electric current inside of an electrolyzer, and then the H2 gas is captured and compressed within storage tanks before being dispensed into a vehicle.

From an infrastructure development standpoint, hydrogen stations require pressurized tubes and storage tanks, chillers, compressors, a dispenser, an electrolyzer, and the utility interconnection.[41] This poses additional space considerations for the Port, fleets, and/or any other stakeholder involved in infrastructure development. Hydrogen fueling can be completed faster than EV charging, depending on charger power levels and the setup of the hydrogen fueling station, making hydrogen fuel cell trucks a possible option for operations that require fast re-fueling.

Hydrogen infrastructure costs vary depending on delivery system design, hydrogen storage capacity, and scale. Early cost estimates indicate hydrogen fueling stations for heavy-duty vehicles can cost in the millions. A March 2020 infrastructure development study for the West Coast Collaborative, which obtained survey responses from fleets and fuel providers on their desired medium- and heavy-duty alternative fuel infrastructure sites and scope, shows that respondents reported H2 infrastructure capex estimates ranging from $4M to $10M with varying station sizes.[42,43] Another important factor to consider is that the cost of hydrogen is significantly higher relative to other alternative transportation fuels (e.g., electricity, renewable diesel). For example, the average retail price of hydrogen in Q3 2019 was $16.54/kg, with a range from $14.99 to $18.71/kg, according to CEC and CARB.[44]

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[40] AFDC. n.d. *Hydrogen Fueling Station Locations.* Available online at: https://afdc.energy.gov/fuels/hydrogen_locations.html#/find/nearest?fuel=HY&hy_nonretail=true&location=california&page=5. Accessed January 2021.

[41] CEC & CARB. 2015. *Join Agency Staff Report on Assembly Bill 8: Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California*. Available online at: https://ww2.energy.ca.gov/2015publications/CEC-600-2015-016/CEC-600-2015-016.pdf. Accessed January 2021.

[42] CALSTART. 2017. *Best Practices in Hydrogen Fueling and Maintenance Facilities for Transit Agencies*. Available online at: https://www.energy.gov/sites/prod/files/2017/05/f34/fcto_bop_workshop_sokolsky.pdf. Accessed January 2021.

[43] CALSTART. 2020. *Alternative Fuel Infrastructure Corridor Coalition (AFICC).* Available online at: https://westcoastcollaborative.org/files/sector-fuels/wcc-aficc-mhd-infrastructure-development-plan-2020-03-12.pdf. Accessed January 2021.

[44] CEC & CARB. 2019. *Join Agency Staff Report on Assembly Bill 8: 2019 Annual Assessment of Time and Cost Needed to Attain 100 Hydrogen Refueling Stations in California*. Available online at: https://ww2.energy.ca.gov/2019publications/CEC-600-2019-039/CEC-600-2019-039.pdf. Accessed January 2021.

Truck Demonstration and Pilot Projects

Current and Recent Projects

In 2019, Californians consumed approximately 114 million gasoline gallon equivalents of electricity for transportation, accounting for approximately 5% of the total alternative fuel demand in the state.[45] While vehicle electrification for HD trucks has been slower to evolve than light- and medium-duty applications, several technology demonstrations for Class 7-8 trucks have been deployed across the country.

TRK-B Table 3 summarizes the heavy-duty truck demonstration projects currently ongoing or recently completed statewide. Project funding also includes matching funds in many cases.

TRK-B Table 3. Current Heavy-Duty Truck Demonstration and Pilot Projects

Demonstration Program	Year and Cost	Location	Trucks	Types of Cargo
California Collaborative Advanced Technology Drayage Truck Demonstration	2018 $40M	Ports of Stockton, Oakland, Los Angeles, Long Beach, and San Diego	44 HD pre-commercial Class 8; 37 battery electric trucks 25 EV trucks with 100-124 mile range; 12 Peterbilt/Transpower trucks with 110–150 mile range	Containerized cargo
Daimler Trucks North America (also known as Freightliner)	April 2019 $16M	Throughout Southern California	20 battery-electric trucks	Containerized cargo
CARB Zero and Near Zero-emissions Freight Facilities	Late 2018 $205 million	Throughout California	10 projects: zero emission HD truck and off-road equipment	Containerized cargo/ Food & Beverage
Volvo Low Impact Green Heavy Transports Solutions ("LIGHTS") Project	March 2019 $90.7 million	Ports of Long Beach and Los Angeles	23 HD battery electric trucks; up to 175 mile range with charging	Containerized cargo
Sustainable Terminals Accelerating Regional Transformation ("START") Project	January 2019 Unknown	5 at the Port of Long Beach; 10 at the Port of Oakland	Peterbilt and Transpower battery electric Class 8 drayage	Containerized cargo
Frito Lay Transformative Zero	March 2019	Modesto, California	15 HD Tesla battery-electric tractors along	Food & Beverage

[45] CARB. 2019. *Data Dashboard: 2011-2019 Performance of the Low Carbon Fuel Standard.* Available online at: https://www.arb.ca.gov/fuels/lcfs/dashboard/dashboard.htm. Accessed August 2020.

Demonstration Program	Year and Cost	Location	Trucks	Types of Cargo
and Near-Zero Emission Freight Facility Project	$30.8 million		with 38 Low NO_X trucks and 8 Peterbilt e220 battery-electric trucks.	
Zero-Emission Beverage Handling and Distribution at Scale	March 2018 $11.3 million	Four Anheuser-Busch facilities: Pomona, CA, Riverside, CA, Carson CA	21 battery-electric Class 8 BYD trucks 40 kW BYD chargers	Food & Beverage
San Diego Port Tenants Association Sustainable Freight Demonstration	August 2016 $8.2 million	Port of San Diego	4 Class 8 BYD Trucks	Autos; Break-bulk products

These demonstration and pilot projects are helping the industry surrounding ZE/NZE, heavy-duty trucks to advance this technology. Below are status updates on some of the projects listed above.

The California Collaborative Advanced Technology Drayage Truck Demonstration began in 2016 and deployed 44 heavy-duty pre-commercial Class 8 zero- and near-zero emission trucks across the Ports of Stockton, Oakland, Los Angeles, Long Beach, and San Diego. The deployed fleet consisted of 37 battery electric trucks including 25 BYD trucks with 100-124-mile range, and 12 Peterbilt/Transpower trucks with 110-150 mile range. The project is currently in Phase 2, which will support deployments informed by lessons learned during the Phase 1 field demonstrations. Phase 2 vehicles are anticipated to have faster onboard charging and an energy storage redesign, among other improvements.[46]

The Volvo Low Impact Green Heavy Transports Solutions ("LIGHTS") Project began in March of 2019, and deployed 23 heavy-duty battery electric trucks to the Ports of Long Beach and Los Angeles for goods movements routes from Port to four freight handling facilities located in disadvantaged communities. The Volvo battery electric technology features multiple truck configurations with electric ranges of up to 250 miles, and charging technology that includes the nation's first publicly accessible fast charging truck stations, integration of onsite solar panels, and use of second-life batteries which offset total cost of ownership.[47]

The Sustainable Terminals Accelerating Regional Transformation ("START") Project began in January 2019 and features various zero- and near-zero emissions port technologies that are anticipated to reduce emissions by approximately 13,000 MT CO_2e, 26 tons NOx, and marginal amounts of ROG and diesel PM annually. Among these technologies are fleets of Peterbilt and Transpower battery electric Class 8 drayage trucks including five 500-hp trucks at the Port of Long Beach, and ten 400-hp trucks at the Port of Oakland.[48]

[46] CARB. 2015. *California Collaborative Advanced Technology Drayage Truck Demonstration Project.* Available online at: https://ww3.arb.ca.gov/msprog/lct/pdfs/drayagedemo.pdf?_ga=2.35440545.1444818296.1599075411-2062905748.1586389966 Accessed September 2020.
[47] Volvo Lights. 2020. *Battery Electric Vehicle Technology.* Available online at: https://www.lightsproject.com/vehicle-technology/ Accessed September 2020.
[48] CARB. 2020. *Sustainable Terminals Accelerating Regional Transformation (START) Project Phase 1.* Available online at: https://ww3.arb.ca.gov/msprog/lct/pdfs/start.pdf Accessed September 2020.

Planned and Approved Projects

To continue to prove the feasibility of Class 8 zero-emission trucks, future pilot projects are expected in the state of California. TRK-B Table 4 shows two CARB and CEC program solicitations that were either released recently or planned to be released soon. In addition to this, State funding for infrastructure development is expected to be made available in the near future. The CEC issued a Notice of Proposed Award on December 16, 2020 with CALSTART proposed to administer its Block Grant for Medium-Duty and Heavy-Duty Zero-Emission Vehicle Refueling Infrastructure Incentive Projects. This program is expected to fund $20 million to support development of medium- and heavy-duty, zero-emission vehicle charging and fueling infrastructure.[49]

TRK-B Table 4. Planned and Announced Heavy-duty Truck and Infrastructure Projects and Programs

Demonstration Program	Year and Funding	Location	Trucks	Types of Cargo
Zero-Emission Drayage Truck and Infrastructure Pilot Project	Submission deadline: 02/16/21 $44.1M	Throughout California	Zero-emission Class 8 drayage and regional haul trucks (Note: large-scale deployment of 50+ trucks or more is preferred)	Containerized cargo Bulk cargo
Research Hub for Electric Technologies in Truck Applications (RHETTA)	Submission deadline: 03/29/21	Throughout California	High power charging systems; corridor charging strategies	N/A

The Zero-Emission Drayage Truck and Infrastructure Pilot Project solicitation is was recently released. This joint project between CARB and CEC seeks to deploy and test a relatively large number of zero-emission trucks and infrastructure. In workshops about the solicitation, CARB and CEC officials expressed a preference to have 50 or more trucks deployed within one fleet so that the study could test the ability of the fleet and the local electric grid in handling a large-scale deployment.[50] The San Diego Air Pollution Control District partnered with Duran Freight Corporation, which met the preferred fleet size requirements, and submitted its application on February 15, 2021. The Port coordinated with SDAPCD on its application and will continue to work with SDAPCD and other regional partners if grant monies are awarded.

Though it is not technically a demonstration or pilot project, the Research Hub for Electric Technologies in Truck Applications (RHETTA) solicitation is also currently open with a submission deadline of March 29, 2021. This CEC project aims to create a research hub to conduct applied research on high power charging systems and corridor charging.[51]

[49] California Energy Commission. n.d. *GFO-20-603 - Block Grant...Infrastructure Incentive Projects*. In *California Energy Commission*. Retrieved January 25, 2021, from https://www.energy.ca.gov/solicitations/2020-07/gfo-20-603-block-grant-medium-duty-and-heavy-duty-zero-emission-vehicle
[50] CEC. 2020. *GFO-20-606 - Zero-Emission Drayage Truck and Infrastructure Pilot Project*. Available online at: https://www.energy.ca.gov/solicitations/2020-11/gfo-20-606-zero-emission-drayage-truck-and-infrastructure-pilot-project.
[51] CEC. 2020. G*FO-20-306 – Research Hub for Electric Technologies in Truck Applications (RHETTA)*. Available online at: https://www.energy.ca.gov/solicitations/2020-12/gfo-20-306-research-hub-electric-technologies-truck-applications-rhetta.

Costs and Emissions Reductions

Cost

The cost of heavy-duty ZE trucks can be assessed based on the capital cost; however, considering the total cost of ownership (TCO) is a more thorough metric in order to understand what the total cost to purchase, operate, and maintain the vehicle. TCO is case specific and depends on a number of variables, including the purchase price of the baseline vehicle and the vehicle that is expected to replace it, the fueling and maintenance costs for both, the incentive amounts for the clean fuel vehicle, infrastructure costs, and insurance. While TCO is case specific and depends on the variables identified above, there is potential for electric trucks to have lower lifetime TCO (Total cost for the life of the vehicle) than diesel or natural gas trucks if the conditions are right. The payback period, or breakeven point, when the clean fuel vehicle becomes less expensive than the conventionally fueled vehicle will vary as well. Currently, the California's Hybrid and Zero-Emission Truck and Bus Voucher Incentive Program (HVIP) incentives improve the TCO of Class 8 drayage trucks but going forward there is uncertainty to what degree incentive programs will be available.[52]

Understanding how the Port's investments lead to reductions in emissions can help inform what level of investment and what timeframe is necessary to achieve emissions reductions goals. TRK-B Table 5 presents varying levels of investment over the 7-year lifetime of a truck and how a truck's VMT impacts the cost to reduce one pound of diesel particulate matter per day. A simple method where the investment amount divided by pounds of DPM produced depending on daily VMT was used to calculate estimates. These results show that with high investments – which are necessary at the moment to cover the incremental cost of electric trucks – the cost to reduce daily DPM is relatively high. As investments increase as well as other industry mechanisms that narrow the price gap between conventional and electric trucks, which lower the amount of investment needed, the cost to reduce daily DPM lowers. In addition, as truck utilization increases (e.g., miles/day) the cost effectiveness improves across all investment amounts.

TRK-B Table 5. Summary of Investment Levels on DPM Emission Reductions ($/lb/day DPM Reduced)

$/invested in ZEV	Miles/day					
	25	50	100	150	200	500
$10,000	$15,528	$7,764	$3,882	$2,588	$1,941	$776
$25,000	$38,820	$19,410	$9,705	$6,470	$4,853	$1,941
$50,000	$77,641	$38,820	$19,410	$12,940	$9,705	$3,882
$75,000	$116,461	$58,231	$29,115	$19,410	$14,558	$5,823
$100,000	$155,282	$77,641	$38,820	$25,880	$19,410	$7,764

Note: Analysis based on dollars invested per vehicle per year. Trucks are assumed to operate 26 days per month or 312 days per year.

[52] ICF. 2019. *Comparison of Medium- and Heavy-Duty Technologies in California*. December.

A summary of technology capital cost and cost per emissions saved for zero-emission trucks is presented in TRK-B Table 6 Technology costs were obtained from analyses by the California Electric Transportation Coalition, as well as from conversations with OEMs. It is important to note that technology cost is for 2020 and, while capital costs for battery electric trucks are the highest, costs are expected to decrease significantly in the near- and mid-term as economies of scale lowers the cost of key vehicle components, namely batteries.

Currently, cost-effectiveness per pound of emissions suggests that renewable natural gas may be more cost effective than electric. However, this does not tell the whole story because technology cost here is based solely on the capital cost of the vehicle and does not consider any costs associated with refueling infrastructure, fuel and operating costs, incentives, and insurance costs. In particular, operations and maintenance costs for EVs are lower than diesel, which over the lifetime of the vehicle can significantly improve the difference in upfront cost compared to diesel.[53]

TRK-B Table 6. Summary of Cost and Emission Savings per Cost

Vessel	Option	Technology Cost	Cost Per Pound of Emissions Saved		
			NOx	DPM	CO_2e
Class 8 Trucks	Renewable Natural Gas	$140,000	$234	$85,069	$996
	Renewable Diesel*	$110,000	-	-	$615
	Electric	$350,000	$526	$170,138	$1,809
	Hydrogen	$375,000	$609	$182,291	$3,682

*Renewable diesel is considered a drop-in fuel and can be used in conventional diesel engines without modification.

Emission Reductions

In this section, the emission reduction potential of three technologies – renewable natural gas, renewable diesel, and battery electric – are estimated and compared for trucks. For fleets operating diesel trucks, using renewable natural gas or battery electric technology means truck replacement or repowering. For renewable diesel, however, existing diesel vehicles can be utilized because renewable diesel is a drop-in fuel such that no modifications or vehicle replacements are necessary.

The focus of this analysis is on zero or near-zero emission technologies. While other fuel sources, such as biodiesel and fossil-fuel natural gas, exist, these are either not readily available or would not achieve requisite emission reductions. For example, while biodiesel would achieve emission reductions similar to renewable diesel, biodiesel is not considered a drop-in fuel, as it can affect engine performance in some diesel engines. Additionally, while fossil-fuel natural gas emits fewer air toxics than conventional diesel, conventional natural gas is still derived from non-renewable sources.

Emission reductions are based on the average specifications for each technology type. As shown in TRK-B Table 7 replacing Class 8 diesel trucks with battery electric trucks would result in the elimination of all NOx and DPM emissions, while emissions of CO_2e would decrease substantially. Importantly, grid emissions in these calculations are based on SDG&E's emission

[53] ICF. 2020. Zero Emission Truck Feasibility Study for Mitsubishi Cement Corporation.

rate as of 2018. Because SDG&E's procurement of carbon-free renewable energy sources will increase over time, so too will the GHG benefit of electric trucks, leading to expected increases in GHG reduction compared to estimates presented below. Natural gas used in trucks is considered low NOx due to heavy-duty low NOx standards.

TRK-B Table 7. Summary of Annual Average Emissions per Truck (metric tons per year)

Vessel	Option	Emissions Per Year (MT)		
		NOx	DPM	CO_2e
Class 8 Trucks	Existing Diesel	0.302	0.001	0.119
Class 8 Trucks	Renewable Natural Gas	0.030	0.0002	0.055
Class 8 Trucks	Renewable Diesel	0.302	0.001	0.038
Class 8 Trucks	Electric	-	-	0.031
Class 8 Trucks	Hydrogen	-	-	0.073

Truck Survey Results and Potential Routes for Short-Haul Pilot Projects

TAMT to National City

Refrigerated Containers

Refrigerated containers are one of three major cargo types that are processed at the TAMT, which results in approximately 700 containers per week. Of the 700 containers, about 130 containers are moved by truck from TAMT to the National Distribution Center (NDC) in National City, approximately five miles south. The remaining containers are transported outside of San Diego, mostly toward Los Angeles. Once at NDC, produce is transferred from 40-foot containers to 53-foot long-haul trailers before being transported out of the Port. The truck survey determined that currently, one company is responsible for the five-mile route to NDC, and it uses both company-owned and contracted vehicles. This route is a potential candidate to test electric truck and charging technologies give that it is relatively short and regular.[54]

TAMT to Otay Mesa/Working Waterfront

Dry Bulk

The primary bulk products passing through TAMT are bauxite, sugar, and fertilizer. Unlike the refrigerated container cargo that has a vessel call every week, none of the bulk carriers arrive with a regular cadence. The fertilizer has the shortest trip of two to three miles depending on the route; however, the trucking company handling this commodity also does many long hauls in the region. The bauxite goes to Victorville, California (roughly 164 miles one way) and Tucson, Arizona (roughly 408 miles one way). Sugar is hauled to a plant in Otay Mesa, approximately 30 miles away. Staff have learned that these operations require each truck to drive four or five trips per shift and to change drivers so that two shifts can be performed in one day. This sugar route may be another good candidate for testing electrification.

Break Bulk

Cargo that arrives at TAMT includes steel for shipbuilding, wind turbine blades and tower pieces, military ordnance, and electrical gear. The locations where trucks haul break bulk

[54] San Diego Unified Port District. 2020. Presentation and Direction to Staff on Clean Air and Emission Reduction Advancements.

include the Working Waterfront, which is three miles away; Riverside, approximately 100 miles away; Tehachapi, approximately 235 miles away; and Palm Springs, approximately 140 miles away. There is a current terminal service provider that is located at TAMT and has equipment that can move heavy, break bulk items. The short-haul route along the Working Waterfront may be a possible candidate for electrification.

NCMT to Otay Mesa

Approximately 400,000 vehicles pass through NCMT per year. The site is a confluence of ships, trains, and trucks that import vehicles from foreign ports. About 37% of cargo leaves NCMT by train, 18% leave by ship to Hawaii, and 45% leave by truck. Of those that leave by truck, roughly 5% are delivered within San Diego County, 80% go north toward Los Angeles, and 15% go east toward Arizona and Nevada. A good route candidate for electrification is one used to transport vehicles from NCMT to an offsite storage facility in Otay Mesa, roughly 15 miles away. Currently, Pasha, the NCMT terminal operator, has three BYD electric Class-8 trucks that can haul eight cars at a time on this route. Pasha does not currently need another truck for this route, but there may be an opportunity to electrify with trucking companies that are subcontracted.[55]

The route candidates highlighted above are good starting options as the Port pursues ways to pilot electric trucks and charging infrastructure. Given their lengths, they are strong project candidates to help the Port accomplish the actions and goals set forth by the SDAPCD in its Community Emissions Reduction Plan, which aims to develop and implement a short-haul, on-road electric truck pilot, displace between 3,000 and 10,000 diesel VMT annually, install needed charging infrastructure, and develop a strategy to support electric truck and infrastructure expansion beyond pilots.[56]

Commercial Availability

Technology Readiness Levels

CARB lays out a typical commercialization path that new technologies follow on their way to commercial availability. TRK-B Figure 4 shows the various stages in this path along with their associated Technology Readiness Levels (TRLs). Originally developed by NASA, TRLs are used to indicate the maturity of a given technology.

TRK-B Figure 4. CARB Commercialization Path Stages and TRLs

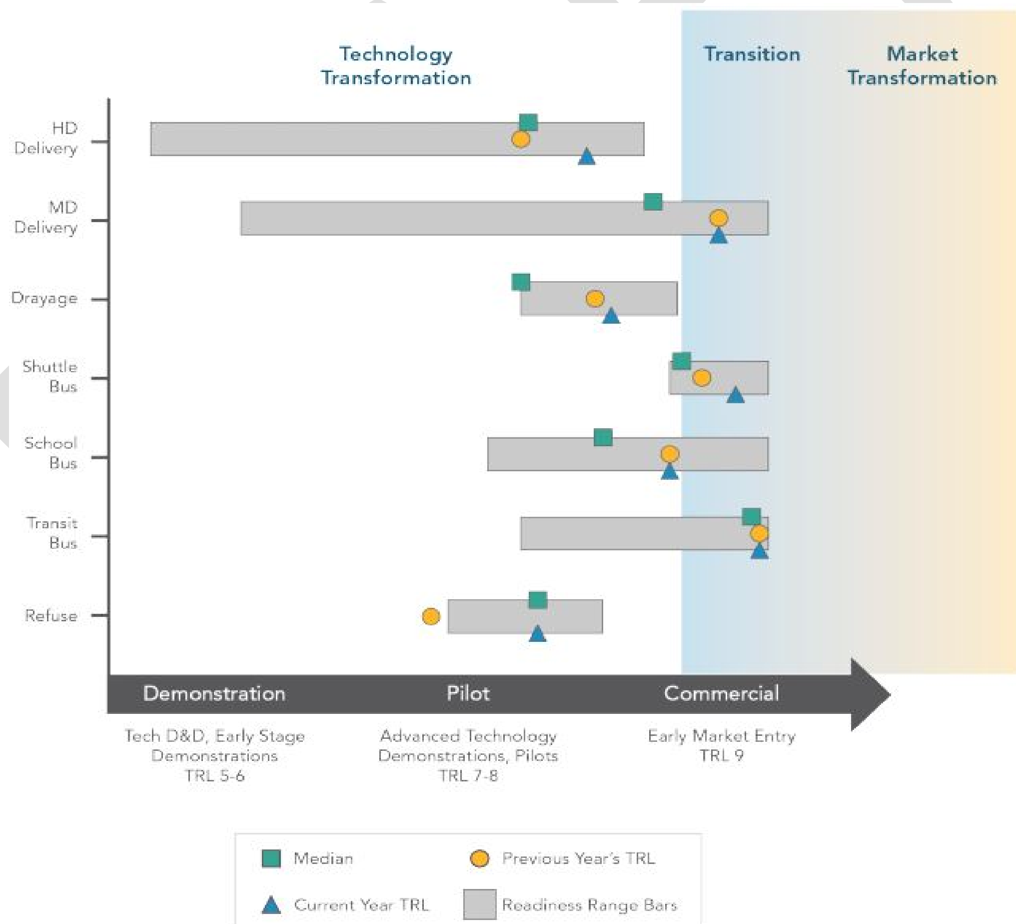
The Feasibility Assessment stage is first and consists of preliminary studies and standards development. After that, technology enters the Technology Research, Design, and Development stage which consists of early demonstration projects. Demonstrations are continued in the Precommercial stage and over time they transition into pilots, which differ in scale and technology maturity compared to demonstrations. Once a technology reaches TRL 9, it is considered to be

[55] San Diego Unified Port District. 2020. Presentation and Direction to Staff on Clean Air and Emission Reduction Advancements.
[56] San Diego Air Pollution Control District. 2020. *2020 Draft Community Emissions Reduction Plan*. Available at: https://www.sdapcd.org/content/dam/sdc/apcd/PDF/AB_617/Portside%20Environmental%20Justice%20DRAFT%20CERP%20Oct%202020.pdf

commercially available and the focus turns to scale-up of the technology within the market. As part of the Low Carbon Transportation Investments and Air Quality Improvement Program (AQIP) Funding Plan, CARB regularly maintains and updates its Long-Term Heavy-Duty Investment Strategy. Among other things, the strategy reports on the status of certain technologies in the ZE HD vehicle market.

According to CARB, ZE HD trucks are out of the early demonstration phase and currently in the pilot stage as they move toward commercial availability. TRK-B TRK-B Figure 4 shows CARB's assessment of on-road battery electric vehicles, per the 2020-2021 version of the strategy. According to CARB, both battery electric HD delivery and drayage trucks are currently in this Pilot stage and quickly approaching early market availability (TRK-B Figure 5). This rating by CARB is based on a few things, including the fact that several prominent HD truck OEMs are nearing production of battery electric models. This includes Volvo, Kenworth, Meritor, and others. Additionally, there are several HD battery electric truck pilot projects happening or planned to take place, such as the Volvo LIGHTS project,[57] the ZANZEFF project,[58] and CEC's Zero-Emission Drayage Truck and Infrastructure Pilot Project.[59]

TRK-B Figure 5. On-Road Battery Electric Vehicles Technology Status Snapshot

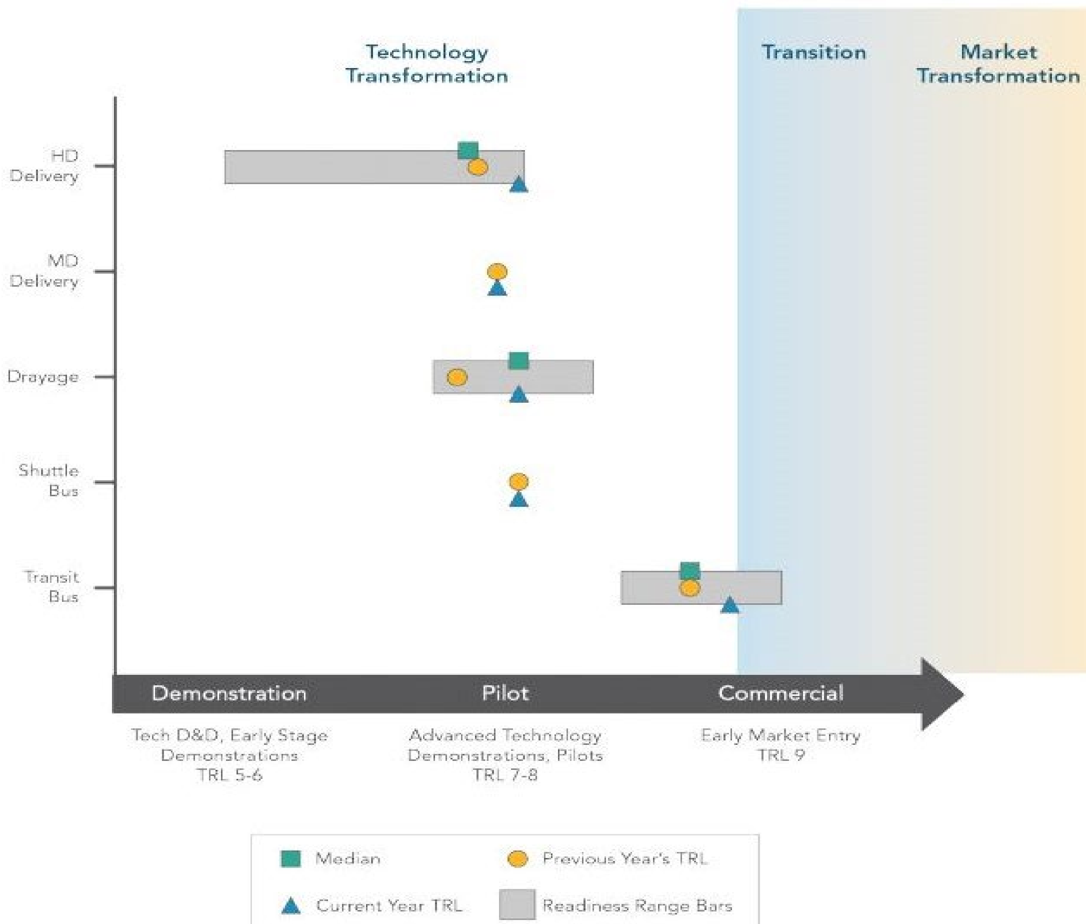


[57] Volvo LIGHTS. n.d.. About Volvo LIGHTS. In Volvo LIGHTS. Available online at: https://www.lightsproject.com/about/
[58] California Air Resources Board. 2018. *CARB announces more than $200 million in new funding for clean freight transportation*. Available online at: https://ww2.arb.ca.gov/news/carb-announces-more-200-million-new-funding-clean-freight-transportation#:~:text=The%20goal%20of%20CARB's%20Zero,commercialization%20of%20these%20technologies%20statewide.
[59] California Energy Commission. n.d. Available online at: https://www.energy.ca.gov/solicitations/2020-11/gfo-20-606-zero-emission-drayage-truck-and-infrastructure-pilot-project.

On-road, HD, fuel cell (FC) electric trucks for delivery and drayage are also working their way through the Pilot stage (TRK-B Figure 6). As mentioned in previous sections, fuel cell trucks are likely to work best in applications that require longer range, longer duration of operations, quicker refueling, or other demanding duty cycles. This makes them a good compliment to battery electric vehicles in the right applications.

Their current place in the commercialization path is based on recent activity by OEMs in the market, including Hyundai's delivery of their Xcient FC electric truck in Switzerland,[60] and Daimler and Volvo's agreement to jointly produce fuel cell powertrains.[61]

TRK-B Figure 6. On-Road Fuel Cell Electric Vehicles Technology Status Snapshot



In general, hybrid electric technology development in heavy-duty applications has slowed due to the rapid growth of fully electric technology (TRK-B Figure 7). Start-stop hybrid systems are becoming increasingly available for terminal tractors, however not much progress is currently being made for hybrid systems in drayage trucks, largely due to the focus on fully electric systems.

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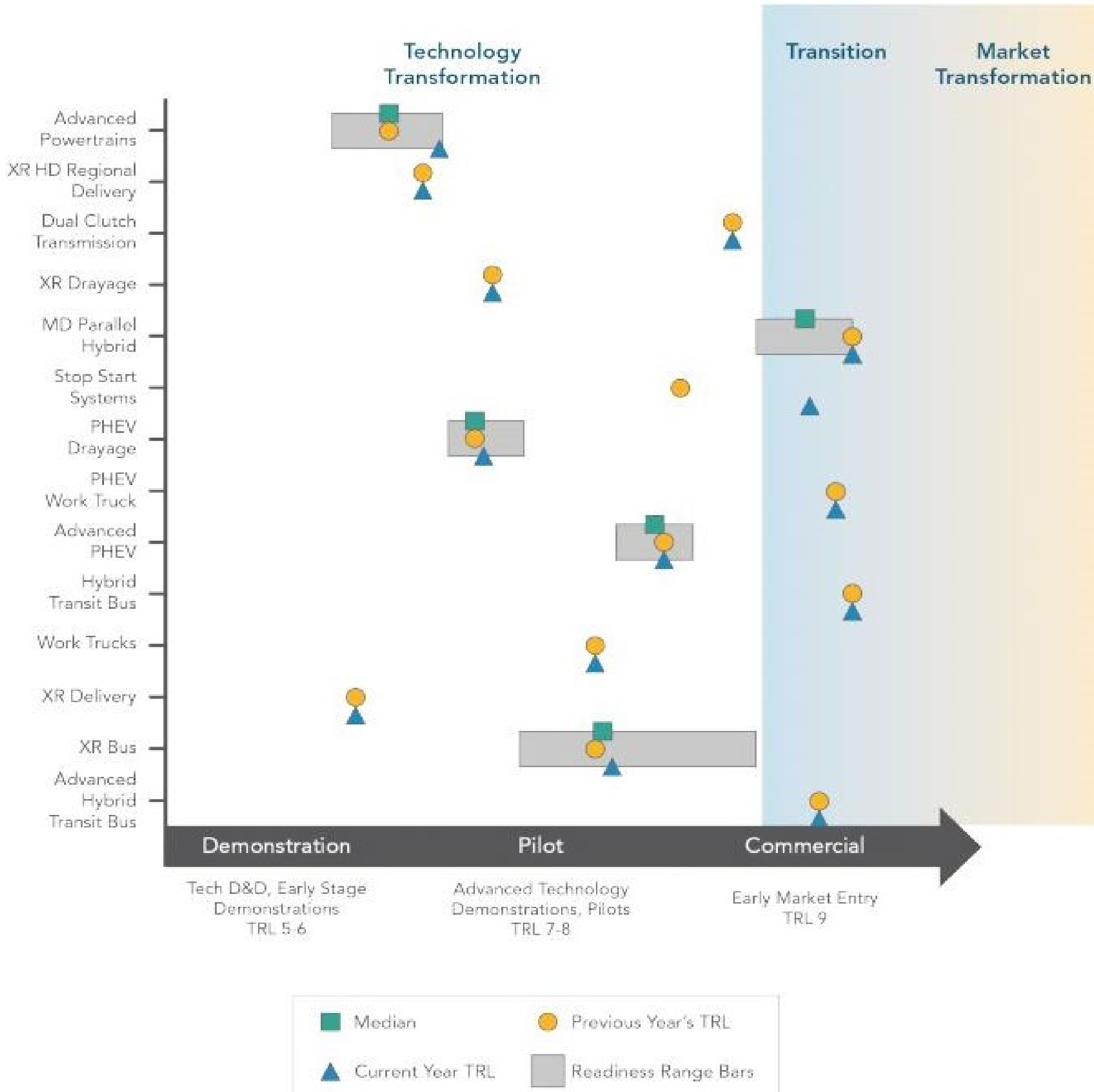
[60] Reuters Staff. 2020. *Hyundai delivers first fuel cell trucks to Switzerland.* Available online at: https://www.reuters.com/article/hyundai-switzerland-hydrogen-trucks/hyundai-delivers-first-fuel-cell-trucks-to-switzerland-idUSKBN26S1FM.

[61] Daimler. 2020. *Joint venture for large-scale production of fuel-cells: Volvo Group and Daimler Truck AG...joint venture*. Available online at: https://media.daimler.com/marsMediaSite/en/instance/ko/Joint-venture-for-large-scale-production-of-fuel-cells-Volvo-Group-and-Daimler-Truck-AG-sign-binding-agreement-for-new-fuel-cell-joint-venture.xhtml?oid=47981806.

TRK-B Figure 7. On-Road Hybrid Electric Vehicles Technology Status Snapshot



Vehicle Types at the Port

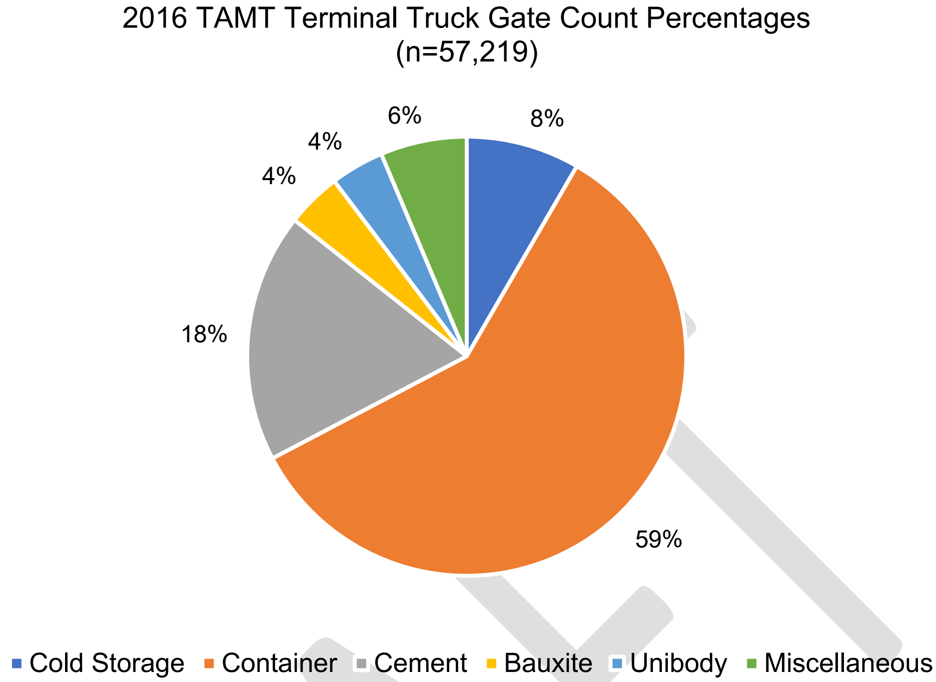
TRK-B

TRK-B Table 8 shows the count of vehicles that visited TAMT and NCMT in 2016 by truck type, according to the 2016 Maritime Air Emissions Inventory. TRK-B Figure 8 and TRK-B Figure 9 show the same information in percentages rather than discrete counts.

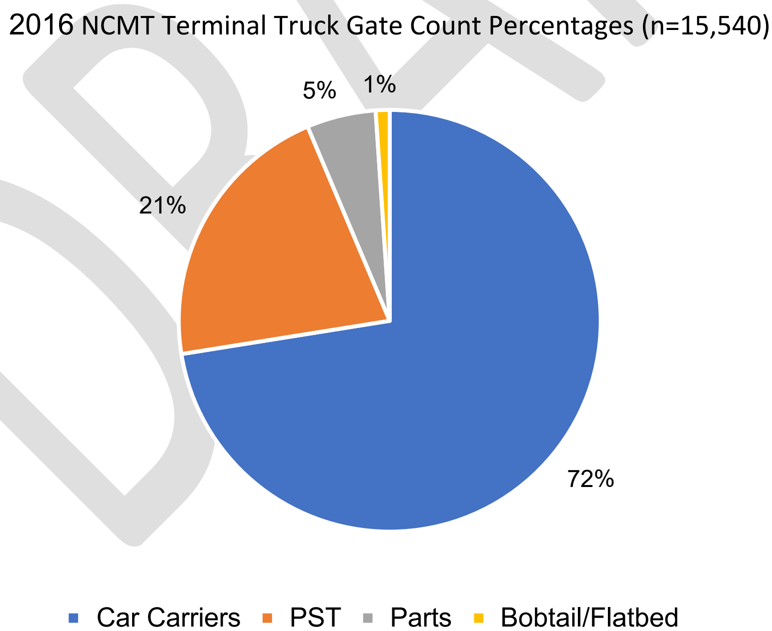
TRK-B Table 8. Port of San Diego 2016 Terminal Heavy Duty Truck Gate Counts by Type and Cargo

Truck Type	Counts	Cargo
TAMT	**57,219**	**-**
Container	33,721	Refrigerated Containers
Cement	10,504	Dry Bulk/Cement
Cold Storage	4,784	Refrigerated Containers
Miscellaneous	3,642	Miscellaneous (deliveries, etc.)
Bauxite	2,312	Dry Baulk/Bauxite
Unibody	2,256	Other Dry Bulk
NCMT	**15,540**	**-**
Car Carriers	11,263	Automobiles
Pasha Stevedoring & Terminals (PST)	3,288	Automobiles
Parts	823	Material Deliveries
Bobtail/Flatbed	166	Project/General Cargo

TRK-B Figure 8. Port of San Diego 2016 TAMT Terminal Truck Gate Count Percentages



TRK-B Figure 9. Port of San Diego 2016 NCMT Terminal Truck Gate Count Percentages



The vast majority of trucks that visited TAMT in 2016 were container trucks, followed by cement trucks. At NCMT, most trucks were car carriers, followed by PST trucks also hauling automobiles. In addition to the trucks that visit TAMT and NCMT, the Port also tracked the types of vehicles that traveled to and from the Port for cruise ship calls in 2016 which included heavy-duty tractors used for box deliveries.

As the Port examines opportunities for implementing ZE trucks, it is important to understand what types of trucks operate at the Port as well as the electric and fuel cell models that are either available today or are planned to be released in the near future. TRK-B Table in the Technologies and Strategies Section, above, shows several heavy truck models that are either available now or are planned to be made available in the near future, using data from the Global Commercial Vehicle Drive to Zero Program's Zero-Emission Technology Inventory (ZETI)[62].

Available Incentives

For technologies that are in pre-commercial stages, government subsidies and other incentives are helpful methods for accelerating adoption of that technology, and ZE HD trucks are no different. California HVIP, a first-come first-serve voucher incentive program for ZE/NZE medium- and heavy-duty vehicles, is one program in California that can help fleets offset the purchase price of these vehicles. The vouchers are applied at point-of-sale, effectively creating a discount on the purchase price of new and eligible vehicles. TRK-B Table 9 shows a breakdown of the HVIP incentive amounts for ZE trucks by GVWR.[63]

TRK-B Table 9. California HVIP Zero-Emission Truck Voucher Amounts FY 20-21

Vehicle Weight Class	Base Vehicle Incentive	Base Vehicle Incentive in Disadvantaged Community (+10% in funding)
Class 2b	TBD	TBD
Class 3	$45,000	$49,500
Class 4-5	$60,000	$66,000
Class 6-7	$85,000	$93,500
Class 8	$120,000	$132,000
Class 8 Drayage Truck Early Adopter	$150,000	$165,000

Finally, TRK-B Table 10 shows the funding caps for electric power takeoff units (ePTOs),[64] based on their energy storage capacity. Like the funding structure for plug-in hybrids, ePTO vouchers will cover up to 50 percent of incremental costs between the ePTO and the existing technology, up to the caps shown in the table below.

TRK-B Table 10. California HVIP Eligible ePTO Voucher Caps FY 19-20

Energy Storage Capacity	Base Vehicle Incentive*
3 – 10 kWh	$20,000
10 – 15 kWh	$30,000
> 15 kWh	$40,000

Note: *According to CARB, "ePTO funding amounts may cover up to 50 percent of the incremental cost of the ePTO vehicle, not to exceed the funding levels listed in this table." Funding n 20/21 remains the same as previous years.

[62] CALSTART. 2020. Zero-Emission Technology Inventory. In Global Commercial Vehicle Drive to Zero. Available online at: https://globaldrivetozero.org/tools/zero-emission-technology-inventory/. Accessed January 2021.
[63] California Air Resources Board. n.d. F*Y 20-21 HVIP Funding Tables*. Available online at: https://www.californiahvip.org/how-to-participate/. Accessed March 2021.
[64] Power take-off (PTO) is used in cement and other bulk material trucks to denote power and energy requirements when a trailer's power needs are supplied by the engine of the truck. For an electric PTO (ePTO), this power need would be powered by the vehicle's electric battery.

Recently, CARB launched a new voucher program for off-road vehicles, the California Clean Off-Road Equipment Voucher Incentive Project (CORE). Like HVIP, this program offers point-of-sale vouchers applied to the purchase of eligible off-road equipment. As seen in TRK-B Table 11 CORE provides funding for on- and off-road terminal tractors, TRUs, forklifts, container handling equipment, airport cargo loaders, aircraft tugs, railcar movers, mobile power units, ground power units, and mobile shore power cable management systems[65].

TRK-B Table 11. California CORE Voucher Amounts (as of January 2021)

Equipment	Description	Base Voucher Amounts
On- and Off-Road Terminal Tractor	New Battery-Electric Tractor (less than or equal to 160 kWh)	$150,000
	Battery-Electric Conversion Kit (less than or equal to 160 kWh)	$100,000
	New Battery-Electric Tractor or Conversion Kit (over 160 kWh)	Additional $400 per kWh over 160 kWh up to an additional $50,000
	Fuel Cell (New or Conversion)	Up to $200,000
Truck and Trailer Mounted TRU	New Truck-Mounted TRU	Up to $50,000
	New Trailer-Mounted TRU	Up to $65,000
Large Forklift	New 8,000-12,000 lbs. lift capacity	Up to $15,000
	New 12,001-20,000 lbs. lift capacity	Up to $20,000
	New 20,001-33,000 lbs. lift capacity	Up to $90,000
	New > 33,000 lbs. lift capacity	Up to $200,000
Container Handling Equipment (New or Conversion)	> 33,000 lbs. capacity	Up to $500,000
Airport Cargo Loader (New or Conversion)	10,000-20,000 lbs. capacity	Up to $50,000
	> 20,000 lbs. capacity	Up to $100,000
Wide-body Aircraft Tug (New or Conversion)	Lead Acid	Up to $80,000
	Lithium-ion or Fuel Cell	Up to $200,000
Railcar Mover	20,000-35,000 lbf tractive effort	Up to $225,000
	> 35,000 lbf tractive effort	Up to $500,000
Mobile Power Unit (MPU) and Ground Power Unit (GPU)	Battery-electric (lithium-ion only)	$400/kWh up to $300,000 total
	Fuel Cell	Up to $300,000
Mobile Shore Power Cable Management System	6.6 kV minimum; Land-Slide Only	Up to $500,000

[65] California Air Resources Board. n.d. CORE Resources. Available online at: https://californiacore.org/resources/. Accessed January 2021.

In addition to the incentives available for the off-road equipment, CORE also offers infrastructure enhancements for certain types of equipment, as shown in TRK-B Table 12.

TRK-B Table 12. California CORE Infrastructure Enhancements (as of January 2021)

Infrastructure Enhancements		
Equipment	**Description**	**Base Voucher Amount**
On- and Off-Road Terminal Tractor, Container Handling Equipment, Airport cargo Loader, Widebody Aircraft Tug, Railcar Movers, MPUs, and GPUs	Charging < 50 kW	$3,000
	Charging (greater than or equal to 50 kW)	$30,000
	Hydrogen Fueling	$30,000
Truck and Trailer-Mounted TRUs (Up to 3 units per trailer-mounted battery-electric TRU funded through CORE)	Charging	$3,000
	Hydrogen Fueling	$9,000
Large Forklift (greater than or equal to 8,001 lb lift capacity)	Charging < 50 kW	$3,000
	Charging (greater than or equal to 50 kW and less than or equal to 20,000 Pound Lift Capacity)	$3,000
	Charging (greater than or equal to 50 kW and greater than 20,000 Pound Lift Capacity)	$30,000
	Hydrogen Fueling	$30,000
Mobile Shore Power Cable Management System	Infrastructure Enhancement	Not Applicable

CORE also provides an enhancement for equipment that is deployed in disadvantaged or low-income communities (DACs). This takes the form of a 10% enhancement from the given equipment's base voucher amount.

Finally, California's Low Carbon Fuel Standard (LCFS) represents an additional source of potential funding support. The California LCFS is a market-based program developed to incentivize low-carbon fuel production and use. Credits are traded within a market program between fuel consumers and fuel producers in which consumers, including fleets, can earn credits for low-or no-emission fuel use. Consumers can then sell those credits to fuel producers that do not meet certain emissions standards. This encourages fuel producers to either develop fuels with lower carbon intensities or offset their compliance deficit with credits. One credit represents one metric ton of carbon emissions reduced, and their price fluctuates based on market dynamics. For the week of January 11, 2021 to January 17, 2021 the average price of a credit was $199.55.[66]

[66] California Air Resources Board. n.d. Weekly LCFS Credit Transfer Activity Reports. Available online at: https://ww3.arb.ca.gov/fuels/lcfs/credit/lrtweeklycreditreports.htm. Accessed January 2021.

Overall Feasibility

The commercial availability of ZE HD trucks lags slightly behind other vehicle types which have been targeted in earlier markets, however HD truck technology is not very far behind. Battery electric and fuel cell drayage trucks are currently participating in pilot projects within California and beyond. As these pilot projects continue, the vehicle and charger manufacturers are expected to improve their technology as the vehicles approach full commercial availability. California’s regulatory environment is also evolving: CARB’s Advanced Clean Trucks (ACT) regulation was instituted in 2020, and this will put pressure on manufacturers to achieve increasing zero emission truck sales targets over time. CARB is also working on a medium- and heavy-duty ZE fleet regulation, including drayage trucks, to complement the ACT regulation as it seeks to achieve the State’s ZE truck goals by 2045. Given the State’s goals for accelerating the adoption of ZE HD trucks, the state of the market with an increasing list of technology available, and the momentum that ZE HD trucks are seeing in California, the Port of San Diego has several vehicle options as they consider piloting this technology in the near future, and it can expect to see a rapidly maturing market for on-road ZE HD trucks.

Short-Haul Zero / Near-Zero Truck Route

California has ambitious plans for vehicle electrification and is developing regulations and incentive programs to support a transition to ZE transportation. This includes heavy-duty trucks, with drayage trucks and infrastructure development expected to take priority in the near-term. Technically, deployment of ZE trucks for a short-haul pilot appears to be technically feasible, and the routes identified as part of the Port’s Truck Survey (Spring 2020) may be good starting points for the Port to consider. This includes the following:

- **TAMT to National City:** Approximately 130 refrigerated containers are transported per week by truck from TAMT to NDC, five miles south. This route may be a potential candidate for electrification.
- **TAMT to Otay Mesa (Bulk):** Sugar is hauled regularly from TAMT to Otay Mesa, approximately 30 miles away. With four to five trips per truck per shift and two shifts per day, the daily operations amount to 480 to 600 miles of driving per truck in a 24-hour period. Longer than the TAMT to NDC route above, this would be a good candidate for testing electric trucks and infrastructure on a haul that would increase the test vehicles’ daily range, comparatively.
- **TAMT to Otay Mesa (Break Bulk):** A equipment operator has equipment at TAMT which can move heavy items, including hauling steel to the working waterfront and other items for temporary storage in Otay Mesa. The working waterfront route is within close proximity to TAMT and may be a good candidate for electrification.
- **NCMT to Otay Mesa:** Car carriers regularly transport vehicles from NCMT to an offsite storage facility in Otay Mesa, about 15 miles away. The NCMT terminal operator currently has three class-8 electric trucks that can haul eight cars at a time, and while they do not currently need another truck for this route, there may be an opportunity for a pilot with subcontracted trucking companies.

Estimated Emissions Reduction from VMT Reduction at 3,000 and 10,000 VMT Intervals

To get a sense of the potential emissions reduction from replacing a heavy-duty diesel truck with a battery electric truck, the Port used the following emissions factors and assumptions from CARB’s

EMFAC 2017 web database. These factors were generated using EMFAC data from calendar year 2020 on trucks in San Diego with a model year of 2020 under EMFAC's T7 Other Port vehicle type. T7 Other Port is defined by the EMFAC 2017 User Guide as "Heavy-Heavy Duty Diesel Drayage Truck at Other Facilities"[67], and can also be defined as a standard tractor trailer. The factors shown in the table below were derived by aggregating separate factors for when trucks are running, idling, or on start-up. PM factors do not include brake and tire emissions.

TRK-B Table 13. Aggregated EMFAC 2017 Emissions Factors

EMFAC Vehicle Category: T7 Other Port Trucks (Rounded to Thousandths)			
	Diesel (g/mile)	Natural Gas (g/mile)	EV (g/mile)
NOx	2.187	0.219	0
DPM (PM10)*	0.006	0.001	0
ROG	0.026	0.026	0
GHG	2,057	1,803	541

Note: *Does not include brake and tire PM

TRK-B Table 13 shows the estimated emissions associated with operating a standard tractor trailer for 3,000 VMT and 10,000. For all emissions types except GHG, the values shown under the Diesel and Natural Gas columns can be assumed as the total potential emissions reduction associated with replacing 3,000 and 10,000 VMT with an electric vehicle. For GHG, one must subtract the EV emissions from the diesel or natural gas emissions to calculate the net reduction. For a diesel to EV replacement, that results in a reduction of roughly 4,549,377 grams of GHG for 3,000 VMT and 15,164,590 grams of GHG for 10,000 VMT. For a natural gas to EV replacement, the reductions equal 3,785,039 grams of GHG for 3,000 VMT and 12,616,796 grams of GHG for 10,000 VMT.

TRK-B Table 14. Estimated Emissions Associated with VMT Reduction for One Truck (EMFAC Vehicle Type: T7 Other Port)

Grams per 3,000 Miles			
	Diesel	Natural Gas	EV
NOx	6,560.84	656.08	-
DPM (PM10)*	16.79	3.36	-
ROG	78.55	78.55	-
GHG	6,172,396	5,408,058	1,623,019
Grams per 10,000 Miles			
	Diesel	Natural Gas	EV
NOx	21,869.46	2,186.95	-
DPM (PM10)*	55.97	11.19	-
ROG	261.83	261.83	-
GHG	20,574,653	18,026,860	5,410,064

Note: *Does not include brake and tire PM

The percent emissions reduction from any given baseline will depend upon the baseline's value. As an example, one diesel truck traveling 100 miles per day, 365 days per year (36,500 miles per year) would see a roughly 8% reduction in diesel NOx, DPM, and ROG emissions from an annual reduction in 3,000 diesel VMT, and it would see a roughly 27% reduction in the same emissions from a 10,000 diesel VMT reduction. A truck that incurs more VMT per year but reduces diesel VMT by the same amounts will see lower percentages.

[67] California Air Resources Board. 2018. *EMFAC2017 Volume 1 – User's Guide V1.0.2*. California Air Resources Board. Available online at: https://ww3.arb.ca.gov/msei/downloads/emfac2017-volume-i-users-guide.pdf.

TRK-B Table 1 provided earlier identifies several HD class-8 battery electric and fuel cell electric trucks that are either on the market today or expected to become available within the next couple years. In the current stage of market development, these trucks are being built primarily to serve shorter routes for drayage, local, and regional delivery operations. The Beachhead Strategy and CARB's Long-Term Heavy-Duty Investment Strategy suggest that now is the time for ZE HD trucks to be piloted in short-haul operations, and the learnings and best practices from those pilots will inform stakeholders as they refine technology and operations to enable long-haul ZE trucking.

From a technical and operational standpoint, a short-haul ZE/NZE route will require a few things to be successful. Obviously, ZE trucks and charging or hydrogen fueling infrastructure will need to be deployed. The type and setup of infrastructure will depend on the operational profile for the project, including items like route structure, daily mileage, and expected stopping or idling locations. For EVs, overnight plug-in charging is generally recommended for fleets that can do so, but for others opportunity charging is available, and future public charging development is being discussed by industry stakeholders. For fuel cell trucks, hydrogen infrastructure can also be developed on-site or off-site with varying types of equipment. Infrastructure setup will be a challenge for small owner-operators in particular, and so thorough planning will be required to address their needs. Strong and early communication between project partners – including the Port, fleets, OEMs, and funders – will ensure that a pilot is developed and executed successfully. In addition to proper vehicles and infrastructure, project partners are recommended to test vehicles on routes that are within the range capabilities of the vehicles, and on routes that are used in a predictable way on a regular basis.

Financially, a short-haul pilot is currently feasible, but only under certain conditions and not without the help of incentives. Generally, lifetime total cost of ownership (TCO) for electric vehicles can be lower than that of internal combustion engine (ICE) vehicles in certain applications. While the upfront purchase price of ZE vehicles is significantly higher than ICE vehicles, operating costs can often be lower due to reduced maintenance costs and with attractive electricity rates. Heavy-duty ZE trucks in California have several incentives available to make them more financially viable, including:

- California HVIP
- California CORE
- LCFS credits
- Utility make-ready infrastructure programs
- Anticipated: CEC's block grant for MHD ZE vehicle infrastructure

In addition to that, there are several government-funded HD ZE truck and infrastructure demonstration and pilot projects currently underway. CARB and CEC's solicitation for a ZE drayage truck and infrastructure pilot project is open and is designed to pilot a large-scale (50+ vehicles) deployment of this technology to test the ability of fleets and the grid to handle it. There are other government programs announced and proposed to further support ZE truck deployment, including CEC's solicitation to establish a research hub to test high-power and corridor-based charging, and Governor Newsom's proposed 2021 budget which sets aside over $1.5 billion of investment into ZE vehicles and infrastructure development. These government incentives and programs paired with maturing vehicle and infrastructure options make a short-haul pilot project feasible. The longer-term feasibility of scaling-up the number of ZE trucks will depend on when ZE trucks reach price parity to ICE trucks, and how the technology improves to handle a growing set of use cases.

Future Long-Haul Opportunities

According to the Beachhead Strategy, zero-emission trucks capable of performing long-haul operations are expected to be developed by leveraging existing components and supply chains used for trucks operating drayage or regional routes. As stated in previous sections, heavy-duty battery electric and fuel cell electric trucks are currently in pilot stages with a focus on meeting the demands of short-haul and regional routes. Over the next couple years, the learnings from these pilots will inform all involved stakeholders, especially fleets and OEMs, and will help those stakeholders improve vehicle and infrastructure technology such that it can meet the demands of long-haul routes. In the meantime, planning for scale is an important step that must be taken in order to increase the capacity of fleets, ports, and other facility partners to enable zero-emission vehicle use on long-haul routes. The scale-up of carefully planned and deployed charging and fueling infrastructure is particularly important, as it will be needed to enable long-haul operations.

Conclusion

Overall, zero- and near-zero emission, heavy-duty trucks are an option for the Port to reduce emissions. Given the technology's rapid development, the State of California's focus on supporting zero-emission vehicle and infrastructure technology development, and the presence of multiple incentives, there are a significant amount of resources available for the Port and its fleet partners to pilot this technology. Given the state of technology and State funding priorities the recommended next step is to test this technology by applying it to a consistent and predictable short-haul drayage route. From there, the Port can identify key lessons learned and plan to expand the application of battery electric and fuel cell electric truck technologies into longer-range and more demanding operations.