CALIFORNIA ENERGY COMMISSION

California Energy Commission

Clean Transportation Program

FINAL PROJECT REPORT

Port Community Electric Vehicle Blueprint

Prepared for: California Energy Commission

Prepared by: Port of Long Beach

Grant Farm

Center for International Trade & Transportation

Zero Net Energy Alliance

Gavin Newsom, Governor

July 2021 | CEC-600-2021-037

California Energy Commission

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ACKNOWLEDGEMENTS

Given the complexity of advancing zero emissions in a heavy-duty port environment composed of loosely connected stakeholders, the port could not have been successful in developing the Port Community Electric Vehicle Blueprint Report[1], without the support of others. To that end, the port assembled a guidance committee consisting of highly qualified and diverse industry experts.

- **Port of Long Beach (POLB)**: Representatives from environmental planning, finance, and engineering provided project oversight, insight into port operations, and strategy.
- **Southern California Edison (SCE)**: Provided insight on how the Blueprint might affect grid and utility rates, accounting for behavior and increasing loads from vehicle electrification while achieving community energy savings and zero-net-energy community status.
- **National Renewable Energy Laboratory (NREL)**: Evaluated power demand and impact analysis and identified relevant analytical tools and models.
- **Center for International Trade and Transportation (CITT)**: Identified workforce development needs and opportunities.
- **Pacific Merchant Shipping Association (PMSA)**: Represented the needs of terminal operators and shipping companies in relation to transportation electrification.
- **City of Long Beach Office of Sustainability**: Provided insight on the tourist-serving areas of Long Beach, including the hotels and Queen Mary.

The port enlisted the company Momentum[2], formerly known as Grant Farm, to manage the blueprint planning, outreach, and development. Moreover, the port established a broader stakeholder advisory group of environmental justice and community-based organizations, labor and workforce development groups, technology developers, original equipment manufacturers, utilities, terminal operators, trucking companies, charging station manufacturers, hydrogen fuel providers, regulatory agencies, and finance organizations. The engagement across the entire port community made the Blueprint possible.

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[1] Port Community Electric Vehicle Blueprint Report https://polb.com/environment/our-zero-emissions-future/#program-details

[2] Momentum Website https://buildmomentum.io/about-the-momentum-team/

PREFACE

Assembly Bill (AB) 118 (Núñez, Chapter 750, Statutes of 2007) created the Clean Transportation Program, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program. The statute authorizes the California Energy Commission (CEC) to develop and deploy alternative and renewable fuels and advanced transportation technologies to help attain the state's climate change policies. Assembly Bill 8 (Perea, Chapter 401, Statutes of 2013) reauthorizes the Clean Transportation Program through January 1, 2024, and specifies that the CEC allocate up to $20 million per year (or up to 20 percent of each fiscal year's funds) in funding for hydrogen station development until at least 100 stations are operational.

The Clean Transportation Program has an annual budget of about $100 million and provides financial support for projects that:

- Reduce California's use and dependence on petroleum transportation fuels and increase the use of alternative and renewable fuels and advanced vehicle technologies.
- Produce sustainable alternative and renewable low-carbon fuels in California.
- Expand alternative fueling infrastructure and fueling stations.
- Improve the efficiency, performance, and market viability of alternative light, medium, and heavy-duty vehicle technologies.
- Retrofit medium and heavy-duty on-road and nonroad vehicle fleets to alternative technologies or fuel use.
- Expand the alternative fueling infrastructure available to existing fleets, public transit, and transportation corridors.
- Establish workforce-training programs and conduct public outreach on the benefits of alternative transportation fuels and vehicle technologies.

To be eligible for funding under the Clean Transportation Program, a project must be consistent with the CEC's annual Clean Transportation Program Investment Plan Update. The CEC issued GFO-17-604 to proceed towards implementation of the electric vehicle ready community. In response to GFO-17-604, the recipient submitted an application that was proposed for funding in the CEC's notice of proposed awards April 6, 2018, and the agreement was executed as ARV-17-048 on June 18, 2018.

ABSTRACT

The Port of Long Beach has adopted some of the world's most aggressive clean-air strategies, including goals of zero-emissions terminal equipment and trucks within the next 15 years. Seaports are faced with unique constraints when deploying zero-emissions vehicles and equipment due to, among other factors, high energy demand, restrictive duty cycle requirements, and diverse tenant and operational interests.

The Blueprint is a critical step toward making California's zero-emissions future real and tangible. The Blueprint establishes a comprehensive strategy to help identify the most cost-effective technologies, financial incentives, and infrastructure upgrades for creating the model sustainable, zero-emission port ecosystem of the 21st century. The Blueprint is designed to accelerate the deployment of electrified transportation at local and regional levels with a holistic and futuristic view of regional transportation planning.

Keywords: Clean Air Action Plan (CAAP), electric vehicle (EV), greenhouse gas (GHG), Port Community Electric Vehicle Blueprint Report, South Coast Air Quality Management District (SCAQMD), zero-emissions (ZE)

Please use the following citation for this report:

> Moilanen, Renee (Port of Long Beach), Matthew, Hart. James, Dumont, Todd, Trauman, Shawn, Garvey, John, Meissner, (Grant Farm), Tom, O'Brien, Tyler, Reeb (Center for International Trade and Transport). 2021. *Port Community Electric Vehicle Blueprint*. California Energy Commission. Publication Number: CEC-600-2021-037.

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EXECUTIVE SUMMARY

Introduction

A blueprint is a plan to build. It results in something real and tangible. It might be an architect's design for a house or a plan to change the direction of an organization, or, in the case of the Port of Long Beach, a plan to achieve a zero-emissions future.

Purpose

The port has adopted some of the world's most aggressive clean-air strategies, including goals of zero-emissions terminal equipment and trucks within the next 15 years. The port has led the way in helping develop and demonstrate emerging seaport technologies, in designing and constructing heavy-duty charging infrastructure, and in developing tools to inform the next steps. The Blueprint is designed to accelerate the deployment of electrified transportation at local and regional levels with a holistic and forward-thinking view of regional transportation planning.

The blueprint development was supported by a "guidance committee," including representatives from the port's environmental planning, finance, engineering, real estate, and commercial operations; Southern California Edison; the National Renewable Energy Laboratory; Center for International Trade and Transportation; Pacific Merchant Shipping Association; and the City of Long Beach, Office of Sustainability. Furthermore, the port established a broader stakeholder advisory group of environmental justice and community-based organizations, labor and workforce development groups, technology developers, original equipment manufacturers, utilities, terminal operators, trucking companies, charging station and hydrogen fueling providers, regulatory agencies, and finance partners.

Process

The Blueprint, which was created as a result of this project, was developed through a four-step process:

- Preplan development
- Plan development
- Final plan
- Knowledge transfer

The blueprint development was structured to incorporate information from across a spectrum of relevant topic areas including uncertainty, equipment/vehicles, infrastructure, financing, workforce development, and community.

Findings

The Blueprint resulted in the identification of near-term next steps, which are summarized and presented in Table 20 of the Blueprint, and each of the five categories are shown in Tables 1-5 on pages 36 and 37 of this report. Actions in **bold** require leadership from a stakeholder other than the port itself, reaffirming the importance of the entire port community.

CHAPTER 1: Introduction

EV-Ready Communities Challenge Phase I

The POLB was awarded funding from the CEC for Phase I of an expected two-phase effort for EV ready communities. Phase I is for developing the planning blueprints to identify the actions and milestones needed to proceed toward implementing the EV ready community. Successful implementation of Phase I will allow the port to have the opportunity to submit its completed Blueprint to compete for and receive future funding under Phase II for implementing its completed blueprints.

About the Blueprint

A blueprint is a plan to build. It results in something real and tangible. It might be an architect's design for a house or a plan to change the direction of an organization or, in the case of the POLB, a plan to achieve a zero-emission (ZE) future.

The POLB has adopted some of the world's most aggressive clean-air strategies, including goals of ZE terminal equipment and trucks within the next 15 years. It has led the way in helping develop and demonstrate emerging seaport technologies, in designing and constructing heavy-duty charging infrastructure, and in developing tools to inform next steps.

The port has laid the foundation. Now it needs to build. The Blueprint is a critical step toward making the port's ZE future real and tangible.

This Blueprint reflects the unique character of the port's seaport community, incorporates lessons learned from the port's substantial progress to date, and defines concrete actions to help us achieve the port's ambitious ZE goals. This Blueprint is meant to be:

- **Inclusive**: Just as a house cannot be built without carpenters, electricians, and painters, the port's ZE future cannot be built without a diverse ecosystem of independent stakeholders, from terminal operators and labor unions to environmental justice groups and finance agencies. The port needs collaboration among all these players to reach its goals, and this Blueprint reflects their input.
- **Replicable**: The port would benefit from having other seaports join the move toward ZE to improve economies of scale and to broaden the market for the cleanest equipment. As such, it has developed this Blueprint to be replicated by other seaport communities, creating a "user's manual" for others to follow. The Blueprint includes helpful checklists, tips, tools, and case studies to assist other port communities in making the transition.
- **Dynamic and Iterative**: Each element of the Blueprint is informed by another element. Equipment has an effect on infrastructure. Infrastructure has an effect on workforce. Funding availability and costs affect the scale of community benefits. Thus, the Blueprint is more aptly seen as a dynamic and iterative process rather than a static plan of action. As the port learns more from early technology demonstrations and deployments, it must continue to work with its stakeholders to refine the Blueprint.

This plan represents the first EV Blueprint for a seaport community. With no template to follow, the port has charted its own path. The project team's hope is that this work can support other seaport communities as they move down the ambitious and exciting road to ZE.

Background

California's interconnected system of ports, railroads, highways, and roads are responsible for one-third of the state's economic activity, with freight-dependent industries accounting for more than $740 billion in gross domestic product and more than five million jobs. Maintaining the competitiveness of this economic engine is vital. Yet, freight transportation in California also generates a high portion of air emissions in parts of the state with poor air quality. Reducing these pollutants is an important local, regional, and state priority, as well as a matter of compliance with the Federal Clean Air Act.[3]

To that end, the POLB has adopted the world's most aggressive strategies to reduce port-related air emissions, chiefly by accelerating the transition to ZE. The 2017 Clean Air Action Plan Update, which was jointly adopted by the Boards of Harbor Commissioners for the POLB and Port of Los Angeles, formalized the path to ZE with two key goals:

- Transition up to 100 percent of the terminal equipment to ZE by 2030.
- Transition up to 100 percent of the drayage trucks to ZE by 2035.

The path to achieving these goals will not be easy. Seaports are faced with unique constraints when deploying ZE vehicles and equipment due to, among other factors, high energy demand, restrictive duty-cycle requirements, and diverse tenant and operational interests. Even more, at most California seaports, including the POLB, the port authorities do not typically own or operate the equipment targeted for ZE transformation and thus must work with private operators to turn over equipment and vehicles and install infrastructure suitable for a company's operations. Further complicating matters in this dynamic, 24/7 port environment, everything is interdependent, with an astonishingly broad array of light, medium, and heavy-duty equipment, and vehicles in operation.

No other seaport complex in the world has set such ambitious ZE goals, and without significant and deliberate planning, the port cannot achieve them.

To address this challenge, the POLB has developed the Blueprint to establish a comprehensive strategy to help identify the most cost-effective technologies, financial incentives, and infrastructure upgrades for creating the model sustainable, ZE port ecosystem of the 21st century. The Blueprint is designed to accelerate the deployment of electrified transportation at local and regional levels with a holistic and forward-thinking view of regional transportation planning.

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[3] California Clean Air Act https://oag.ca.gov/environment/clean-air

Project Goals

The goals of the Blueprint are to:

- Establish a comprehensive, yet nimble, strategy to help identify the most cost-effective technology suites, financial incentives, infrastructure upgrades, and equipment mixes for creating the model sustainable, ZE port ecosystem of the 21st century.
- Establish communication pathways between technology developers and terminal operators to share information about duty and drive cycles, address performance demands specific to the port community, and promote awareness of best-in-class-technologies.
- Establish communication pathways between ZE fueling providers, terminal operators, utilities (including Southern California Edison (SCE) and hydrogen distributers), and port engineering staff to develop technology standards and best-practices to serve off-road heavy-duty equipment within the port community.
- Evaluate private financing opportunities that have been developed in the light- and medium-duty sectors for potential opportunity within the port community for equipment fleets or infrastructure or both (for example, using Low Carbon Fuel Standard (LCFS) credits, power purchase agreements, and so forth).
- Strategically identify public funding that can support early-stage demonstration and information gathering for priority projects that will derisk[4] the transition to ZE technologies.
- Accelerate the deployment of ZE transportation at local and regional levels with a holistic and forward-thinking view of regional transportation planning.
- Build the ZE transition into the port's internal work structure to establish milestones and actionable steps toward the ZE transition.
- Establish the port as a local and regional champion of ZE technologies and infrastructure in the port's visitor-serving areas (for example, the Queen Mary). As a local and regional champion, support efforts to prepare the workforce and local businesses for the ZE transformation.
- Develop energy management strategies to prepare for the influx of new energy (increased electricity consumption and new hydrogen utilization).
- Work with regional stakeholders to develop the infrastructure and network needed to support the port's ZE on-road truck goals.
- Propagate, organize, and simplify the process of transitioning one of the world's busiest seaports to ZE operations.
- Establish strategic pilot/demonstration goals with terminal operators to learn about and evaluate new technologies, solidifying the port's statewide position as an early adopter and ZE technology advocate.
- Structure master planning efforts to prepare for the ZE transition and terminal operator lease negotiations.
- Establish workforce development partnerships to prepare relevant stakeholders for the introduction and operation of new ZE technologies.

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[4] Derisk Meaning https://dictionary.cambridge.org/us/dictionary/english/derisk

Project Scope: The Port Community

The Blueprint provides a detailed map of the POLB, one of the second busiest ports in the United States. The port provides economic benefits at the local, regional, state, and national levels by supporting more than 50,000 jobs in Long Beach, nearly 580,000 jobs throughout Southern California, and 2.6 million jobs throughout the United States. The port's robust economic activity, however, has an effect on the communities surrounding these operations. While the port has a positive effect on neighboring communities by providing high-paying jobs and generating significant local tax revenues, it also, has environmental and public health impacts on the surrounding communities through increased air, noise, light, and water pollution, as well as the disruption of local transportation systems.

The port has made important strides to address these negative environmental impacts through its Green Port Policy[5], as well as through project-specific mitigation measures implemented as requirements of the California Environmental Quality Act (CEQA). Over the last decade, the port has been a leader in addressing its environmental and public health impacts through such groundbreaking efforts as the Clean Air Action Plan and the Water Resources Action Plan[6], which contain numerous aggressive and innovative pollution-reduction strategies.

The port's success is evident. Since 2005, port-related air pollution is down 87 percent, and the San Pedro Bay is home to a thriving array of plant and animal life. The port recognizes, however, that its environmental impacts have had years to accumulate, and even the port's cutting-edge and aggressive mitigation efforts do not fully address the cumulative effects of port operations on neighboring communities.

To identify the direct impacts of port-related operations on the local community and community-based mitigation measures to relieve these impacts, the port conducted a Community Impact Study in 2016.[7] The study identified port-related community impacts through an analysis that used quantitative and qualitative, industry-accepted technical methods to demonstrate a connection between port operations, the impact on the community, and possible ways to reduce these impacts. The impact study examined community impacts outside the Harbor District. Some key findings include:

- Port-related operations have a direct impact on criteria pollutant and greenhouse gas (GHG) emissions in the community.
- Population-weighted cancer risk associated with operations at the POLB averages 66 in a million, rising to an average of 143 in a million for residents living within about 1.25 miles of the port and major goods movement routes.
- The area experiencing the most significant port traffic impact encompasses areas within about 10 miles of the port. These areas experience about 371,939 daily vehicle miles traveled, equating to 102,283,225 vehicle miles traveled over a year.

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[5] Green Port Policy https://www.porttechnology.org/technical-papers

[6] Water Resources Action Plan https://wildlife.ca.gov/Conservation/Watersheds/Instream-Flow/Action-Plan

[7] Port of Long Beach Community Impact Study https://www.ebp-us.com/en/projects/port-long-beach-economic-impact-study

- Noise from port-related trucks exceeds 65 A-weighted decibels L_{dn}[8] (a common threshold for excessive noise) at land uses directly adjacent to many of the roadways in the affected region.
- Locations where port trucks make a perceptible or noticeable increase to the overall traffic noise levels are generally located within five miles of the port.

Because port impacts extend beyond its perimeter, the port determined that its Blueprint had to include the Harbor District, which includes hotels and the Long Beach Carnival Cruise Ship Terminal. The port must also consider the possible impacts on and benefits to adjacent residential, commercial, and industrial areas including many census tracts categorized as disadvantaged area communities and the immediate vicinity of driving routes into the port.

Project Team

Given the complexity of advancing ZE in a heavy-duty port environment composed of loosely connected stakeholders, the port could not be successful in developing a blueprint without the support of others. To that end, the port assembled a "guidance committee" consisting of highly qualified and diverse industry experts.

- POLB representatives from environmental planning, finance, and engineering provided project oversight, insight into port operations, and strategy
- SCE provided insight on how the Blueprint might affect grid and utility rates, accounting for behavior and increasing loads from vehicle electrification while achieving community energy savings and zero-net-energy community status
- National Renewable Energy Laboratory (NREL) evaluated power demand and impact analysis, identified relevant analytical tools and models
- Center for International Trade and Transportation (CITT) identified workforce development needs and opportunities
- Pacific Merchant Shipping Authority (PMSA) represented the needs of terminal operators and shipping companies in relation to transportation electrification
- City of Long Beach, Office of Sustainability, provided insight on the tourist-serving areas of Long Beach, including the hotels and Queen Mary

The port enlisted the company Momentum[9], formerly known as Grant Farm, to manage the blueprint planning, outreach, and development. Additionally, the Port established a broader stakeholder advisory group of environmental justice and community-based organizations, labor and workforce development groups, technology developers, Original Equipment Manufacturers (OEMs), utilities, terminal operators, trucking companies, charging station manufacturers, hydrogen fuel providers, regulatory agencies, and finance organizations.

[8] Daylight Average Sound Level

https://www.flydenver.com/about/administration/noise_management/FAQs/what_day_night_average_sound_leve

[9] Momentum Website https://buildmomentum.io/about-the-momentum-team/

Blueprint Process

The Blueprint, which was created as a result of this project, was developed through a four-step process:

1) Preplan development

2) Plan development

3) Final plan

4) Knowledge transfer

Preplan development included a baseline data collection phase to accumulate the existing resources, activities, and knowledge available to the port stakeholders. Preliminary data collection included outreach to key stakeholders to create a metric by which to evaluate the successes of blueprint activities.

The blueprint development process was structured to incorporate information from across a spectrum of relevant topic areas:

- **Technology:** Technologies represent the equipment and components that will be deployed to successfully achieve the CAAP goals. A defined approach to technology including equipment analysis, demonstration projects, and feasibility assessments is an important aspect of the Blueprint.
- **Infrastructure:** The transition to ZE technologies requires the adoption of new energy sourcing, requiring significant infrastructure improvements. The port needs to create a pathway to balancing the long-lead-time nature of major capital improvement projects with a rapidly changing technology ecosystem. Infrastructure, as it relates to the Blueprint, includes standardization of fueling/charging infrastructure, site specific analyses, cybersecurity concerns, energy resiliency, and integration into the port's well-established capital improvement process.
- **Financing:** The ZE transition is projected to cost billions of dollars in capital costs to adopt new technologies and install new infrastructure. While the port has access to significant capital, additional financing models will be important to limit risk associated with technology deployments and accelerate the timeline for technology and infrastructure adoption.
- **Workforce:** The port supports a robust economic hub in the South Coast region, supporting hundreds of thousands of workers. The transition to ZE will require the workforce to adopt new protocols and procedures to operate, maintain, and service new equipment. Education is the key component to successful inclusion of the workforce. With thousands of impacted workers, the port must proactively develop strategies to prepare the workforce well before large-scale technology deployments occur.
- **Community:** The port has identified a broad and expansive list of stakeholders across the port community. The success of the ZE transition is predicated on the community working together to achieve a goal that is based primarily on environmental stewardship but also key economic and equity metrics.

CHAPTER 2:
Pre-Blueprint Preparation

To develop the Blueprint, the project team gathered background information to better assess the state of knowledge about and action toward ZE transformation. This information gathering created a foundation upon which meaningful action steps were identified.

Research

The research report, which can be found in Appendix A of the Blueprint, was created to address key background information, including:

- **State of ZE transformation.**
  - Assessment of regional and local planning documents and efforts to promote ZE vehicles and infrastructure
  - Identification of zoning and parking policies
  - Aggregation of relevant local building codes
  - Guidance for permitting and inspection processes
  - Discussion of relevant utility interconnection processes
  - Identification of key technologies of interest and ZE deployments
  - Evaluation of baseline equipment utilization
  - Identification of available analytical tools and software applications
- **Existing incentive programs and financing sources.**
  - Discussion of the port's budget process and tenant relationships
  - Overview of public funding opportunities
  - Overview of traditional private funding
  - Identification of potential innovative strategies for deploying ZE vehicles and infrastructure

The research report documented an advanced state of local and regional engagement in the ZE transformation, with key stakeholders already advancing ZE policies, regulations, and initiatives. The port already has 178 ZE equipment and an additional 97 ZE deployments funded as part of technology demonstration and deployment projects, more than 19 percent of the total equipment population at the port.

Outreach and Engagements

The engagement report, within the Blueprint, summarizes a first-of-its-kind outreach effort to engage a broad spectrum of port community stakeholders to better understand perceptions about the ZE transformation. Outreach was conducted using an online questionnaire and the results, which do not represent statistically significant results, were effective in identifying and highlighting discrepancies in perception and opinion among stakeholders. A selection of key graphics that highlight discrepancies in stakeholder understandings are highlighted below.

Appendix B in the Blueprint presents the findings from a question that asked participants to select ZE vehicles/equipment that they would consider commercial (instead of precommercial). The figure highlights a discrepancy among the subcategories of 1) terminal operators, trucking companies, labor, and utilities; 2) technology developers and OEMs; and 3) all other stakeholders. The first two groups (terminal operators, trucking companies, labor, technology vendors/OEMs, and utilities) have relatively consistent views of ZE technology commercial availability, while all other stakeholder groups (community-based organizations, environmental justice groups, and regulatory agencies and private finance) believe that the status of technology commercialization is significantly advanced, particularly with respect to yard tractors, grid-tied rubber tyred gantry cranes (RTGC), and on-road trucks. These responses may indicate a difference of opinion of the technology capabilities or simply a difference in definition. Either way, there appears to be value in communication among these groups to solidify a common understanding of the status of relevant technologies.

Also presented are responses to a specific question about what level of operational change will be necessary for port-related companies to adopt ZE vehicles/equipment. Overall, the responses indicate a perception from technology vendors/OEMs that the operational impacts of the transition to ZE equipment will be less significant than is perceived by all other stakeholder groups. The responses to this question suggest that coordination between technology vendors/OEMs with other port stakeholders should be encouraged to help develop a better understanding of operational changes that may be required and to understand the potential magnitude of the effects associated these operational changes.

Results of the one of many questions about the effects of the ZE transformation on the workforce are presented. The responses indicate a wide range of understanding for the need for training around charging and refueling. Generally, the terminal operators, trucking companies, and labor indicated a greater need for training (60 percent selecting "significant" or "complete overhaul") than the other stakeholder groups (21 percent selecting "significant" or "complete overhaul").

Findings from two of several questions assessing knowledge of the emerging ZE technology sector are offered. The findings presented are specifically in response to a prompt asking how many companies you are aware of that provide charging/hydrogen refueling infrastructure. While there is a considerable spread of awareness among all stakeholder groups, it is notable that the terminal operators, trucking companies, and labor groups all knew fewer than three companies that provide charging infrastructure. This finding is starkly contrasted by the groups that could identify more than 15 companies, principally regulatory agencies/private funding, technology developers, and utilities.

Unlike electric charging equipment, almost all stakeholder groups are unaware of three or more hydrogen refueling companies. This lack of awareness may be reflected by the dominance of battery EV in the light-duty space.

With a dynamic marketplace, it is important to make sure that all stakeholders are aware of the technical and business opportunities that are emerging and to identify opportunities for ZE infrastructure at the Port.

Data gathered shows how well fleet operators understand equipment/vehicle drive cycles. The responses indicate an important discrepancy among terminal operators/OEMs, trucking companies, and labor and all other stakeholders. Specifically, the equipment users do not believe the data about drive cycle are as readily available as other stakeholders believe it to be.

Stakeholders were asked if there is a competitive advantage in the marketplace by "going green." This prompt addressed an important theme around the ZE transition, specifically if the transition is considered to have a competitive advantage. The focus on competitive advantage centers on financial implications of the technologies and specifically excludes external attributes (benefits or costs), such as environmental or health impacts. Interestingly most respondents indicated "yes," while the terminal operators and trucking companies those generally responsible for purchasing the equipment all answered with "no" or "don't know."

Not surprisingly, the regulatory agency/financing stakeholders unanimously responded "yes." While the definitions of "competitive advantage" and "going green" were left to the respondents' own interpretation, the results indicate a clear need for stakeholders to help terminal operators and trucking companies understand how this transition may be financially beneficial in a highly competitive marketplace.

Additionally, stakeholders were asked to select which financing mechanisms their organization knows for ZE vehicles/equipment or infrastructure or both. The results highlighted a limited awareness of financing mechanisms beyond grant funding for the new ZE sector.

Workforce Development

The CITT at California State University, Long Beach, worked with the port to project workforce development impacts and identify the necessary career pathways to support the transition to ZE.

The transition to ZE equipment and vehicles is expected to create significant workforce development challenges in the port environment. From operations and maintenance to the installation of charging and energy management systems, new career pathways will be required to plan for, support, and maintain the future fleet of ZE equipment and vehicles.

Incumbent workers may need retraining, and new employees will need to acquire the skills necessary for success in a ZE port environment. Importantly, the port does not have a direct role in workforce development; thus, the port must work closely with its partners in organized labor, educational institutions, and professional certification programs to ensure a rapid workforce transition to support ZE.

Current Workforce

Workforce opportunities generally include these classifications:

- **Terminal Equipment Operators:** Terminal equipment, such as RTGC, yard tractors, and forklifts, are operated by members of International Longshore and Warehouse Union.
- **Terminal Equipment Mechanics:** Terminal equipment is maintained at each terminal by either the International Longshore and Warehouse Union or the International Association of Machinists.
- **Truck Drivers:** Drayage truck drivers are either independent owner-operators or employees of trucking companies.
- **Truck Mechanics**: Drayage trucks are maintained by inhouse mechanics at large trucking companies or at off-site maintenance facilities.
- **Fleet Mechanics:** The port has mechanics to service its own fleet of vehicles. These mechanics are city employees represented by the International Association of Machinists.
- **Infrastructure Engineers and Installers:** The port is responsible for developing and maintaining the landside infrastructure at each port terminal. The port has a large staff of engineers that oversees the design and execution of major infrastructure projects, including those related to ZE. The actual construction and installation of charging outlets are largely bid to outside contractors.

Each of these workforce opportunities may require certifications or educational credentialing.

Workforce Projects and Potential Impacts

The CITT found there is likely to be a high demand for the following job titles:

- Electrician
- Solar photovoltaic installer
- Automotive specialty technicians
- Electrical engineer
- Electrical power-line installer and repairer (lineman)
- Maintenance technician

Moreover, the CITT found that many of these classifications will require skills beyond what is currently expected. Electrical engineers, for example, will require not only traditional electrical engineering skills, but also experience in energy management systems integration and even energy policy. The Long Beach City College Workforce Assessment Report[10] concurred with this finding and recommended the need for more cross-disciplinary programs.

Workforce Development Actions

The following sections describe ways in which the port community can prepare its incumbent and future workforce for widespread ZE deployment. These actions have been informed by the

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[10] Long Beach City College Workforce Assessment Report https://www.lbcc.edu/workforce-development

CITT report, the Long Beach City College Workforce Assessment Report, and conversations with other relevant stakeholders in the port community.

Equipment and Vehicle Operations

The International Longshore and Warehouse Union represents the more than 8,000 longshore workers who drive and operate ZE terminal equipment. The Pacific Maritime Association provides training for longshoremen on skills universally required at all terminals, such as lashing.[11] Terminals are responsible for on-the-job longshore training when introducing a new piece of equipment.

Conventionally operated ZE equipment should not require new operating skills, and most of the training is expected to take place at the worksite, between the terminals and the longshoremen, as needed; however, the port should work closely with the Pacific Maritime Association and International Longshore and Warehouse Union to monitor whether there is a need for new universal training modules related to ZE.

Similarly, there is not expected to be a significant need for new skills in driving a battery-electric or fuel cell drayage truck outside fueling, but the port should continue to monitor potential operational impacts with partners such as Long Beach City College and the Harbor Trucking Association.

Equipment Maintenance

The switch to ZE equipment and trucks is likely to have a significant effect on mechanics, whose experience is built around combustion engines, not batteries or fuel cells. At the terminals, training is likely to occur through equipment manufacturers or technology developers instructing a lead mechanic, who, in turn, trains the maintenance team. This "train-the-trainer" model is the model currently used at terminals to teach and apply maintenance skills for a new piece of equipment.

Recently, the Pacific Maritime Association and Long Beach City College piloted a program by which longshoremen could receive training to become terminal equipment mechanics; this program should continue to be evaluated and may need to be expanded to accommodate the increasing demand for highly trained electric-automotive technicians, who could be sourced from the existing longshore workforce.

Trade schools and community colleges, including Long Beach City College, provide technician training certifications and coursework for truck mechanics. These programs have evolved in the past to suit changing technologies and policy shifts, as was the case during the port's first Clean Trucks Program (see case study: "Workforce Partnerships to Advance Clean Air Goals"), and are poised to adapt again to ZE.

The port should work closely with Long Beach City College to align curriculum and training programs for the ZE transition, evaluating the need to create cross-disciplinary programs; extend these training programs into the Long Beach Unified School District to generate early interest in ZE workforce opportunities; and identify and address potential barriers to entry for the incumbent workforce, which may include financial assistance. Moreover, the port should

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[11] Lashing Definition https://en.wikipedia.org/wiki/Load_securing

work with Long Beach City College and other workforce partners to advocate for more funding for ZE workforce development and curriculum development.

As the port and city introduce more EV's into their own fleets, the port should evaluate its job classifications to ensure that its workers have skills in EV maintenance, potentially by providing access to nationally recognized credentialing programs, such as the Certified EV Technician Training Program.[12]

Infrastructure Engineering and Installation

The CITT projected a significant need for electricians with experience in high-voltage electrical work as well as electrical engineers. As noted above, the port should evaluate the need for safety requirements or additional credentials for the contractors likely to install the charging or fueling equipment. The port should also consider additional training requirements for its own employees, who may be tasked with maintaining or installing high voltage charging units.

Also, the port must gear up to expand its own electrical engineering staff, which plays a critical role in designing terminal and potentially truck infrastructure within the Harbor District. The port should evaluate job classification specifications to ensure that engineers have the requisite skills in electrical design, hydrogen, energy systems integration, and energy policy and should prioritize additional training for the incumbent port workers.

Planning

The workshop report, which can be found in Appendix C of the Blueprint, detailed the first stakeholder workshop where representatives from a broad stakeholder audience participated in discussions intended to share findings from the stakeholder outreach and build a common understanding of the port's ZE transition efforts. This workshop included presentations, group activities, and roundtable discussions. The Blueprint Planning Workshop was successful in achieving its goals. Several key findings were identified as the project team debriefed from the meeting and reviewed the material collected during the workshop.

- **Risks and Uncertainties Surrounding Design, Permitting, Planning, and Finance:** The roundtable discussions had substantial focus on design, planning, and financing of ZE technologies. As with many port communities, POLB handles a significant portion of its own permitting, and the City of Long Beach has developed an expedited process for ZE technology deployments. Key discussion points around design and planning across all the tables included a lack of awareness and understanding of duty and drive cycles; the need for more information about life-cycle costs (including maintenance, operations, fuel, equipment life, and capital); the importance of demonstration projects to validate assumptions; and the need for financing alternatives.
- **Assessment of Current Levels of Relevant Training and Education:** The roundtable discussions had substantial focus on workforce effects associated with the transition to ZE technologies. Across all tables, there was a clear indication that workforce training around maintenance needs were paramount to those for operations. Not surprisingly, participants such as the International Brotherhood of Electrical Workers and SCE indicated comfort with the existing resources available to train workers in the electrical fields, while other

[12] Certified EV Technician Training Program https://cleantechinstitute.org/Training/CEVT

stakeholders, those who do not work with electricity on a daily basis, were more concerned about the potential impacts. Many roundtable discussions identified challenges associated with the cost of training, particularly the cost of training a unionized workforce.

- **Documentation of Specific Restrictions and Requirements for EV Infrastructure Unique to Seaport Communities:** The workforce roundtable discussion centered on workforce training needs; however, that conversation was built on a foundational discussion of the impacts of ZE equipment on port operations. Almost every table had a terminal operator or labor stakeholder group represented, allowing open discussion about the real-world effects of the new equipment on existing operations. Critical restrictions and requirements include the space required to add in chargers, the time associated with moving equipment to a charger and plugging it in, the difference between current refueling practices and electrification, and the intricacies of the port community labor unions. Each of these factors is unique to port operations and addressing these challenges in the Blueprint will be critical to helping create a measurable and actionable pathway toward ZE.
- **Assessment of Replicability to Other California Seaports:** While this discussion topic was not directly addressed in a roundtable forum, the "Case Studies in Port Electrification"[13] was an interactive presentation using real-time lessons learned from demonstration projects to foster a discussion about how these early-stage projects at POLB can be used to reduce challenges at subsequent deployments both at POLB and other ports. Notably, more than 90 percent of the port's cargo-handling equipment is operated at container terminals. Port of Los Angeles and Port of Oakland are also major container ports; however, the remaining eight ports in California are predominantly break and bulk points.[14] Understanding how the Blueprint can apply to its own bulk and break-bulk points will be important for creating a highly replicable blueprint.

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[13] Case Studies in Port Electrification http://css.umich.edu/publication/life-cycle-emissions-port-electrification-case-study-cargo-handling-tractors-port-los

[14] Break and Bulk Point Definition https://en.wikipedia.org/wiki/Breakbulk_cargo

CHAPTER 3:
Port Community EV Blueprint

Building upon the background work, the port developed the Blueprint to build upon the current state of the ZE transition and define actionable steps to accelerate the ZE transition. The Blueprint includes several key sections highlighted in this chapter.

Framing the Blueprint

Transitioning to ZE in a port community is fraught with uncertainty. With few exceptions, much of the port suitable ZE equipment remains in the prototype phase and, even when commercialized, faces a tough working environment with ambiguous long-term operations and maintenance costs. To complicate matters, heavy-duty infrastructure standards are still under development, and detailed understanding of workforce implications are only now beginning to emerge.

The port's ability to achieve its 2030 and 2035 ZE goals depends on identifying the risks and uncertainty ahead and, more importantly, addressing them. To do that, the port must engage in a thoughtful process to uncover the main barriers and identify opportunities.

The engagement report, which can be found in Appendix B of the Blueprint, started this process by identifying the port community's understanding of and expectations for ZE across a wide range of issue areas. Stakeholders expressed a high degree of uncertainty around ZE equipment costs, the availability of necessary infrastructure, and the long-term benefits of transitioning to a ZE future. The discrepancies in stakeholder expectations and understanding of the issues underscored the need for robust analysis and planning before forging ahead.

To refine these uncertainties, the port built upon this initial survey by conducting a more targeted risk assessment analysis. Like the analysis in the engagement report, responses from the uncertainty questionnaire were analyzed to see how consistently respondents selected likelihood and impact rankings. The project team used the consistency level of the responses as a measure of agreement among stakeholders. The factors with the highest level of response consistency were:

- Adoption of ZE technology improves air quality and public health.
- Warranties for ZE equipment adequately protect the purchaser.
- Upfront cost of purchasing/leasing ZE equipment is significantly more than traditional equipment.
- One hundred percent ZE terminal equipment is deployed successfully by 2030.
- The lack of noise will not lead to an increase likelihood of collisions/accidents.
- Adoption of ZE technology creates increased job opportunities in the local area to service the new technology.

The factors with the lowest level of response consistency were:

- Nontraditional financing of ZE equipment assigns rights to financing parties other than the owner/operator.
- Purchasers find that their revenue increases after adoption of ZE equipment.
- Terminal operators must engage in/adapt to significant operational changes to achieve ZE terminal equipment goals (for example, yard reconfiguration, moving piers).
- The adoption of ZE equipment results in increased insurance costs due to the higher cost of electric equipment, limited qualified maintenance facilities, and general unfamiliarity by insurance providers.
- Purchasers find that their costs increase after adoption of ZE equipment.
- Adoption of ZE terminal equipment reduces the flexibility of your operation to make changes.
- ZE equipment is unlikely to cause operational disruption.

These inconsistencies represent areas that may require more investigation, stakeholder engagement, or concerted action to drive the port community toward a common understanding of the risks and opportunities associated with transitioning to ZE and, more importantly, to the solutions.

The Blueprint is separated into five segments: vehicles/equipment, infrastructure, finance, workforce, and community benefits. For each of these segments, it discusses a logical and stepwise process that can be followed to make choices responsibly that will overcome uncertainties and advance the ZE goals. Short-term action steps are identified in addition to a discussion of the broad overall trajectory of ZE.

ZE Technologies

The port is leading an effort that will require equipment and vehicles that have never before been demonstrated or, in many cases, even built. ZE technologies, particularly for the heavy-duty sector, have only recently appeared on the market after significant advancements in battery and fuel cell technologies. Evaluating and incorporating new technologies add a unique layer of complication as the port community monitors new innovations, evaluates technical and operational feasibility, and considers, in real time, the technologies needed to make lasting changes to its core business models.

As part of the CAAP, the port has already initiated actions to support technology development and technology acceptance consistent with the CAAP goals. This section captures and outlines a strategic process that any port can use to support development of ZE technologies suitable for the port environment, and, equally important, garner acceptance of these technologies through the port community, particularly from operators:

1. Establish a baseline.
2. Identify priorities.
3. Evaluate technologies.
4. Create market acceptance.

This strategic process applies to heavy-duty and light-duty technologies, although the port acknowledges that its sphere of influence is significantly greater with heavy-duty technologies.

Establish a Baseline

The port maintains a database of equipment operating in and around the port. As part of its Annual Emissions Inventory,[15] the port also quantifies the air emissions impacts of the equipment. Establishing the equipment and environmental baseline provides clear metrics to measure success and improvement and is critical to developing a strategy that can target areas of concern.

There are more than 1,400 pieces of terminal equipment operating at the port, everything from yard trucks and forklifts to excavators and cranes. This also includes electric equipment includes ship-to-shore cranes, automated guided vehicles, and automatic stacking cranes.

There are roughly 17,000 trucks that serve the port complex. About three percent of the active drayage fleet (roughly 360 trucks) is fueled by liquefied natural gas.

Overwhelmingly, equipment and vehicles operating at the port are fueled by diesel, which has significant air quality and public health impacts. The port can use the baseline data to develop informed priorities for reducing these impacts and monitor progress toward the ZE goals.

Identify Priorities

Based on the potential benefits to air quality, the Blueprint has identified yard tractors, RTGC's, and top handlers as the top priority pieces of equipment. The gross emissions data gathered on these pieces of equipment are categorized by equipment type, cumulative emissions, and population count for NO_X and GHG.

In addition to terminal equipment, the project team evaluated drayage trucks. More than 98 percent of the vehicle miles traveled are associated with container terminal operations

To better understand the duty and drive cycles of these technologies, the port can serve as a data aggregator across terminal operators to provide technology developers with information about equipment usage that is critical to product design. Focusing on these priorities can help direct limited resources toward the equipment that could achieve the highest benefits.

Evaluate Technology Development

The port uses two approaches for evaluating technologies: technology assessments and technology demonstrations. By adopting the Framework for Developing Feasibility Assessments as part of the CAAP, the port has established a common approach for evaluating new ZE technologies. The framework can be widely used for all California ports. Furthermore, the port is engaged in demonstration projects to test emerging technologies in a real-world port environment. These efforts make the port one of the world's leading experts in ZE technologies. Gathering, synthesizing, and sharing data, results, and best practices will be vital to the replicability of the blueprint.

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[15] 2017 Emissions Inventory https://polb.com/environment/air/#emissions-inventory

Create Market Acceptance

The combination of technology development and economic feasibility results in commercialization and, ultimately, market acceptance. The port must consider, develop, and adopt a strategic approach to creating a stable and predictable marketplace for ZE technologies using education, incentives, and broad community engagement to create clear signals to manufacturers and operators, including:

- **Integration With OEMs**: New technologies traditionally reach the commercial marketplace through partnerships with established manufacturers to accelerate production scale. The involvement of major manufacturers is key because the port equipment market is heavily concentrated in the hands of a few companies. These manufacturers have begun to invest in ZE terminal equipment and trucks, which has turned the tide on technology advancement; however, these manufacturers are in the beginning stages of development and still have much to learn before ZE vehicles can be considered commercialized.
- **Short-Term Demonstration:** As technologies mature and reach the market, terminal operators and trucking companies must see new equipment and vehicles in action and, if possible, get the chance to test the equipment in short-term, informal demonstrations in the respective duty cycles. "Ride-and-drive" events[16], tours, and short-term demonstrations can help operators gain familiarity with new technologies and, thus, reduce uncertainties around performance without operators having to make major commitments to multiyear demonstrations.
- **Cost Reduction Strategies:** As confirmed by the Blueprint, stakeholder outreach, CAAP feasibility assessments, and the high cost of a ZE piece of equipment (relative to diesel) is a significant barrier to commercialization and widespread market acceptance. Financial incentives can spur initial adoption, and there are numerous public-funding programs to do just that. Rebates and cost subsidies, however, come with inherent uncertainty about long-term availability and do little to bring down the commercialized price of each unit.
- **Community Advocacy for Market Expansion:** Close engagement with other seaports, community organizations, and environmental justice groups can help advance the market for ZE equipment. Many community-based groups engage with other port communities around the country. To the extent that community organizations and environmental-justice groups can help leverage the blueprint findings in other seaport communities, it could increase the deployment of ZE equipment nationwide, thus minimizing real or perceived adverse impacts on Long Beach operators. Moreover, a larger ZE equipment market should lead to better prices and a more sustainable business model.
- **Other Strategies:** Historically, regulation has helped drive widespread adoption of cleaner equipment and trucks. California Air Resources Board (CARB) is working on amendments to the terminal equipment and truck regulations, and these changes may move the market on ZE. Furthermore, CAAP strategies, such as the new Clean Trucks Program[17], which offers

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[16] Ride and Drive Events Website https://pluginamerica.org/plug-in-america-introduces-evs-to-communities-at-ride-and-drive-events/

[17] Clean Trucks Program https://cleanairactionplan.org/strategies/trucks/

incentives for ZE trucks, and the port's "green leases," which require adoption of new equipment over time, should help advance commercialization.

Charging/Refueling Infrastructure

ZE equipment requires a major investment in charging and fueling infrastructure. When surveyed, most port community stakeholders ranked the lack of charging infrastructure as a primary concern, outweighing even the availability of electric equipment. The infrastructure challenge is complicated by the lack of heavy-duty charging standards, the significant cost and long time frames needed to install infrastructure, poor awareness of charging options, and the operational and physical constraints in the port, which limit charging windows and space for charging equipment.

Importantly, infrastructure includes not only the charging delivery systems, of which there are many options, from manual direct-connect to wireless induction, but also the significant investment in new substations, switchgear, transformers, and conduit. This electrical infrastructure is likely to take up substantial space on already crowded terminals and must be installed without affecting the port's 24/7 operations. This installation requires careful phasing and advanced planning.

This section describes a six-step strategic process that any port can use to assess, develop, and support the necessary ZE infrastructure:

1. Establish a baseline.
2. Forecast future need.
3. Evaluate fueling and charging options.
4. Adopt standards.
5. Develop infrastructure design plans.
6. Execute design plans.

The port has already begun working through the six-step process to evaluating and deploying ZE infrastructure.

Establish a Baseline

The port maintains a detailed inventory of the existing infrastructure and capacity of electrical infrastructure and hydrogen pipeline within the port property. Because of security reasons, detailed information will not be shared as part of the blueprint effort; however, port engineers are available to discuss their process with staff from other ports if there are questions about how best to manage this information. Publicly available information includes hydrogen fueling networks in the South Coast Basin, existing and planned charging infrastructure and light-duty charging.

Forecast Future Need

The port has conducted high-level assessments of the potential need for electricity and hydrogen associated with the adoption of ZE technologies. High-level projections of hydrogen demand and power demand were identified and presented in the Blueprint. As the port obtains more information about ZE equipment performance and energy consumption through its technology demonstrations, these assessments will need to be updated. In any event, these assessments clearly indicate a need for additional infrastructure.

Evaluate Infrastructure Options

Through the port's technology demonstrations and as part of blueprint stakeholder outreach and research, the port has identified several key considerations for infrastructure selection:

- **Physical Space and Instructions**: Terminals are tight spaces, and this land is among the most expensive in the country. Charging or refueling infrastructure that consumes a significant amount of real estate takes away from revenue-generating cargo areas. Moreover, any above-ground structure poses a collision hazard on terminals and at trucking centers. Structures require safety bollards, which consume even more space. Operators are likely to prefer charging technologies that require minimal space and do not obstruct cargo movement.
- **Limited Awareness of the Charging/Refueling Options**: When surveyed, operators reported little awareness of the various providers for electric charging infrastructure and hydrogen fueling infrastructure, compared to all other stakeholders, who reported high familiarity.**Error! Bookmark not defined.** This disparity could reflect a simple lack of awareness, necessitating more education, or it could point to the real lack of options for charging/refueling infrastructure in the heavy-duty space as opposed to the light-duty space, in which multiple providers have emerged.
- **High-Voltage Cable Handling and Storage**: The cables used to connect large pieces of terminal equipment, particularly top handlers, which can have one megawatt hour batteries on board, can often weigh 40 pounds or more, given the sheer cross-sectional diameter of cable needed to deliver that much power. Operators must consider the safe handling of these cables during connections, if using manual connections, as well as storage of these cables when not in use.
- **High-Pressure Gaseous or Liquid Fuel Handling and Storage**: Hydrogen is a low-density gas that requires high pressures to transport and store energy without excessive fuel tank volumes. While standards and protocols have already been developed around hydrogen storage, facility design must account for additional safety precautions.
- **Fast Connections**: Terminals operate on rigid work shifts with few breaks. Opportunity charging may be limited to two one-hour breaks in a sixteen-hour cycle with a longer stretch of three to four hours in the early morning hours. Operators may have nearly 200 pieces of equipment requiring connection in those times. Given these tight time frames for recharging and refueling, operators may prefer technologies that enable fast connections or refueling in a short period, such as fast chargers or those that automatically connect upon contact. This issue seems to be less pressing for trucking companies.
- **Ratio of Charging Outlets to Equipment**: On a port terminal, the shift schedule demands that every piece of equipment is in use at the same time during working periods and then, during breaks, parked and connected to the charging outlets. Thus, terminals are very likely to need one charger for each piece of equipment. Operators confirmed this assumption in the blueprint survey. This issue is less pressing for truck operators, who may have more flexibility.

Adopt Standards

A significant challenge to designing and constructing the appropriate infrastructure is the lack of charging and fueling standards for heavy-duty equipment. Furthermore, the port, which maintains strict design criteria and standards for terminals and electrical infrastructure, has not yet formalized criteria for charging or hydrogen fueling infrastructure.

Develop Infrastructure Design Plans

Infrastructure design master plans that integrate ZE will be critical to defining the costs associated with the transition and will be important aspects of lease negotiations in the upcoming decade.

Infrastructure design planning is a well-defined activity between the port and terminal operators. Designs can take place in the context of two approaches: retrofit or redevelopment. The port in collaboration with the operator will decide on a case-by-case basis whether a retrofit or redevelopment makes the most sense for a given project.

- **Terminal Retrofit**: The port and operator work within the constraints of the existing terminal layout to add charging or fueling infrastructure. The terminal does not necessarily gain additional operational efficiency. Moreover, infrastructure may be considered "temporary", useful for less than 10 years, if the terminal is ultimately redeveloped. Retrofits are less cost-effective on a per-installation basis but can be done more quickly than redevelopments. Pier J is an example of a terminal retrofit where nine RTGC's are being electrified. This $8 million electrification will generate immediate air quality benefits once complete; however, long-range plans for Pier J may include filling the open water slips and reconfiguring the layout, which would render the current electrification obsolete.
- **Terminal Redevelopment**: The port and operator reimagine the space from the ground up. Yards are reconfigured. Utilities are moved and upgraded. New land may be added. The port works closely with the operator to design a new terminal layout that maximizes operational efficiency and environmental benefits. Terminal redevelopments are rare, given the port's long lease timelines. Middle Harbor is an example of a redevelopment in which the port combined two outdated terminals into one state-of-the-art electrified terminal. In the process, the port added 60 acres of new land and electrical infrastructure to accommodate 800 pieces of electric terminal equipment with a total electrical capacity of nearly 64 mega-watts. This $2 billion project took 10 years to design and construct.

In either scenario, the terminal design effort is a significant, multiyear process that considers numerous factors including site considerations, resiliency, and cybersecurity described in the Blueprint. Many of the port's terminal operators have leases that will be renewed in the 2020 decade. These leases typically last 20 years. Before the end of these next lease periods, the port should prepare for ZE operations; therefore, working on these plans now will be critically important to advancing the ZE transition.

Execute Design Plans

Following the design-planning phase, which will provide a better understanding of the costs and scope of ZE infrastructure for each terminal, the port must decide how to execute the projects. As noted earlier, the port can construct infrastructure as part of a terminal redevelopment or terminal retrofit. Each terminal should be evaluated on a case-by-case basis considering the timing of the lease expiration of a terminal, the facility design plans, budgets, environmental goals, and long-term land-use plans as informed by the port master plan, a state-mandated plan that characterizes land use and future development in the Harbor District.

Financial and Business Model Considerations

The discussion around ZE technologies and infrastructure is focused on technical and operational feasibility: can it work? Demonstration projects hosted at the port, and at others across California and the world, are accelerating the technological advancement, building a deep understanding of the full breadth of design and infrastructure considerations, and guiding innovation toward solutions that can be broadly deployed in a commercial setting. The transition from demonstration to commercialization represents the intersection of innovation and business sustainability. Terminal operators exist in a low-margin, high-volume, globally competitive environment where operational reliability is paramount and changes to one part of the operations can have cascading impacts. Establishing reliable business models will accelerate the transition to ZE technologies.

To fund the ZE transition, the port has developed a four-step approach:

1. Develop cost estimates.
2. Identify funding and financing options.
3. Address key funding barriers.
4. Develop project funding plans.

Based on findings from the blueprint effort, direct communication and engagement among finance entities, terminal .operators and trucking companies will create a better understanding of the opportunities and challenges of investing in the port's ZE transition. To support development of viable financial pathways and business models, the port may consider further engagement across the four primary steps.

Develop Cost Estimates

To identify sustainable funding strategies for the ZE transition, the port must understand the magnitude of costs. Today's costs are expected to drop over time as battery and fuel cell technology matures and larger-scale deployments enable manufacturing efficiencies, and these trends will improve the financial equation; however, the port community is still facing unprecedented costs to achieve ZE.

The ongoing technology demonstrations and forecast terminal design and planning will result in an important refinement of costs for each facility. The high-level costs already serve as a valuable starting point but refining these estimates to specific terminals will be important for identifying the appropriate financial structure to implement the complete transition.

Identify Funding and Financing Options

As part of the Blueprint, the port has identified the most promising public and private financing options. In general, the funding landscape can be viewed on a continuum of technology readiness. Traditionally, public funding is available with the express goals of supporting the commercialization of new and innovative technologies. Private funding is better geared toward large-scale transitions of commercially available technologies and has less focus on demonstration projects.

Public Funding

Many state and federal agencies, including CARB, CEC, and United States Environmental Protection Agency (U.S. EPA), provide grants and subsidies to support the development and deployment of ZE equipment and infrastructure. These agencies have also created programs that support workforce development, education, and the ongoing operational costs associated with ZE equipment. Public funding is typically competitive, either through grants or first-come, first-served vouchers.

Generally, public funding supports six types of ZE program areas:

- **Research, Demonstration, and Deployment:** This type of funding focuses on limited-scope demonstrations with the goal of gathering three to twelve months of data. Research, demonstration, and deployment funding typically covers infrastructure and equipment purchase with limited funding for operations. Examples include the CEC's Clean Transportation Program and the CARB's Clean Transportation Incentives Program.
- **Infrastructure Expansion**: This type focuses largely on one-time costs to develop charging and fueling infrastructure. There has been significant investment in on-road public charging and hydrogen fueling infrastructure in the past few years to help with the chicken-versus-egg problem in which equipment purchases are not feasible without the supporting infrastructure. The U.S. Department of Transportation's Better Utilizing Investments to Leverage Development program supports large-scale infrastructure projects. Other programs, including the Clean Transportation Program, fund smaller projects.
- **Commercial Equipment Price Buy-Downs:** This funding type focuses on reducing the costs associated with new commercial equipment. Various structures have been developed to validate commercial viability, principally scrap-and-replace, or repower following a registration process with the funding agency. The Federal Clean Diesel Funding Program, Carl Moyer Program, and the Volkswagen Settlement Fund are examples of scrap-and-replace programs.
- **Tax Credits and Revolving Loans:** For large deployments, the state has created programs to help private companies access low-interest debt that is traditionally only available to public entities.
- **Operational Support:** The LCFS program is designed to support the ongoing use of low-carbon transportation fuels, including electricity and hydrogen. Operators can earn and sell credits for using equipment not powered by fossil fuels. Larger deployments earn more revenue. Programs such as this provide ongoing and regular funds to support operations. The port has developed a quick calculator to help operators estimate their potential LCFS benefits, which can be seen in the "In the Toolbox" section of the Blueprint.
- **Workforce Development:** The state provides funding in limited amounts for workforce development related to ZE through the CEC. Furthermore, workforce training may be an eligible project under the Supplemental Environmental Projects program, which uses penalty fees paid from air-quality violations to support efforts that do not have other avenues of funding.

The public funding landscape, particularly for the research, demonstration, and deployment and infrastructure expansion funding, is highly fluid with most agencies developing annual funding plans and soliciting input for the next year's plan.

This process makes long-range planning difficult; however, it also gives the port community a chance to signal needs and barriers to the agencies and engage proactively on funding solutions to support ZE. Joint advocacy efforts may be effective in steering funds to areas that can create the greatest positive impacts. On an annual basis, the port must review the investment plans of major public grant programs and provide comments that reflect its real-life experiences deploying ZE and its needs going forward.

Private Financing

Private financing, which includes traditional models such as bonds and loans as well as emerging innovative business models tailored to ZE deployment, offers unique opportunities for rapid, large-scale investment in new infrastructure and technologies. A selection of relevant models includes:

- **Municipal Bonds, Including "Green Bonds":** As a municipal agency, the port has access to low-interest bonds to help finance major infrastructure projects. The port has issued several series of bonds since 2010 to finance the Middle Harbor Terminal and Gerald Desmond Bridge replacement. A subset of municipal bonds is "green bonds," a relatively new mechanism that allows public issuers to access low-cost capital for public infrastructure projects with environmental benefits.
- **Senate Bill 350 Transportation Electrification Funds:** Under Senate Bill 350[18], investor-owned utilities, including SCE, are required to invest in transportation electrification. To that end, SCE is expanding upon its existing make-ready charging infrastructure program for light duty with a charging infrastructure program for heavy-duty equipment called "Charge Ready Transport."[19] For a given project, SCE installs the necessary electrical infrastructure beyond the meter up to a stub-out on which the charging device can be installed. Operators receive favorable charging rates and reduced demand charges. A certain percentage of funds for Charge Ready Transport must be spent in seaports/goods movement, disadvantaged communities, and forklifts, including port equipment.
- **Tariffed On-Bill Investment Programs:** Also known as "Pay as You Save"[20] or inclusive financing, these programs integrate equipment financing directly into the underlying pricing of the tariff. Voluntary participants in a tariffed repayment program typically carry no debt or lien on the improvement. The capital can be sourced either by the utility or from a third party. The utility recovers the costs on utility bills for improvements at the customer location at a rate that is less than the estimated savings the electrification produces.

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[18] Clean Energy and Pollution Reduction Act https://www.energy.ca.gov/rules-and-regulations/energy-suppliers-reporting/clean-energy-and-pollution-reduction-act-sb-350

[19] Charge Ready Transport https://www.sce.com/sites/default/files/2020-07/Electrification%20%26%20Infrastructure%20Guidebook-Final_06.29.20.pdf

[20] Pay As You Save https://www.cleanenergyworks.org/about-pays-for-ee/

- **Battery Financing**: The FAST ACT[21] established the opportunity for capital leasing of ZE vehicle components and "removeable power sources," including batteries and fuel cells. This provision allows the battery or fuel cell to be leased separately from the remainder of the vehicle. In the electric bus sector, Proterra and BYD have created battery financing models that allow the vehicle operator to own the vehicle and separately lease the battery. This model allows the battery-lease partner to accept the cost and risk associated with new technologies. These organizations typically expect the lease cost to be paid as fuel and maintenance savings are realized over the lifetime of the vehicle. Moreover, these organizations take the used battery and are better positioned to reuse the battery in second-life applications, such as stationary storage.
- **"Charging as a Service" and "Mobility as a Service" Payment Models:** These models typically bundle financing for the vehicle, the alternative energy distribution infrastructure, the charging/refueling equipment, and the energy in a 10 year financing structure with a firm "pay-by-the-unit" or "pay-by-the-mile" fee. In practice, the model requires minimal or no upfront financing and acts similarly to a "Power Purchase Agreement for E-Fueling or E-Mobility."[22] It enables access to capital needed to handle the battery/fuel cell costs and infrastructure upgrades required to make the initial transition to ZE transportation within an operational expense framework that is familiar to operators.
- **Collaborative Approaches to Purchasing ZE Equipment and Infrastructure:** Government agencies have long used collaborative procurement programs to access discount bulk pricing, gather required capital threshold for improved financing rates, and create administrative efficiency through reduced procurement barriers and knowledge transfer. The port has not traditionally been involved in equipment purchases for port operators; however, the new ZE goals have prompted new conversations around bulk purchasing to drive down equipment costs.
- **Vehicle Grid Integration Opportunities:** When not in use, battery-electric equipment could discharge unused energy back into the grid. Operators who can sell this energy to the utility reap the revenue benefits. Given the round-the-clock operations of the port, it is not clear whether there will be such opportunities as electric equipment begins to be deployed in large numbers. That said, the larger capacity of batteries in many port applications will provide a unique test bed opportunity to determine revenue potential.

Address Key Barriers

The port has identified key barriers to financing the ZE transition. In the near term, more educational forums, such as workshops and meetings, can help improve the port community's awareness of the opportunities. Furthermore, regular communication with regulatory agencies and joint advocacy efforts may help communicate barriers to the public funding programs, and the port should evaluate lease terms and other guiding documents to ensure they do not preclude private investment, if desired.

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21 The Fast Act https://www.fhwa.dot.gov/fastact/

22 Power Purchase Agreement https://en.wikipedia.org/wiki/Power_purchase_agreement

Key Barriers to Public Funding

Public funding, particularly grants, is attractive for operators wanting to support the ZE transition but unwilling to shoulder the high risk and high cost of early deployments. The restrictions and guidelines for some public funding programs, however, make these programs less desirable. Moreover, the competitive nature of these grants and vouchers limits the availability for all willing operators. Specific barriers are described below:

- **Scrapping Requirements:** At this early stage of ZE, many operators are unwilling to scrap a piece of functioning diesel equipment for a ZE version with uncertain performance and reliability. Programs such as the Diesel Emissions Reduction Act[23] and Carl Moyer require scrapping, often within 90 days of receiving the new equipment. Uptake of these programs for ZE is likely to be limited until the technology is closer to commercialization.
- **Complicated Applications:** Public funding application processes are often cumbersome and complicated, requiring cost-effective analyses, emission calculations, and other technical components. Many operators need outside expertise to complete these applications, which is an expense without a guarantee of success. The port has assisted many operators with applications, shouldering the administrative and technical burden, and should continue to do so.
- **High Administrative Burden:** Public funding demands strict accountability for taxpayer funds and thus imposes stringent reporting, accounting, and auditing requirements on recipients. Many operators do not have the resources to manage ongoing reporting and grant administration requirements. These often-onerous requirements are a deterrent to many otherwise willing operators. Again, the port can assist by assuming this administrative burden if it has the resources to do so.
- **Short Execution Time Frames:** By legislation, funding agencies often have prescribed windows of time by which to encumber and liquidate the grant funds. Many of CARB's grant funds, for example, must be encumbered within two years and liquidated within two years. This structure often gives grant recipients only two years to design, develop, deploy, and demonstrate unproven ZE technologies and to build out the required infrastructure. Given the legal mandates for competitive bidding and procurement for public agencies, these timelines are often unworkable. Longer liquidation deadlines would greatly enhance the diversity and scale of ZE demonstration projects.

To address these barriers, the port can rely on its technical expertise and resources to help the operators access public funding programs if it has the resources to do so. Furthermore, the port must continue to communicate these challenges to public agencies, who often recognize the challenges but are bound by legislative guidelines. Joint regulatory and legislative advocacy with other members of the port community can raise these issues and generate pathways to resolution.

Key Barriers for Third-Party Private Finance

Port operators rely on private financing for their equipment purchases, and they are very familiar with this model for conventional, diesel-fueled equipment and trucks. The switch to

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[23] Diesel Emissions Reduction Act https://www.epa.gov/dera

ZE, however, introduces new complexities in terms of the uncertainty of equipment performance and availability, charging and fueling infrastructure, and the sheer expense of this new equipment. As noted previously, the price of ZE equipment is two to three times higher than today's equipment. These complexities require new approaches to private financing. Several key barriers complicate the landscape for funding the ZE transition.

- **Multitenant Split Incentives:** Multitenant property management arrangements can result in split incentives between tenants and owners. In some scenarios, the costs of electrical upgrades may be borne by the owner, while the benefits are enjoyed mainly by the tenants. Conversely, if tenants bear the ZE infrastructure upgrade costs, their tenancy may be too short to reap the full benefits over the lifetime of the equipment. This split incentive is apparent at the port in the relationship between terminal operators, who lease their space, and the port as the property owner. ZE solutions must consider the needs, limitations, and benefits of project implementation for terminal operators and the port as the property owner.
- **Prohibitive Capital Costs:** The ZE transition requires significant capital costs not required for traditional diesel equipment. Moreover, little is known about the long-term operating costs and full total cost of ownership implications. Full cost accounting models are better able to capture all aggregate costs, including capital costs of equipment, discount rate, infrastructure retrofit, and variable operations and maintenance costs, to better inform decision making. More information will become available as the early ZE equipment accumulates a higher number of operational hours.
- **Increased Complexity:** Adoption of electrified assets presents new complexities to fleet operators and asset owners. Initial procurements will present challenges relative to operational capabilities, installation, interconnection, and the need to navigate new financing structures. Port staff and other informed stakeholders may need to provide more technical assistance to ensure that terminal operators have the information they need to efficiently adopt and integrate ZE vehicles and related infrastructure.
- **Inexperience:** Uncertainty-driven risk and a lack of deal uniformity for ZE fleet projects is a near-term barrier for widespread adoption and for larger (more than $100 million) ZE equipment and infrastructure deals. Initial projects may be small (less than $15 million) and ad hoc until successful business models, structures, and opportunities can be validated. Infrastructure and utility upgrade timelines and hydrogen availability will be critical risk factors, and a significant barrier, to the port's successful ZE transition.

Traditionally, the port has not been involved in operator financing of equipment. With the transition to ZE, however, the port may want to help alleviate barriers to private finance by broadly distributing information on ZE equipment and infrastructure, convening regular workgroups of operators and finance agencies, and ensuring that lease terms and other guiding documents do not preclude investment by outside firms, if desired by the operators.

Develop Project Funding Plans

Financing the transition to ZE requires a tailored approach for each operator and project. There is a wide diversity of public and private options and no one-size-fits-all approach. Understanding and accessing these different funding options require expertise, time, and resources. The port can apply its own expertise and resources to help operators identify the best funding strategy.

Working closely with operators, the port should develop a funding plan for every ZE project. A project could be small, such as demonstrating a few pieces of electric equipment, or it could be large, such as deploying a 50-piece fleet or redeveloping an entire terminal for ZE and other efficiencies. In either case, the port and operator should identify and evaluate potential funding mechanisms, evaluate whether these mechanisms align with the timeline and objectives of the project, and develop a funding plan for each project.

Funding plans should include:

- Project cost estimates and schedules.
- Identification of all viable funding mechanisms, public and private.
- Expected timeline for funding availability.
- Expected dollar amount, if known.
- Other grant or voucher requirements.
- Roles and responsibilities.

The port has developed informal funding plans on a case-by-case basis to support technology demonstrations, but to advance commercialization, the port should formalize this process.

Community Benefits

The community surrounding the port, which is one of the state's most disadvantaged areas, stands to benefit greatly from the transition to ZE. The obvious benefits are less air pollution and improved public health. Less obvious is the potential to expand job opportunities for local residents and leverage ZE investments for community benefit. This section describes the potential community benefits associated with ZE and includes action steps to maximize these benefits.

Air Quality Benefits

The air quality and public health benefits of ZE are likely to be significant, and most stakeholders agree these benefits are the primary driver for a transition. As part of the Annual Air Emissions Inventory[24], the port reports emissions contributions by equipment and vehicle type. Based on 2017 emissions, the successful transition to ZE terminal equipment and drayage trucks would result in the elimination of these emissions sources, totaling more than 400,000 metric tons of GHG, nearly 1,500 tons per year of NO_x, and nearly 11 tons per year of particulate matter per year.

As noted earlier, yard tractors, top handlers, and RTGC's generate more than 91 percent of the NO_x emissions of the terminal fleet and 95 percent of GHG emissions while representing only 74 percent of the fleet. In light of this, the port should prioritize the transition of these pieces of equipment to accelerate emission reductions for community benefit.

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[24] Air Emissions Inventory https://www.epa.gov/air-emissions-inventories

Community Hire Programs

The ZE transition could open new job opportunities around infrastructure installation, equipment development and maintenance, and energy system installation. The port community should work to ensure that local residents, particularly those in disadvantaged communities, have access to these new jobs. Community hire programs are one way to make sure that jobs in the ZE space are available to Long Beach residents and workers that have traditionally struggled to find placement.

Community hire programs can be formal, as in the case of the port's project labor agreements, or informal, as in the case with some technology developers. The port should continue to evaluate ZE infrastructure projects on a case-by-case basis to determine whether each project should be subject to local hire provisions.

Leveraged Energy and Infrastructure Investments

The port and its operators are poised to invest millions of dollars in ZE infrastructure and equipment, which could have value beyond the Harbor District. For example, the battery inside an electric or fuel-cell drayage truck or yard tractor will one day reach the end of useful life and will no longer be suitable for the demanding port duty cycles; however, this battery still has useable hours for less demanding applications. As identified by port community stakeholders, these "second-life batteries" could be used as backup power systems or microgrids in community centers, particularly during emergencies or power outages

Advocacy

Seaports and community groups can, and should, work together to advance the move toward ZE. The port has been very successful partnering with environmental-justice groups and community-based organizations to strengthen grant applications and advocate for policies that support ZE (See case study "Community Advocacy for ZE.").[25] Although ports and community groups do not always agree on exact approaches, the port should work to identify commonalities to coordinate advocacy efforts and opportunities to expand ZE across the country.

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[25] Zero Energy Project https://zeroenergyproject.org/advocate/advocate-zero-energy-zero-carbon-communities/

CHAPTER 4: Knowledge Transfer Activities

The port's ability to transition to ZE hinges on broader acceptance of these blueprint actions, particularly in other port communities. Equipment manufacturers need higher quantities to scale up production and bring down costs for everyone. Finance organizations need larger markets to create better investment opportunities. The entire ecosystem would benefit from sharing lessons learned from technology demonstrations, infrastructure installations, and workforce challenges. Thus, the port must engage stakeholders, including other seaport communities, to share the blueprint actions and the port's progress in advancing the CAAP's ZE goals.

This section describes the port's actions to share the Blueprint with the following stakeholders:

- Seaports and the shipping industry.
- Engineers and technology developers.
- Regulatory agencies.
- Environmental and community organizations.

Seaports and Industry

The port will distribute the final Blueprint to other seaports, present findings at port-related conferences and meetings, and work with seaport and industry associations to communicate the port's efforts. These forums include conferences and seminars as well as regular meetings of the following associations:

- American Association of Port Authorities.
- California Association of Port Authorities.
- PMSA.
- West Coast MTO Agreement.
- Harbor Trucking Association.
- California Trucking Association.

Engineers and Technology Developers

The port can help advance knowledge about ZE by sharing lessons learned around design, infrastructure development, and equipment. The following organizations offer forums to do so:

- American Society of Civil Engineers.
- Institute of Electrical and Electronics Engineers.
- Association of Energy Engineers.
- California Hydrogen Business Council.
- CALSTART.
- Advanced Clean Transportation Expo.

Regulatory Agency Outreach

Regulatory agencies can benefit greatly from understanding the challenges and potential solutions associated with transitioning to ZE. These agencies include the U.S. EPA, CARB, CEC, and South Coast Air Quality Management District (SCAQMD).

These agencies offer forums for sharing lessons learned, such as those below:

- U.S. EPA West Coast Collaborative.
- U.S. EPA Ports Initiative.
- CEC Ports Collaborative.
- SCAQMD Clean Fuels Advisory Committee.

Environmental and Community Outreach

The port has an extensive community relations program, offering free public boat tours, distributing a port newsletter, and hosting "Let's Talk Port" community meetings. The port also committed to regular community updates as part of the CAAP. The Port plans to share progress of the Blueprint at the CAAP Quarterly Stakeholder meetings, "Let's Talk Port" meetings[26], and other community events. Moreover, the port meets regularly with environmental organizations and community-based groups for informal discussions on port programs. These smaller forums provide an opportunity to share lessons learned and next steps.

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[26] Let's Talk Port Meetings https://www.facebook.com/PortofLB/events/

CHAPTER 5: Recommendations and Conclusions

Actionable Steps to a ZE Future

The actions defined in this Blueprint require a concerted, collaborative effort from the entire port community and every port division, from engineering and finance to environmental planning and security. To be successful, the port must integrate these actions seamlessly into its organizational structure and processes. The Blueprint outlines the key steps for technology, infrastructure, finance, workforce, and community and the many related actions needed to be successful.

Although the flowchart suggests a linear progression of well-defined actions, in today's emerging ZE landscape, the process is more likely to be dynamic and iterative.

In this early stage, incentives for market acceptance are being offered in parallel to the development of the technology. Infrastructure construction is occurring before design standards have been finalized. Workforce training is being identified before we even know the full implications of ZE. Thus, the blueprint flowchart represents an ideal progression for a future, fully commercialized ZE future; today, it is an aspirational pathway.

Organizational Integration

To be successful, the port must integrate these blueprint actions seamlessly into its organizational structure and processes. The Blueprint outlines the key steps for technology, infrastructure, finance, workforce, and community and the many related actions needed to be successful.

To that point, today's incentives for market acceptance are being offered in parallel to the technology's development. Infrastructure construction is occurring before design standards have been finalized. Workforce training is being identified before stakeholders even know the full implications of ZE.

In time, the blueprint actions will coalesce around a sequential progression for a future, fully commercialized ZE future. Today, as the port community continues to learn more and grapple with the uncertainty, adjustments are likely to be needed along the way.

Internal Integration

The following port committees provide an internal venue for executing the blueprint actions and monitoring progress, and it is recommended that the Blueprint become a standing item on these committee agendas:

- **Planning, Environmental, Administration, Commercial, and Engineering Committee:** This committee involves the highest levels of management from all the port's core areas to discuss capital project priorities, environmental and planning initiatives, business opportunities, budget, and cash flow. The committee meets monthly.

- **CAAP Executive Committee:** This committee meets quarterly to discuss progress toward ZE and implementation of the other CAAP strategies. It consists of the executive director, deputy directors, managing directors, and director of environmental planning.
- **Grants Strategy Committee:** This committee meets monthly to discuss funding priorities and grant opportunities and develop strategic approaches to securing funds to support Port projects. It consists of the executive director, deputy directors, managing directors, and division directors involved in grant management.

External Integration

The following groups and forums provide an external venue to share progress on ZE technology and infrastructure advancement with the broader port community:

- **TAP Advisory Committee:** The TAP Advisory Committee consists of representatives from both ports, SCAQMD, CARB, and the CEC. This committee meets every six weeks to provide updates on technology demonstrations, many of them ZE, and consider proposals for new funding. This committee can help monitor the progress on ZE equipment and vehicle advancement.
- **CAAP Stakeholder Implementation Advisory Group:** This group, which is open to the public and does not have a formal membership, meets quarterly to hear progress on achieving the CAAP goals. The port should plan to provide updates on ZE technology demonstrations, feasibility assessments, and infrastructure installations.
- **CEC Ports Collaborative:** Led by the CEC, the ports collaborative brings the state's seaports together monthly to discuss technology demonstrations, funding, and ZE and energy management advancement. The port should plan to share its Blueprint and provide regular updates through this forum.
- **U.S. EPA Ports Initiative:** The U.S. EPA has spearheaded a national conversation around environmental justice in seaport communities. The port should share its Blueprint with this initiative to communicate the community benefits of ZE more broadly.

In addition to these standing committees and forums, the port should strive to keep the guidance committee and the broad stakeholder advisory group engaged in its efforts. To that end, the port should provide an annual update to these stakeholders during which the port will review progress, describe lessons learned, and assess the need for changes to achieve the ZE goals. As stated earlier, the Blueprint is a dynamic, iterative framework, and the Port must have space to evaluate, reassess, and refine the actions of the Blueprint.

Summary of Near-Term Actions

The Blueprint resulted in the identification of near-term next steps, which are summarized and presented in Table 20 of the Blueprint, and each of the five categories are shown in Tables 1-5 on the succeeding pages. Actions in **bold** require leadership from a stakeholder other than the port itself, reaffirming the importance of the entire port community.

Table 1: Summary of ZE Equipment/Vehicles

Inventory	Conduct annual equipment inventories to assess ZE transition progress.
Baseline	Further develop specific duty and drive cycle information to better understand when one-to-one ZE replacement of traditional technology can be achieved.
Demonstrate	Validate new technologies as they emerge in real-world testing.
Assess	Continue technology feasibility assessments on a regular basis as part of the CAAP.
Synthesize	**Develop and maintain, in partnership with other agencies, a library of port-specific data and synthesized analyses associated with ZE port technologies.**
Accelerate	Work with major manufacturers to accelerate commercialization with standard warranties, parts replacement, and customer service.
Experience	Facilitate short-term demonstrations, ride-and-drive events, and tours for operators.
Scale	Explore bulk purchasing programs to scale production and reduce unit costs.
Engage	**Collaborate with other seaport communities in order to spur greater market acceptance.**
Drive	Implement the CAAP and monitor regulatory efforts to drive market acceptance.

Source: Port Community EV Blueprint

Table 2: Summary of the Charging/Refueling Infrastructure

Catalog	Maintain a detailed inventory of existing charging and fueling infrastructure.
Forecast	Update high-level assessments of new energy needs based on equipment performance and energy consumption learned through technology demonstrations.
Evaluate	Organize infrastructure providers to help stakeholder evaluate cost-effective solutions and demonstrate innovative charging options.
Standardize	**Work with associations and state agencies to drive the adoption of heavy-duty charging standards through funding eligibility requirements or other mechanisms.**
Adopt	As standards are developed, adopt these standards into the Port's design process.
Collaborate	**Collaborate on regional infrastructure plans for ZE drayage trucks.**
Integrate	Continue to execute the Energy Initiative Roadmap and integrate ZE into the Port's Business Continuity Plan and Coastal Resiliency Planning efforts.
Secure	Engage security and law enforcement agencies to address cybersecurity concerns.
Design	Develop design plans with terminal operators for the ZE transformation.
Execute	Execute design plans as lease opportunities arise and identify funding mechanisms or incentives to bring terminal operators to the table prior to a lease expiration.

Source: Port Community EV Blueprint

Table 3: Summary of Financial and Business Model Considerations

Refine	Refine cost estimates as equipment matures, and terminal design efforts are conducted.
Relate	**Support the development of more refined TCO calculations to better compare ZE technologies to diesel technologies.**
Incentivize	Encourage the use of public funding programs, including LCFS, where necessary to promote early adoption of high-risk, initial-stage technologies.
Guide	Work with funding agencies to minimize barriers associated with grant funding programs.
Iterate	**Conduct outreach to the private and public finance stakeholders to ensure awareness of the opportunities and challenges associated with port projects.**
Innovate	**Identify innovative financing options and tools to help stakeholders calculate the benefits.**
Fund	Develop funding plans for each project in collaboration with operators.

Source: Port Community EV Blueprint

Table 4: Summary of Workforce Development

Certify	Evaluate national certification programs for applicability to port-related projects and work with community colleges to offer certification trainings.
Train	Review and potentially expand programs that train the existing longshore workforce for electric-automotive mechanic positions.
Align	Align curriculum and training programs for the ZE transition.
Champion	**Champion more funding for workforce education, training, and curriculum development.**
Support	Identify and address potential barriers to entry for the incumbent workforce, which may include financial assistance.

Source: Port Community EV Blueprint

Table 5: Summary of Community Benefits

Document	Continue to monitor emissions benefits and support ways to better aggregate health outcome data to identify on-the-ground community health improvements.
Cultivate	Continue to support programs that hire Long Beach residents and disadvantaged workers to cultivate the local workforce.
Educate	Expand awareness of educational and career pathways to make sure local residents take advantage of workforce training and community hire programs.
Partner	Work with the City and community groups to identify opportunities to demonstrate second-life battery applications for community resiliency.
Advocate	Continue to partner with community groups to jointly advocate for ZE policies and funding, where it makes sense.

Source: Port Community EV Blueprint

Accelerating the Actions

The port community must move expeditiously to advance its 2030 and 2035 ZE goals. Although some of the blueprint actions involve better communication and coordination of existing resources, it is clear, that funding will play a critical role in the port community's ability to execute, and where possible, accelerate many of the blueprint activities.

In the near term, the port sees an opportunity to significantly advance the following actions, particularly if funding sources can be identified:

- Develop design plans with terminal operators to evaluate the opportunities and costs associated with retrofit and redevelopment pathways. This detailed design and engineering effort will consider short- and long-term implications of terminal operations, allowing terminal operators on a site-by-site basis to create a customized vision that fits their geographic, business, operational, and infrastructure constraints. Based on the design plans and regional infrastructure plans, the port will be able to update ROM costs and plan for construction.
- Develop regional truck infrastructure plans to create thoughtfully and carefully a local and regional vision for ZE drayage truck hydrogen refueling stations and battery recharging stations. This effort would include close collaboration with many key stakeholders, including the Port of Los Angeles, SCAQMD, SCE, and major hydrogen fuel providers.
- Refine total cost of ownership models for terminal equipment and drayage trucks that can be developed in an open-source platform with clear and transparent assumptions. This effort would create a customizable model for relevant stakeholders across California and the world to evaluate their own specific equipment and technology needs.
- Evaluate and expand incumbent workforce training, including curriculum development, for longshore workers and truck drivers to gain the skills necessary for ZE operations and maintenance and, potentially, move into new, higher-need jobs, such as mechanic positions.
- Align local college curricula with the ZE transition, including the development and roll-out of curriculum and training programs for these emerging technologies.
- Launch a community campaign to expand awareness of educational and career pathways, ensuring that local residents take advantage of workforce training and community hire programs in support of ZE.

Conclusions

The POLB has adopted some of the world's most aggressive goals for ZE, including a goal of up to 100 percent ZE terminal equipment by 2030 and up to 100 percent ZE trucks by 2035. To support these goals, the blueprint identifies more than three dozen actions to be taken over the next few years to ensure the port community has the necessary ZE equipment, infrastructure, financing, workforce, and community benefits to be successful.

These actions have been informed by substantial input from a broad cross-section of port stakeholders. These stakeholders will be instrumental in helping execute many of the actions identified. Over the next few years, the port will continue to monitor its progress toward meeting the CAAP's ZE goals, working closely with the port community to refine, reassess, and adjust as necessary.

GLOSSARY

ASSEMBLY BILL (AB)—A proposed law, introduced during a session for consideration by the Legislature, and identified numerically in order of presentation; also, a reference that may include joint, concurrent resolutions, and constitutional amendments, by Assembly, the house of the California Legislature consisting of 80 members, elected from districts determined on the basis of population. Two Assembly districts are situated within each Senate district.

CALIFORNIA AIR RESOURCES BOARD (CARB)—The state's lead air quality agency consisting of an 11-member board appointed by the Governor, and just over thousand employees. CARB is responsible for attainment and maintenance of the state and federal air quality standards, California climate change programs, and is fully responsible for motor vehicle pollution control. It oversees county and regional air pollution management programs.

CENTER FOR INTERNATIONAL TRADE AND TRANSPORTATION (CITT)—Is dedicated to delivering education programs, innovative research, and community outreach in the area of goods movement.[27]

CLEAN AIR ACTION PLAN (CAAP)—Update to the original plan, ushering in a new era of aggressive clean air strategies for moving cargo through the nation's busiest container port complex. The document provides high-level guidance for accelerating progress toward a zero-emission future while protecting and strengthening the ports' competitive position in the global economy.[28]

ELECTRIC VEHICLE (EV)—A broad category that includes all vehicles that are fully powered by electricity or an electric motor.

GREENHOUSE GAS (GHG)—Any gas that absorbs infrared radiation in the atmosphere. Greenhouse gases include water vapor, carbon dioxide (CO_2), methane (CH_4), nitrous oxide (NO_x), halogenated fluorocarbons (HCFCs), ozone (O_3), per fluorinated carbons (PFCs), and hydrofluorocarbons (HFCs).

LOW CARBON FUEL STANDARD (LCFS)—A set of standards designed to encourage the use of cleaner low-carbon fuels in California, encourage the production of those fuels and, therefore, reduce greenhouse gas emissions. The LCFS standards are expressed in terms of the carbon intensity of gasoline and diesel fuel and the respective substitutes. The LCFS is a key part of a comprehensive set of programs in California that aim cut greenhouse gas emissions and other smog-forming and toxic air pollutants by improving vehicle technology, reducing fuel consumption, and increasing transportation mobility options.

NATIONAL RENEWABLE ENERGY LABORATORY (NREL)—The United States' primary laboratory for renewable energy and energy efficiency research and development. NREL is the only

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[27] Center for International Trade and Transportation https://www.cpie.csulb.edu/center-for-international-trade-and-transportation

28 Port of Long Beach Clean Air Action Plan https://cleanairactionplan.org/2017-clean-air-action-plan-update

federal laboratory dedicated to the research, development, commercialization, and deployment of renewable energy and energy efficiency technologies. Located in Golden, Colorado.[29]

NITROGEN OXIDES (OXIDES OF NITROGEN, NO_x)—A general term pertaining to compounds of nitric oxide (NO), nitrogen dioxide (NO2), and other oxides of nitrogen. Nitrogen oxides are typically created during combustion processes and are major contributors to smog formation and acid deposition. NO_2 is a criteria air pollutant and may result in numerous adverse health effects.

ORIGINAL EQUIPMENT MANUFACTURER (OEMs)—Makes equipment or components that are then marketed by its client, another manufacturer, or a reseller, usually under that reseller's own name.

PACIFIC MERCHANT SHIPPING ASSOCIATION (PMSA)—Engages in community affairs and legislative and regulatory affairs in California and Washington state. PMSA provides members with information services, including regular updates on matters of interest to the shipping industry. It also serves as a clearinghouse for environmental practices across the industry.[30]

PORT OF LONG BEACH (POLB)—The Port of Long Beach is the premier U.S. gateway for trans-Pacific trade and a trailblazer in innovative goods movement, safety, environmental stewardship, and sustainability.[31]

RUBBER TYRED GANTRY CRANE (RTGC)—A mobile gantry crane used in intermodal operations to ground or stack containers. Inbound containers are stored for future pickup by drayage trucks, and outbound are stored for future loading onto vessels. RTGs typically straddle multiple lanes, with one lane reserved for container transfers.

SOUTHERN CALIFORNIA EDISON (SCE)—One of the nation's largest electric utilities, which delivers power to 15 million people in 50,000 square miles across central, coastal, and Southern California, excluding the City of Los Angeles and some other cities.[32]

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY (U.S. EPA)—A federal agency created in 1970 to permit coordinated governmental action for protection of the environment by systematic abatement and control of pollution through integration or research, monitoring, standards setting, and enforcement activities.

ZERO EMISSION (ZE)—An engine, motor, process, or other energy source that emits no waste

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[29] National Renewable Energy Laboratory https://www.nrel.gov/

[30] Pacific Merchant Shipping Association https://www.pmsaship.com/

[31] Port of Long Beach https://polb.com/port-info/

[32] Southern California Edison Energy Company https://www.sce.com/