PORT OF LONG BEACH

ZERO EMISSIONS WORKFORCE DEVELOPMENT REPORT

Presented by:
Center for International Trade and Transportation
California State University Long Beach

Dr. Thomas O'Brien
Executive Director, Center for International Trade and Transportation

Dr. Tyler Reeb
Director of Research and Workforce Development, Center for International Trade and Transportation

Glen Shepherd
Graduate Research Assistant, Center for International Trade and Transportation
M.S. Geographical Information Science, Long Beach State University

Table of Contents

1. Executive Summary 4
2. Introduction: Research and Analysis 5
3. Literature Review 9
   3.1 Commercializing electrification of bus transit industry 9
   3.2 Vehicles 10
   3.3 Infrastructure 12
4. Case Studies 13
   4.1 Port of Rotterdam – Netherlands 13
   4.2 Port of Metro Vancouver – Canada 15
   4.3 Asian Ports – China, Singapore, and Malaysia 16
   4.4 Case of Microgrids 16
5. Labor Market Analysis 19
   5.1 Methodology 20
6. Inferences on Workforce Impacts 26
   6.1 Questions Raised Through Research 26
   6.2 Initial Stakeholder Workshop Meeting 26
   6.3 Industry Professional Peer Exchange Webinars 27
   6.3.1 12/17/28 Session 27
   6.3.2 12/18/18 Session 28
7. Training for Upskilling Incumbent Workers at POLB 29
   7.1 Electric Vehicle Infrastructure Training Program (EVITP) 29
   7.2 Energy Storage and Microgrid Training and Certification (ESAM-TAC) 30
   7.3 Certified Electric Vehicle Technician (CEVT) Training Program 30
   7.4 Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP) 31
   7.5 Electrical Technology Programs through the California Community Colleges 31
8. Top 5 Critical ZEV-Related Occupations 32
   8.1 Electricians – (O*NET 47-2111.00) 32
   8.2 Solar Photovoltaic Installer – (O*NET 47-2231.00) 33
   8.3 Automotive Specialty Technicians – (O*NET 49-3023.02) 33
   8.4 Electrical Engineer – (O*NET 17-2071.00) 33
   8.5 Electrical Power-line Installer and Repairer (Lineman) – (O*NET 49-9051.00) 34

Appendices: Career Pathways 35

Bibliography 46

1. Executive Summary

Electric vehicle technology and related zero-emission targets are creating significant workforce development challenges in port terminal environments. As combustion-engine focused port terminal operations are superseded by advances in electrification and fuel cell technology, the required skill sets of the future will be very different from the predominantly diesel-fueled industry of the past. From operations and maintenance to leadership and management roles, new pathways will be required for positions associated with the operation of zero-emissions vehicles (ZEVs) moving freight within and beyond the Port of Long Beach (POLB).

Public transit authorities using electric-battery and fuel-cell drivetrains are overcoming barriers to commercialization as technology has caught up with near-term environmental priorities, and alternative fuel options are becoming more viable. Transit operators in California now have ongoing orders to original equipment manufacturers (OEMs) for more Battery-Electric Buses (BEBs). Similarly, the availability of support infrastructure and applicable electric solutions for cargo handling operations has allowed POLB to begin shifting toward a ZEV fleet for terminal operations.

Zero-emissions electric cargo handling equipment (CHE) and charging station technologies provide port terminal operators with viable alternatives to traditional gas and diesel vehicles if costs of implementation are addressed. Global collaborative efforts in the fields of engineering, information technology, and technical trades have shown how these sectors of the workforce will be necessary for innovating and growing ZEV infrastructure. Although ZEVs have already been deployed throughout POLB, results from an October 24, 2018 POLB stakeholder workshop indicate that the majority of the port equipment workforce is not trained or ready to service the new vehicles and there is a need for data collection regarding operations and maintenance of new ZEVs. Furthermore, peer-exchange webinars with ZEV industry professionals, conducted by CITT, revealed a need for standardized ZEV training, a need for energy efficiency planning, and a current lack of high-voltage knowledge among electro-automotive workers. Additionally, there is concern regarding an aging/retiring workforce as this new generation of technology is ushered in in terms of who really needs to be learning these new skills during the transition.

An in-depth labor market analysis of port-related jobs in sustainability and environmental disciplines (green jobs) spotlights a high demand for candidates across a range of education and work experience prerequisites. These roles predominantly include skills in electrical and automotive trades; however, there is also a requirement for engineering roles and knowledge of utility policies. Most existing jobs will require additional safety awareness and familiarization training or work experience in installing, manufacturing, and maintaining ZEV systems. While some of the emerging ZEV systems at the ports will include autonomous functionality, the majority of the port workforce skills gaps will be driven by electrification rather than automation. Therefore, automated technologies are not expected to reduce the ranks of the supply chain workforce moving goods through the ports.

A case study analysis conducted by the CITT team identified other sustainability leaders in the port operations industry in order to compare ZEV approaches being implemented internationally. Comparative analysis makes it possible to gain insights into what can be learned from related ZEV workforce development efforts. The Port of Rotterdam, for example, offers a useful point of reference for applications of renewable energy infrastructure, hydrogen fuel research, and innovative disposal of industrial waste.

Combined insights from research and industry discussions influenced our workforce development analysis and played a key role in identifying a top-five list of ZEV-critical occupations, as follows:

- Electricians
- Solar Photovoltaic Installers
- Automotive Specialty Technicians
- Electrical Engineers
- Electrical Power-line Installers and Repairers

2. Introduction: Research and Analysis

The ZEV blueprint is a part of POLB's grant application to the California Energy Commission (CEC) to support the adoption of zero-emissions equipment and the goal of transitioning to complete zero-emissions port infrastructure by 2030.

Targets include:

- Improve freight system efficiency by 25% relative to the amount of carbon that it produces by 2030;
- Deploy more than 100,000 freight vehicles and equipment capable of zero-emissions operations and maximize near-zero-emission freight vehicles and equipment powered by renewable energy by 2030; and
- Establish targets for increased state competitiveness in zero-emissions adoption, developed by leaders in industry, government, and research and development.

Although adoption of renewable energy technologies and ZEVs have been increasing for decades, the recent growth in commercialization of battery-powered transit vehicles and CHE is unprecedented. However, the implications for workforce opportunities and development are somewhat unclear as this technology evolves. As the POLB establishes itself as a leader in adopting zero-emission solutions to port terminal management and operations, it is important to understand the shifting trends in job availability and openings as first-generation ports shift into obsolescence and electrification becomes the new developing industry standard.

CITT is assisting this process by analyzing the current labor market and identifying pathways into emerging opportunities resulting from electrification of cargo handling and hauling vehicles/equipment and its associated infrastructure in the supply chain industry.

This research addresses parallels in the increasing electrification of the U.S. bus transit system and the barriers faced in the transition. The research identifies the necessity for additional charging infrastructure. Furthermore, our investigation identifies current solutions to adopting this technology in the port environment, recognizing the current climate of government investment and support from utilities. Understanding financing and the availability of support infrastructure allows for a sense of how large entities such as POLB can introduce the new zero-emissions fleet over the coming years. The vehicles and the facilities needed for their operation opens the potential for entirely new job opportunities at the port in operations, maintenance, and leadership roles. This report outlines those positions, as well as pathways for the future workforce.

The report is outlined as follows:

- A literature review encompassing electrification of bus-transit technology, ZEV infrastructure advancements, and current zero-emission CHE;
- Labor Market Analysis of current career pathway trends and identification of occupations related to designing, developing, operating, and maintaining ZEVs and related infrastructure; and

- Case Study analysis of electrification in the port environment from a global perspective, with relation to the POLB focus.

Below, Table 1 outlines the hierarchy of workforce opportunities at POLB and the implications of large investment in the ZEV blueprint on employment. Decisions made by the port regarding the ZEV blueprint and future plans for development have wide-ranging implications for the individual bodies which make up the POLB network. Understanding the structural workings provides insight into how systems will change and the new normality that the current workforce will need to adapt to.

Stakeholders	Overview	ZEV Blueprint Implications
Port of Long Beach	Governed by the City of Long Beach Harbor Division, the port authority does not own or operate port equipment systems but rather owns the land and leases the land to cargo/terminal tenants who occupy the various piers, berths, and terminals. POLB is responsible for developing and maintaining landside infrastructure.	POLB has set policy goals to work with operators to transition to zero-emissions vehicles and to construct the necessary infrastructure upgrades on terminal tenants in accordance with the ZEV blueprint.
Terminal Tenants **Terminal Vendors**	Encompassed under four categories of cargo operations: ● Containerized ● Dry Bulk ● Liquid Bulk ● Break Bulk & Roll On-Roll Off These POLB clients have their own employees; some are company-hired but workforce across the port is represented largely by the International Longshore & Warehousing Union (ILWU).	Transformation to ZEV requires specifying the required infrastructure to support the new vehicles and designing plans for roll-out of the new equipment when it is purchased and becomes available. New vehicles have new implications for workforce training, as workers must become fluent in occupational health and safety associated with working on high voltage systems. Terminal vendors, including Original Equipment Manufacturers (OEMs), supporting ZEV operations may require upskilling and training of new hires for retrofitting or manufacturing new equipment, and for operator and technician jobs in maintenance and infrastructure installation (Long Beach City College (LBCC) draft report for CEC, *Zero-Emissions Terminal Equipment Transition Project*, 2018).
Organized Labor	The ILWU (Local 13) represents the longshore workers of Long Beach.	Equipment operators will need to become familiarized with standard procedures for new technology, perhaps requiring a

	There are no pre-requisites for most of these blue-collar jobs, as the union and terminals provide training for longshoreman and similar positions. Many workers will be employed for over a decade as casuals before moving up to leadership roles and part-time/full-time presence. The International Association of Machinists (IAM) represents mechanics at some terminals. Mechanics must be certified and go through a more rigorous pre-qualification process. POLB has on-going partnership with the International Brotherhood of Electrical Workers (IBEW) in Long Beach. This is where workers are often sourced for POLB infrastructure installation projects (Port of Long Beach, 2017). IBEW Local 11 offers paid apprenticeships through the Electrical Training Institute of Southern California.	completely new training curriculum to be implemented by the Pacific Maritime Association (PMA), which handles training for ILWU current and prospective employees. Mechanics will require new training in zero-emissions equipment maintenance. The potential for a decrease in certain employment prospects may encourage ILWU or IAM to upskill incumbents to retain jobs. IBEW union labor contracted by electrical firms will continue to install infrastructure. Workforce competencies required include high voltage safety; battery and charging station installation, operation and maintenance skills; and working with electrical systems in a corrosive environment (LBCC 2018).
External Bodies	Contractual workers make up another considerable portion of on-site operations for POLB. These jobs are generally specialized trade qualification roles and/or collaborations with other companies.	ZEVs require less regular maintenance. There is large potential for increase in outsourcing vehicle maintenance and part replacement to manufacturers and specialized electric vehicle experts. New renewable energy-generating infrastructure such as the planned solar carport projects – large in scale – will create opportunities and require external contractors for installation. Collaboration with experts in environmental policy will be required for auditing compliance with sustainability targets and standards. For example, the US Green Building Council (USGBC) has awarded Leadership in Energy and Environmental Design (LEED) ratings to completed middle harbor projects.

	Public utilities such as Southern California Edison monitor and regulate the supply and associated costs of providing electricity to POLB.	An increase in electricity demand from the grid as POLB shifts towards zero-emissions operation will put pressure on public utilities and new standards will have to be developed regarding tariffs and regulation, i.e. operations during peak usage hours.

Table 1: Hierarchy of workforce operations at POLB and the implications of ZEV blueprint on workforce groups

3. Literature Review

3.1 Commercializing electrification of bus transit industry

Acknowledging changing alternative fuel trends in other industries provides insight into barriers facing the adoption of ZEVs. Electric buses are particularly applicable when drawing a parallel with ZEV CHE, as the required infrastructure is similar in respect to changing workforce norms. For example, industry leaders in California have developed safety awareness and familiarization courses for operators transitioning to electric drive operations, and a lot can be learned from these processes as the port prepares for implementing ZEVs across their terminals.

The commercialization of medium-duty (MD)/ heavy-duty (HD) ZEV substitutes has been led by the increasing market for BEBs and their integration into the public transit fleet. In the early 2000s, the emerging use of BEBs was undermined by the lack of technological advancement in battery range and charging infrastructure. Additionally, investigations showed that the initial price premium of buying alternative fuel buses would not be offset by fuel savings over the vehicle's lifetime, and incentives were lacking with regard to utility subsidies (North-east Advanced Vehicle Consortium (NAVC), 2005).

However, changing trends in legislation, environmental outlook and the utilities market—coupled with advances in BEB range and charging capability—brought alternative fuels back into the limelight as a feasible solution to a large emissions issue. Battery-electric technology has become a clear favorite regarding overall efficiency, reliability, and reduction of life-cycle environmental footprint. Commercialization trials have increased in scale and begun establishing more extensive potential for charging infrastructure throughout the U.S. Furthermore, BEB manufacturing companies have seen increasing orders for fleets (Eudy, Prohaska, Kelly, & Post, 2016). This rise in demand occurs as issues relating to battery exchange from a decade prior are being satisfied by technological advancement. Now the high initial price premiums are offset by life-cycle fuel and emissions savings (not to mention Vehicle 2 Grid (V2G) savings benefits); however, the price of purchasing a new BEB is much higher than that of a commercial diesel engine bus, and, therefore, large fleet industry companies must pave the way for electrification to make a broader integration (Ercan, Mehdi, Zhao, & Tatari, 2016).

The emerging electrification market highlights a new area for workforce development in which jobs in installation and maintenance of charging facilities will be required as infrastructure grows. During BEB training in safety awareness and familiarization, drivers have been found to adapt to the new technology well. Mechanics required extra training in how to service and troubleshoot electric propulsion components and understanding on-board diagnostics, increasing their skill set (NAVC, 2005). Furthermore, during commercialization trials, charging stations have been found to require maintenance and monitoring, opening up a new area of expertise for operators and electricians/mechanics alike (Eudy, Prohaska, Kelly, & Post, 2016).

The capacity for these vehicles to compete with that of the commercially accepted combustion engines continues to increase. At the forefront, the Proterra E2 BEB is capable of storing 660kWh of energy and holds the world record for having travelled 1000 miles on a single charge in November 2017 (Miller & Hye-Jin, 2018). Findings continue to portray electric-battery alternatives as having higher efficiency, lower maintenance costs and more environmental appeal. As manufacturers move BEB products through commercialization trials, the operations and maintenance responsibilities move to the fleet operators, creating new positions and training standards (Eudy, Prohaska, Kelly, & Post, 2016). A parallel growth in manufacturing, maintenance and support workforce opportunities can be expected as technology continues to grow in other industries, such as port operations cargo-handling and hauling equipment.

3.2 Vehicles

Rubber Tyred Gantry (RTG) cranes, top handlers, and yard tractors (gasoline and diesel) represent a large portion of the terminal operations fleet and resulting emissions. Similar to the bus transit industry, these vehicles have begun to be superseded by electric-battery alternatives and solutions. RTGs can now be retrofitted for use in a zero-emissions environment, wherein they will operate via connection to the port electrical grid and only use diesel power during block changes and maintenance requirements (Vujicic, Zrnic, & Jerman, 2013). As POLB continues to roll-out more conventionally operated ZEVs over the coming years, there are also terminals at both POLB and POLA using automated ZEVs. At Middle Harbor, diesel RTGs have been replaced by electric Automated Stacking Cranes (ASCs), and Diesel yard tractors (hostlers) are competing with the emerging use of Automated Guided Vehicles (AGVs). Battery powered AGVs operate autonomously in cooperation with ASCs and provide increased efficiencies in time management and utilization of space and greatly reduced environmental impacts due to reducing human interaction - not to mention greatly reducing hazards caused by human error. This growing trend will see more specialized roles become available in remote operations and monitoring from the port's control center for automated terminals (Marine Terminals Corporation, 2017). Interaction between automated systems and manned machines such as street trucks still requires remote control intervention from a human operator at the Terminal Operating System (TOS), relying on the use of cameras, lasers, and other precision instruments. Although this technology may seem to have serious implications for the workforce population, large-scale automated systems like the one at Middle Harbor are only viable for tenants with long term contracts, and are hence unlikely to be implemented amongst the majority of terminal tenants. In addition, electric top handler and forklift operators will still be required for specialized manual operations, and those operators will require training in safety awareness and familiarization with new zero-emissions operating systems. This ensures an on-going presence of conventional CHE equipment and operators.

Overall, there are many jobs in the port terminal environment which require close interaction between workers and machines or containers (Marine Terminals Corporation, 2017):

- Container securing devices known as "inter-box connectors" (IBCs) or "cones" are used to hold containers in place on waterborne vessels and can only be effectively handled by workers.
- Refrigerated containers ("reefers") must be connected and disconnected to shore power outlets by human workers.
- Most terminals require workers to check the status of reefers while in storage.
- CHE frequently needs close attention by mechanics for routine diagnosis, maintenance, and repairs, as well as for swapping specialized cargo-handling hardware.

Figure 1: Autonomous container terminal system. AGVs and ASCs pictured.
(Dekker & Rotterdam, 2016)

Consolidation in the container business has seen ships grow in capacity. Successes in instances such as the APMT and RWG automated container terminals at Port of Rotterdam are inspiring new port developments and spurring growth in the market for automation (Dekker & Rotterdam, 2016). This opens up new workforce opportunities for engineers, architects and scientists in supply chain logistics, as there are still many hurdles to overcome in automated design/artificial intelligence. Furthermore, increased inbound container capacity requires increased outbound capacity in the trucking sector, wherein heavy-duty drivetrain technology will face the movement to zero emissions. The ZEV blueprint is establishing the port as a site for cutting edge innovations in this technology.

At the Toyota Warehouse (at POLB), the new generation of hydrogen fuel-cell semi-trucks are being built, which have a 300-mile range between refills. Infrastructure for these vehicles is being established by the construction of the Toyota zero-emission power plant project and the hydrogen fueling stations in Ontario, to support the trucking routes and begin establishing a support network for the new vehicles (Evarts, 2018). The California Air Resources Board (CARB) assists in funding this project by supplying approximately 50% of the required $82 million funding, which also includes new hydrogen forklifts and zero-emissions yard tractors to adhere to POLB zero-emissions standards (Evarts, 2018). This expands hydrogen fuel cell equipment at the port and contributes to growing the POLB micro-grid through producing renewable energy, increasing the ZEV fleet, and establishing alternative fuel infrastructure, which can be used as the building blocks for ZEV network growth.

3.3 Infrastructure

Smaller businesses in the U.S. currently have unclear incentives for installing ZEV charging facilities or establishing new fast-charge service stations to support the growing electric vehicle population. In California, the current 12,000 (approximate) publicly accessible charging stations falls short of the infrastructure required to support Governor Brown's goal of 1.5 million in-use electric vehicles by 2030 (Elkind, 2017). However, as seen in the evolving bus-transit industry, larger businesses can lead the way as utility services adapt to the new paradigm shift in technology.

At Long Beach Container Terminal (LBCT), which is almost entirely zero-emissions, an international engineering collaboration between European and American engineers and builders designed and constructed a Battery Exchange Building (BXB) (Farrell & McKie, 2016) to support battery-powered automated guided vehicles. This project provides insights into the kind of jobs which may become available as the POLB carries out planned projects for more similar ZEV charging stations and infrastructure. Those jobs mainly include:

- Engineering: robotics, mechanical, electrical, thermal and construction
- Specialized trades: refrigeration mechanics, electricians and builders
- Automotive technicians specializing operations and maintenance of alternative fuel vehicles.
- Environmental impact inspection and auditing

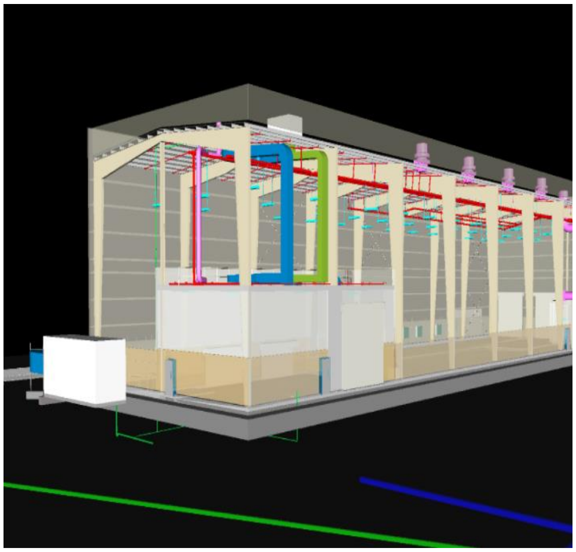

Figure 2: 3D schematic visualization of the BXB at the LBCT

Furthermore, plans for constructing large-scale solar energy generating facilities at the port open up opportunities for jobs in installation and maintenance. The time scale for these new jobs moves to more of a contractor scope rather than permanent port employment; however, there are already multiple projects planned throughout 2019-2021, and more will be created as the ZEV fleet grows.

It is the culmination of renewable energy solutions, V2G technology, and energy storage facilities on-site, such as BXBs that support the port's microgrid and zero-emissions initiative (Ercan, Mehdi, Zhao, & Tatari, 2016). Supporting the microgrid infrastructure and capacity of POLB also increases the efficiency of shore power (or "cold ironing") as an emissions reducing solution. Legislative mandates administered by CARB regulate energy use at-berth and require shipping lines to transition their vessels to shore power capabilities. This transition is incentivized as regulations increase each year, and violation of these laws incur harsh penalties for fleet operators. This is a good example of policy driving change and setting new standards for sustainable port operations. Furthermore, utilities can hopefully be expected to follow suit. Southern California Edison has indicated that new utility rate tariffs will be changing in response to demand and the new structure will incorporate higher expenses for MD/HD electric vehicle classes. Therefore, it is in POLB's best interests to streamline electrification and take advantage of current neutralization of demand tariffs as rate structures change, hopefully driving growth in jobs for electrification and renewables.

4. Case Studies

The impact of technology is evident across all avenues of businesses today, and the port sector is no exception. The future of a port complex will rely on hyper-connected environments comprised of devices sharing data in real-time, simultaneously improving knowledge, understanding, and productivity. A representative from the Agriculture Transportation Coalition (AgTC), the largest national trade organization for agriculture and forest product exporters, said in an interview with the Long Beach Business Journal that “technological advances and automation are not an option or a choice; they’re a requirement” (Belk, 2015. *Technology Will Inevitably Change Labor’s Role At Local Ports But With Long-Term Benefits*, p.1). Jobs are therefore becoming more mechanical and technology-oriented with rapid disruptions to the regular structure of work.

Low-carbon electrification options are driving demand for new skills to facilitate the transition to ZEVs in infrastructure. Given that these trends are global, it is important to garner information about strategies adopted and practiced by other ports around the world as primary leaders in energy management.

In a report published by the United Nations Conference on Trade and Development (UNTCD), global maritime trade is said to increase at the rate of 3.2 percent annually between 2017 and 2022. Cargo flows across all segments, especially containerized and dry bulk, will record the fastest growth (UNCTAD, 2017). This growth adversely impacts the environment via harmful emissions. Hence, there is a growing need to decarbonize the ports with a view towards sustainable energy practices within the port complex.

In this section of the report, three case studies are identified that describe innovative and consistent approaches to port electrification with the aim of decarbonizing.

4.1 Port of Rotterdam – Netherlands

The Port of Rotterdam is the largest port in Europe. It contributes nearly 3.3 percent of Netherlands’ gross domestic product and moves approximately 13.7 million twenty-foot equivalent units (TEUs) of freight annually. As a leader in the maritime world, the port has committed to cut its carbon emissions 95% by 2050, from the baseline year of 1990 (The Port of Rotterdam, 2017).

Energy is the lifeblood of the port for non-stop operations. Low-carbon electrification requires dedicated efforts by port officials and private sector partners. The port has established seven themes along which it will implement energy transition programs.

- **Energy through biomass**: The port is committed to produce energy using biomass as a raw material. Biomass originates from vegetable or animal material, as well as from waste streams from agriculture and production processes. It is a good replacement for fossil fuels in applications such as liquid fuels and chemicals. The Port of Rotterdam houses the world’s largest industrial cluster that uses biomass as raw material.

- **Energy efficiency practices**: The port is on a constant search for effective energy efficiency practices through optimizing processes and introducing new technologies such as improved heat integration, insulation, and process optimization, potentially resulting in an additional 20% of energy savings.

- **Investment in onsite and offsite renewable energy**: The port has installed nearly 200 mega-watts (MW) of onsite wind energy and will add another 150 MW of wind power to its energy mix. There is also an effort to maximize solar power onsite. The port is working with a private sector partner to explore large scale energy generation of wind power at sea with the option of converting the power into hydrogen. The port is also in its pilot phase of testing ultra-deep geothermal power.

- **Circular economy**: The port aims to be a center for reusing all products and substances effectively. It is committed to using waste as a raw-material to other industrial synergistic processes and aims to potentially reduce introduction of any new raw materials. In a circular economy, production and consumption are as clean as possible.
- **Alternative fuels:** The port has envisioned transportation to become more electric and carbon free. There is an initiative to support alternative fuels such as biomass, hydrogen, and emission free propulsion systems.
- **Energy infrastructure:** The port is developing a central infrastructure for residual heat, steam, and CO_2. The large quantities of heat and steam that are released in the port can thus be reused effectively, and CO_2 can be transported to locations for storage or reuse.
- **Large scale electrification:** Industrial companies in the port mainly use energy to generate heat for their production processes. By 2050, industry will switch to a new energy system. Electrification based on solar or wind power or produced from hydrogen will then be an important energy carrier.

There are over 40 projects at various stages of development at the Port of Rotterdam that administer clean and sustainable energy (Port of Rotterdam, 2017).

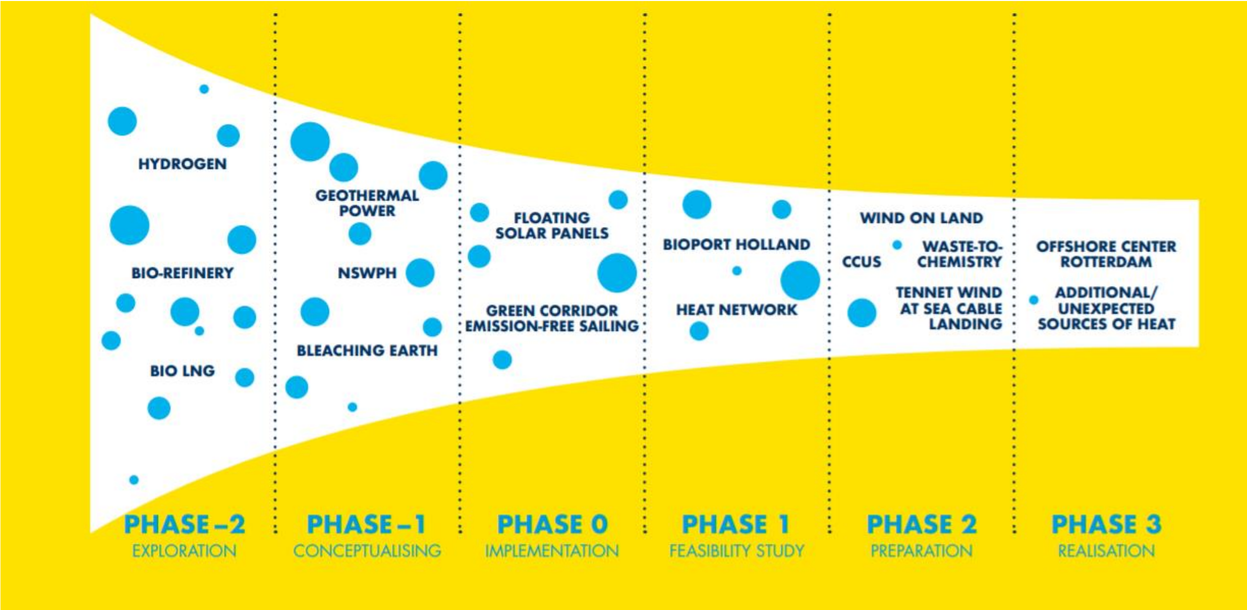

Figure 3: Chart representing various phases of energy strategy at the Port of Rotterdam (Port of Rotterdam, 2017)

The Port of Rotterdam has a clear energy pathway that presents several new workforce opportunities in the fields of renewable energy, energy infrastructure, hydrogen fuel research, alternative fuel research, and innovative industrial waste applications.

4.2 Port of Metro Vancouver – Canada

The Port of Metro Vancouver and related tenants and terminals are working to reduce port-related air emissions that affect air quality and contribute to climate change. They have set up the following goals for the sustainability of the port complex:

- Protect air quality through the reduction of criteria air contaminants such as sulphur oxides, nitrogen oxides, and particulate matter emissions;
- Reduce port contributions to climate change through reduction in greenhouse gas emissions and black carbon;
- Promote a culture of continuous improvement and energy conservation throughout the port, with a focus on operational efficiency and clean technologies; and,
- Collaborate with government and industry on the development of goals and objectives, performance monitoring, and progress reporting.

The Vancouver gateway moves more than 120 million tons of cargo annually, and this activity needs sustainable sources of energy. The port sources its electricity from BC Hydro, which uses 98 percent renewable sources, thereby reducing life-cycle emissions. In 2014, 50 shore power equipped container vessels visited this port for a total of 156 calls, increasing from 92 calls in the previous year (Port of Metro Vancouver, 2017). This has spurred the port to begin offering shore power to berths at the end of 2017, incentivizing this process through the EcoAction Program. This program offers shippers discounted harbor rates and creates an incentive mechanism to transition to shore power. The Port of Metro Vancouver is part of a larger coalition with Port of Seattle-Tacoma, forming the Northwest Ports Clean Air Strategy.

Internally, the port is also engaging in energy efficiency practices such as replacing and retrofitting LED lights in most of its property and performing electrical energy assessments to identify opportunities.

Figure 4: Shore power services at Port of Metro Vancouver
(The Port of Metro Vancouver, 2017)

4.3 Asian Ports – China, Singapore, and Malaysia

The ports in the Asia have taken a cue from their counterparts in the west like in Rotterdam, Long Beach, and Los Angeles. Shanghai's Yangshan Port has a fully automated terminal that is aiming for zero emissions and has cut overall energy consumption by 70%. According to World Resources Institute, China will see 493 berths equipped with shore power by 2020 due to government subsidies (Green Port, 2018). This shore side electrification is extending to port CHE, such as ship-to-shore (STS) cranes.

In Southeast Asia, the Maritime and Port Authority of Singapore (MPA) launched the Sea Transport Industry Transformation Map (ITM). ITM's goal is to make port operations more efficient by capitalizing on emerging technologies to achieve faster clearances. MPA hopes to grow the maritime sector by $4.5 billion and create over 5,000 jobs by 2025 (Green Port, 2018).

The port authority also signed a memorandum of understanding with Shell to advance clean fuel technologies, including greater automation to reduce emissions. For its part, PSA Singapore is installing an eco-friendly 4MW solar photovoltaic system. Built by Sunseap Group, the clean energy system will power five PSA facilities, including terminal buildings, gates, and a maintenance base.

The Port of Tanjung Pelepas (PTP) in neighboring Malaysia has installed new cable reel technology to provide electrical power for high-reach STS cranes. The reels will boost green efficiency by optimizing productivity and reducing the environmental impact of CHE operations.

Johor Port Authority (JPA) has teamed up with Universiti Teknologi Malaysia to develop an online Ship Emission Management System (SEMS). Terminal operators, such as PTP, are required to report ship activities using SEMS, which helps JPA to monitor, calculate, and regulate emissions through web-based and mobile applications (Green Port, 2018).

These case studies are global examples of port infrastructure that have showcased strategic direction in achieving port efficiencies with low-carbon priorities. While it is natural to address the port sector alone, it is imperative to highlight the innovations in energy infrastructure as well. Newer and more modern forms of electrification, such as microgrids, are a successful model for ports to adopt in their own journey towards increasing capacity and reducing risks associated by connecting to the grid.

4.4 Case of Microgrids

The U.S. Department of Energy defines a microgrid as "a local energy grid with control capability, which means it can disconnect from the traditional grid and operate autonomously" (U.S. Department of Energy, 2014. *How Microgrids Work*, p.1). A microgrid not only provides back up in case of emergencies, but acts as a mechanism to be energy independent and environmentally friendly. There are about 1,900 microgrid systems in the US that are operational as of 2018, and their numbers are expected to grow. Microgrids can power a single facility like the Santa Rita Jail in California, or they can power a larger area such as Fort Collins in Colorado (U.S Department of Energy, 2014).

Microgrids attempt to use renewable sources of generating energy such as solar PV, small-scale wind, natural gas, fuel cell, biomass, and rice husk, with storage options ranging from batteries to thermal. The Stone Edge Farm microgrid in Sonoma, California boasts of five separate forms of storage.

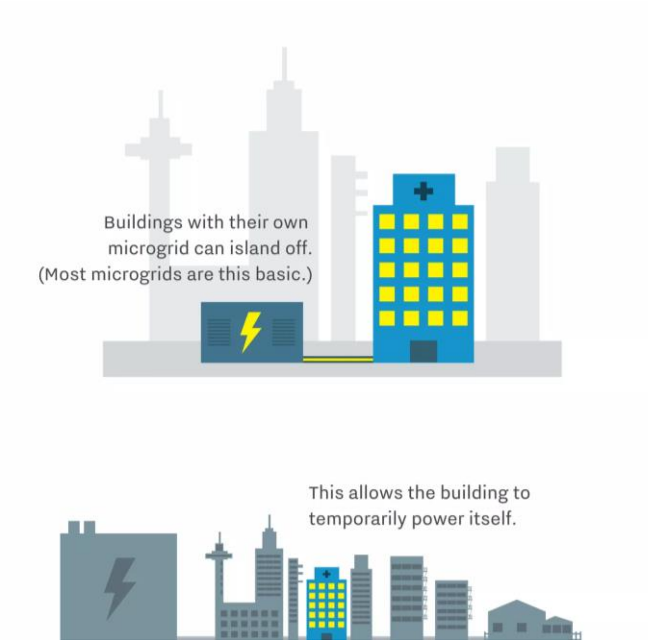

Figure 6: UCLA Energy and Environment Climate Lab
(Roberts & Chang, 2018)

The Port of San Diego has demonstrated the use of microgrids in its energy mix. The CEC along with the Port of San Diego has provided funds to set up a 700-kilowatt solar power microgrid with an equal storage capacity. This project is expected to cut the port's energy costs by 60% (Micro-grid Knowledge, 2018). This project is expected to test how well a microgrid can operate independently from the grid and eliminate nearly 300 metric tons of carbon dioxide from being released into the community adjacent to the port. A representative from the Port of San Diego articulated California's leadership role in the implementation of policies surrounding clean energy and vehicles stating, "With more electric vehicles at the port, this project can support transportation electrification by providing demand response when demand for grid electricity is high, taking the port offline for a few hours, if necessary" (Cohn, L. 2018. *Port of San Diego to Demonstrate How Microgrids Benefit Ports Worldwide,* p.1).

While the aforementioned new technology boasts improvements in sustainability and efficiency, zero-emissions systems must be managed properly to ensure optimization of cost-benefits after implementation. The need for expertise in energy policy and management has highlighted a gap in the workforce, which has influenced the emergence of new education disciplines, particularly in California. The following case study outlines the emerging energy engineering pathways available in California's higher educational institutions.

4.5 Case for Energy Engineering Profession

During peer exchange webinars (Section 6.3), industry professionals identified some critical roles not yet being met regarding ZEVs in the transit industry. Two of these roles were managing and optimizing the new electrical systems and complying with the regulations related to the new ZEV fleet. The job title that best fits both these roles was referred to as an "energy engineer." CITT chose to designate particular attention to this emerging job title and skill set as the expertise will be complementary to other engineering roles at POLB.

Energy engineering is a relatively new discipline that has developed as an academic response to emerging technologies and increasing demand placed on utilities for power generation. New educational pathways deal with energy efficiency management, alternative energy technologies, and environmental compliance. Transit industry professionals emphasized difficulty navigating the regulations in this new field of ZEV and were planning to hire full time employees to focus purely on the regulations-related skills gap. Also, battery life is a particular challenge facing management of ZEVs. With training in basic engineering concepts as well as efficiency standards and environmental compliance with regard to ZEVs, energy engineers can serve a pivotal role in facilitating a smoother transfer to commercializing ZEVs. Additionally, the BLS projected a 9.2% growth in demand for energy engineers between 2016 and 2026 nationwide so the availability of energy engineering educational programs could logically be expected to increase as well (Bureau of Labor Statistics, 2018).

Two energy engineering bachelor's degree programs are currently offered in California at Stanford and UC Berkeley. Undergraduate programs in energy engineering at Stanford[1] and UC Berkeley[2] aim to build foundational knowledge and engineering skills such as resource assessment, carbon management, and a basic technical and scientific background all engineers should possess. With this skill set, students have the ability to contribute in the energy industry immediately or pursue graduate studies. Students are required to study courses such as "Optimization of Energy Systems" that may be particularly beneficial to ports on their paths to becoming more energy efficient. Students are also required to take numerous courses addressing the broader issues related to the energy industry that will provide them with an understanding of the regulatory framework that is currently in place.

Beyond undergraduate studies, there are a number of relevant master's programs offered at Stanford, UC Davis[3], San Francisco State University (SFSU)[4], and University of San Francisco (USF)[5]. These graduate programs cater their curriculum to students of different undergraduate backgrounds. While the programs at Stanford and SFSU are focused on educating engineering graduates, the programs at UC Davis and USF are accessible to both engineering and business/management graduates. These programs also offer opportunities for professionals interested in energy systems to upskill and help meet the increased demand for energy engineers in coming years.

Energy engineers can serve two pivotal roles, both of which make them critical to the success of the zero-emissions initiative: they will be well-versed in both technology relevant to increasing energy efficiency and in the new regulatory standards of large scale zero-emissions equipment-use. An understanding of energy efficiency will be crucial to suppressing utility costs at the port while reducing waste and emissions and will be an emerging green skill as industry changes.

---

[1] https://exploredegrees.stanford.edu/schoolofearthsciences/energyresourcesengineering/#bachelorstext

[2] https://engineering.berkeley.edu/academics/undergraduate-guide/degree-requirements/engineering-science/energy

[3] https://energy.ucdavis.edu/education/energy-graduate-group/for-prospective-students/

[4] http://engineering.sfsu.edu/academics/graduate/engineering/coursework_es.html

[5] https://www.usfca.edu/arts-sciences/graduate-programs/energy-systems-management/program-details

5. Labor Market Analysis

There are multiple occupations for workers in the ZEV and charging infrastructure workforce, encompassing both the electric-battery and hydrogen fuel-cell vehicle options: the OEM engineers and architects who research, innovate and design alternative fuel drive technology, the manufacturing technicians who build the vehicles, and the electro-automotive maintenance workers who operate and maintain the vehicles. Most of these occupations require specialized training or work experience in ZEV manufacturing and/or maintenance.

Employment growth is expected in most occupations in the ZEV industry, according to a study by the Center for Entrepreneurship and Technology at the University of California, Berkeley (Draper, Rodriguez, Kaminsky, Sidhu, & Tenderich, 2008). Growth is expected in manufacturing industries and the domestic energy sector as the need for batteries and charging stations increases; as a result, the demand for grid support also increases. New automobile manufacturing jobs will be created; however, many of these jobs will be filled by current manufacturing employees or those that were displaced by recent downsizing of the automobile manufacturing industry (Hamilton, 2011).

Using the Labor Insight/Jobs™ tool from Burning Glass Technologies and drawing data from the Bureau of Labor Statistics (BLS), we conducted an occupational deep-dive to understand the job profiles associated with zero-emission and sustainable-focused jobs within the port sector. We investigated existing jobs to understand new jobs that will emerge, based on changing infrastructure and administrative requirements. Looking into future projections for zero-emission jobs, we have correlated the demand for key positions within the ZEV field with industries relating to port operations to make an educated prediction of occupations that will be critical to the ZEV blueprint at POLB.

Additionally, utilizing keywords from research and industry professional peer-exchanges, we used O*NET OnLine occupation searches to identify those jobs which are classified as “Green Jobs” and predicted growth in the near future. This “Green Jobs” mantle is given to those occupations that are increasing in demand due to economic activities and technologies which support environmental sustainability. This categorization further assisted our decision making process, shortlisting critical workforce opportunities relative to the ZEV blueprint, as identified in Table 2.

5.1 Methodology

We conducted an initial analysis of the labor market with a focus on professions requiring a four-year higher education degree due to the innovative, cutting-edge nature of the developing ZEV industry. This methodology identified professions in engineering, architecture, and scientific development. While these jobs are still relevant to port operations, many are at the managerial and administrative levels and account for a small percentage of the port workforce. After conducting group peer exchanges with professionals across the transit, port, and education industries, new avenues of research relating to the ZEV job market emerged. Discussion of workforce development highlighted the following gaps: expertise in the field of electro-automotive technicians (mechanic and electrician roles with high-voltage experience), energy efficiency planning, and utility policy. There was also noteworthy mention of potential for a steady rise in infrastructure installation and maintenance technician positions, with discussion revolving significantly around community college-based trade and technical education as the dominant qualification.

Using Labor Insight/Jobs™ Burning Glass, commonalities in job titles posted (relating to ZEVs) were discerned across multiple industries relating to the port environment and across a range of education/certification levels. Frequency of key terms used in our peer-exchange transcripts were plotted alongside conclusive notes to develop baseline keywords for the Labor Insight/Jobs™ occupation searches.

- Input keywords used as a baseline dependent variable were as follows:
  - Zero emission
  - Battery electric
  - Hybrid vehicle
  - High voltage
  - Renewable energy
- Furthermore, the following BurningGlass filters were applied as constant influencing factors:
  - Green Jobs
  - STEM
  - Hybrid Tech
  - Middle Skill
  - Advanced Manufacturing

Chart 1 was created in Labor Insight/Jobs™ and depicts job postings within the 365 days of 2018, according to the aforementioned baseline inputs. With the exception of Electrical Engineer, there is less demand for jobs which require university level education, even though those positions are still applicable to the criteria. Professions such as Electrician and Maintenance Technician are in highest demand, as the requirement for more individuals in these fields is increasing. Furthermore, variations of automotive mechanic professions are present, supporting opinions from our peer-exchange (section 6.3) that electro-automotive skills will be highly desirable in the ZEV-related job market.

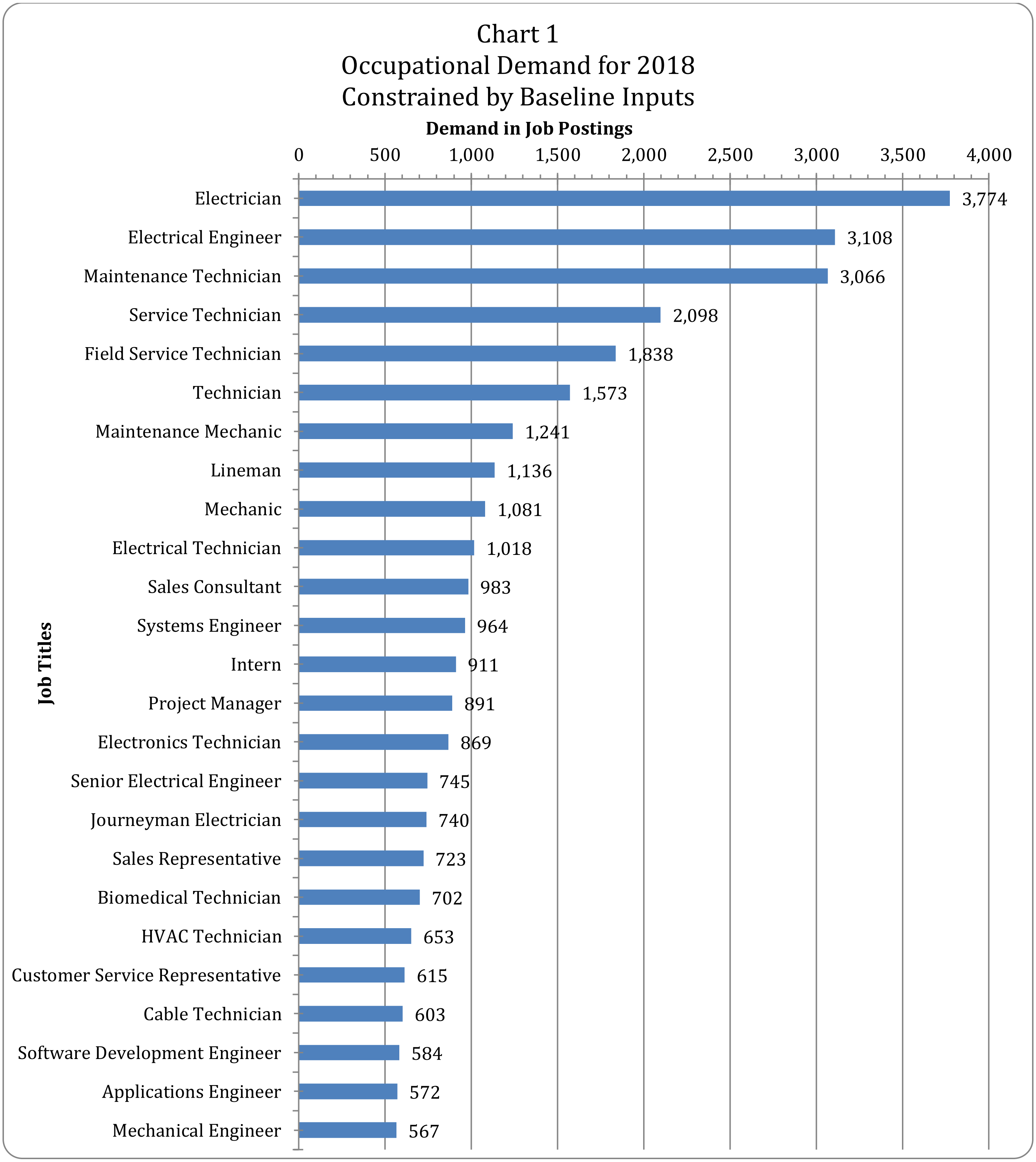

Chart 1
Occupational Demand for 2018
Constrained by Baseline Inputs
Demand in Job Postings
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
Job Titles
Electrician 3,774
Electrical Engineer 3,108
Maintenance Technician 3,066
Service Technician 2,098
Field Service Technician 1,838
Technician 1,573
Maintenance Mechanic 1,241
Lineman 1,136
Mechanic 1,081
Electrical Technician 1,018
Sales Consultant 983
Systems Engineer 964
Intern 911
Project Manager 891
Electronics Technician 869
Senior Electrical Engineer 745
Journeyman Electrician 740
Sales Representative 723
Biomedical Technician 702
HVAC Technician 653
Customer Service Representative 615
Cable Technician 603
Software Development Engineer 584
Applications Engineer 572
Mechanical Engineer 567

Search criteria filters were further applied to the aforementioned BurningGlass output, in an attempt to represent the job market directly relating to port operations. The following filters were applied using the “OR” Boolean operator in order to identify positions which may relate to port operations across different combinations of these constraints and thereby provide an output of the most common positions in-demand for this research focus. Level of education was kept open to encompass all pathways, and time window was constrained to the 365 days of 2018 in order to gain a contemporary snapshot of this labor market: this eliminated the influence of trends in the job market for previous years when activity in the green economy was different from the current climate.

- Industry:
  - Professional, Scientific, and Technical Services
  - Transportation and Warehouse
  - Utilities
- Occupation:
  - Construction, Extraction, and Architecture
  - Maintenance, Repair, and Installation
- Skills
  - Energy and Utilities
  - Supply Chain and Logistics
  - Architecture and Construction
  - Education and Training
  - Environment
  - Information Technology
  - Science and Research
  - Engineering.
- Education:
  - Any level of education

Chart 2 portrays the occupational demand within 2018, constrained by any combination of the above categories relating to port operations. Reflecting the opinions conveyed by industry professionals during our industry professional peer-exchanges (see section 6.0), Electricians, Mechanics, and Technicians have polled highest as roles required for ZEV fleet roll out. Although the top three constitute very broad job titles, those positions become more specialized moving down the chart, as Service Technician, Maintenance Mechanic, and Industrial Electrician are specified. Other interesting occupation fields include information technology roles, such as Computer Technician and C++ Technician, as well as installation roles, such as Solar Installer. These are areas of the workforce that have often been referred to in our research and are pertinent to POLB developments projected for 2019-2022. Some of these positions may require advanced college education, however the majority of these roles require trade-technical expertise, as expected.

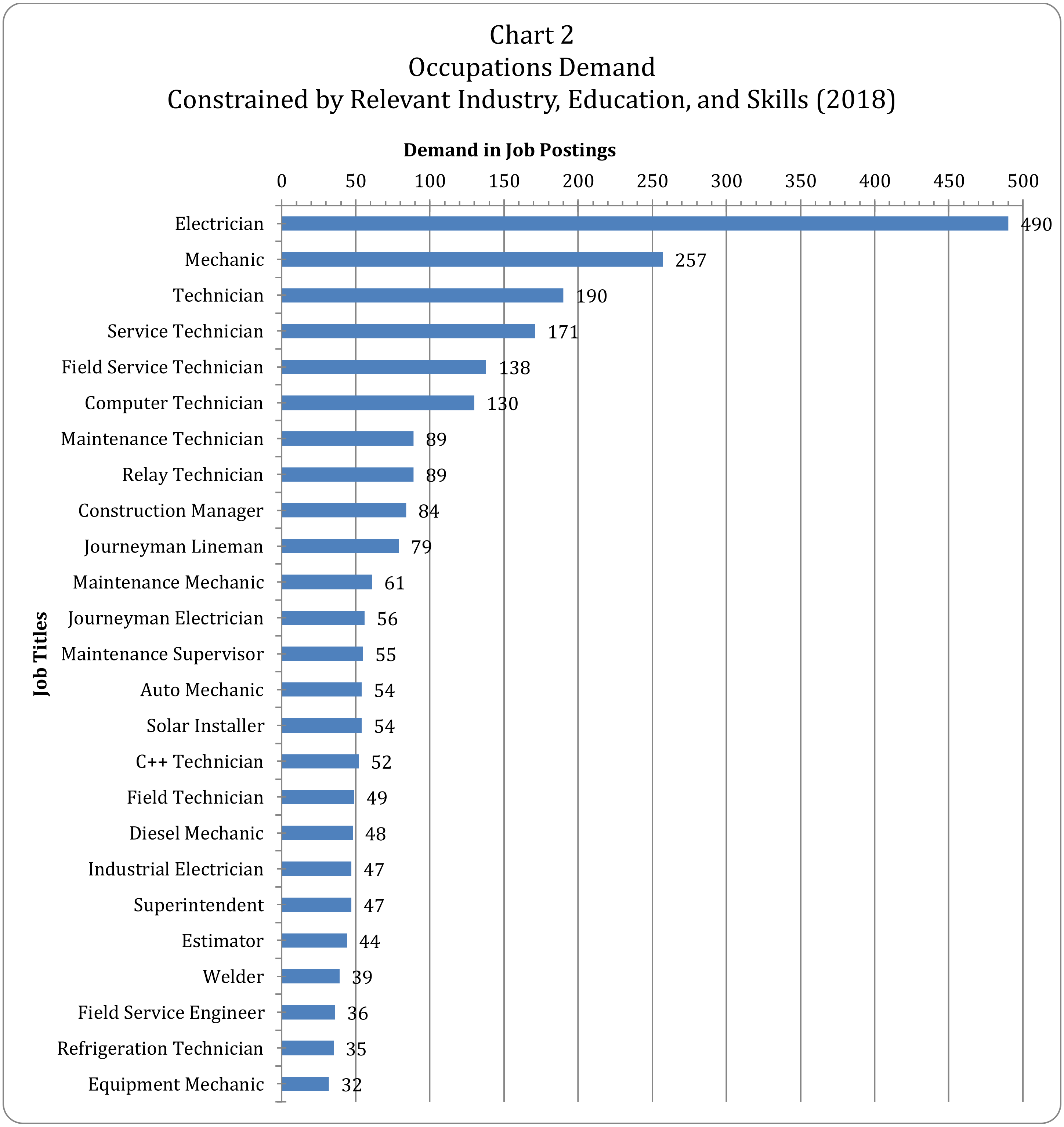
Chart 2
Occupations Demand
Constrained by Relevant Industry, Education, and Skills (2018)
Demand in Job Postings
0
50
100
150
200
250
300
350
400
450
500
Job Titles
Electrician 490
Mechanic 257
Technician 190
Service Technician 171
Field Service Technician 138
Computer Technician 130
Maintenance Technician 89
Relay Technician 89
Construction Manager 84
Journeyman Lineman 79
Maintenance Mechanic 61
Journeyman Electrician 56
Maintenance Supervisor 55
Auto Mechanic 54
Solar Installer 54
C++ Technician 52
Field Technician 49
Diesel Mechanic 48
Industrial Electrician 47
Superintendent 47
Estimator 44
Welder 39
Field Service Engineer 36
Refrigeration Technician 35
Equipment Mechanic 32

Using O*NET OnLine, the previously mentioned keywords were then used in an occupation search. Job titles relating to the "green economy" and "bright outlook" were identified for correlation with Labor Insight/Jobs™ results.
Green jobs are subdivided into three categories by O*NET:

- **Green Increased Demand**
  Green economy activities and technologies are likely to increase the employment demand, but will not lead to significant changes in the work and worker requirements.
- **Green Enhanced Skills**
  Green economy activities and technologies are likely to cause significant change to the work and worker requirements. New tasks, skills, knowledge, credentials may be needed. Employment demand remains the same, but there is potential for increase
- **Green New and Emerging**
  The impact of green economy activities and technologies is sufficient to create the need for unique work and worker requirements, which results in the generation of new occupations.

The above sub-categories, reflect our goal to find jobs that are new, existing, or require upskilling, for a complete understanding of the current potential in the ZEV-related labor market.

We used the Employment Projections data tool on the BLS website to gather the employment change predictions for the time span: 2016 – 2026 (the maximum future projection provided). The following table depicts our developed job title shortlist, including O*NET codes, green occupation status, projected employment change, 2017 median wage, entry-level education requirement, and on-the-job training required.

On the following page, Table 2 displays shortlisted ZEV-related professions with a range of different factors affecting career pathways. Electrical and automotive backgrounds are predominant requirements for the majority of positions here; however, entry-level education can range from high school diploma to college-level degrees. Coupled with the predicted increase in workforce demand relating to the green economy, there is a positive outlook for individuals looking attain ZEV-related occupations.

Percentage employment increase data provides insight into how large that particular job demand is predicted to grow. For example, Solar Photovoltaic Installers are predicted to see 104.9% growth in available jobs over the 2016-2026 decade. However, this only accounts for 11,800 individuals. Conversely, Electrician jobs are predicted to grow 8.9% over the same period, accounting for 59,600 job openings. This data and research into port operations has assisted us in predicting growth and critical importance to POLB, as well as identifying viable pathways to the positions we have selected for submittal, outlined in Section 7.0.

Table 2. Shortlisted Critical ZEV-Related Occupations, Relevant Statistics and Prerequisites							
Occupation	O*NET Code	Green Occupation Category	Employment Change 2016-2026 (increase in thousands)	Percentage Increase (%)	Median Wage (USD)	Typical Entry-Level Education	Typical On-The-Job Training
Electricians	47-2111.00	Green Increased Demand	59.6	8.9	54,110	High School Diploma or Equivalent	Apprenticeship
Electrical Engineers	17-2071.00	Green Enhanced Skills	16.2	8.6	95,060	Bachelor's Degree	None
Automotive Engineers	17-2141.02	Green New & Emerging	25.3	8.8	85,880	Bachelor's Degree	None
Automotive Specialty Technicians	49-3023.02	Green Enhanced Skills	45.9	6.1	39,550	Post-Secondary non-degree award	Short Term On-The-Job Training
Electro-Mechanical Technicians	17-3024.00	Green Enhanced Skills	0.5	3.5	56,740	Associate's Degree	None
Transportation Vehicle, Equipment and Systems Inspectors	53-6051.07	Green Enhanced Skills	1.7	5.9	72,140	High School Diploma or Equivalent	Moderate Term On-The-Job Training
Energy Engineers	17.2199.03	Green New & Emerging	8.5	6.4	97,250	Bachelor's Degree	None
Software Developers, Systems Software	15-1133.00	Green Increased Demand	47.1	11.1	107,600	Bachelor's Degrees	None
Electric Power-line Installers and Repairers	49-9051.00	Green Increased Demand	16.8	13.9	69,380	High School Diploma or Equivalent	Long Term On-The-Job Training
Computer Systems Engineers/Architects	15-1199.02	N/A	26.6	9.3	88,510	Bachelor's Degree	None
Solar Photovoltaic Installers	47-2231.00	Green New & Emerging	11.8	104.9	39,490	High School Diploma or Equivalent	Moderate Term On-The-Job Training
Maintenance Technician	49-9071.00	Green Enhanced Skills	112.5	7.9	37,670	High School Diploma or Equivalent	Moderate Term On-The-Job Training

6. Inferences on Workforce Impacts

6.1 Questions Raised Through Research

Although research has outlined the potential trends in the growing shift to zero emissions, there are still gaps in literature pertaining to how companies are managing or planning for the change in workforce skills requirements. In particular, case studies have reflected a strategic approach to managing, generating, and innovating energy resources in and around port complexes. A key takeaway from the approaches adopted by the ports indicates that ports use incremental efficiency methods like retrofits, shore powering ships, and process improvements to generate swift results. Ports also take long term sustainability approaches that incorporate technology-based innovative carbon management and energy capacity improvements that redefine traditional management techniques.

Although not immediately evident, this trajectory of strategic approach has altered the fabric of port workforce needed to handle, maintain, and manage future energy systems. Some of the implicit questions that emerge include the following questions:

- Are any private companies retrofitting diesel engine CHE to electric-power in Southern California? Is POLB considering this alternative to new ZEV fleets?
- Are any companies already prepared for upskilling their workforce to safety awareness and familiarization with ZEVs?
- Who is currently providing ZEV training for maintenance and operations at POLB? How can current ZEV training for maintenance and operations at POLB further develop to meet current and future demand? OEMs (Train the Trainer programs), contract training, community colleges, unions (in particular, the IBEW), employers through Employment Training Panel (ETP)-funded workforce development, and Long Beach USD through Linked Learning pathways can provide ZEV training. Recommendations include providing short-term training to new hires as well as incumbents to meet the immediate needs of industry and piloting new curriculum that can be integrated into existing credit-bearing certificates and degrees (LBCC draft CEC workforce gap analysis report).
- Are there currently any POLB partnerships with educational institutions for promoting supply chain management pathways in the engineering and technical trade divisions?
- What is the current climate of relationships with organized labor? Is there pushback or concerns raised regarding the future of longshoreman positions?
- How do ports train or retrain existing energy managers to adapt to the changes in the energy dialogue at port complexes?
- Are there skill sets that ports adopt when hiring for a strategic position - for example, positions that will be responsible for attaining the energy goals for 2050?
- How have competencies changed with respect to hiring in energy management?

6.2 Initial Stakeholder Workshop Meeting

On October 24th 2018, CITT attended a stakeholder workshop which was designed to bring involved parties up to date with the POLB zero-emissions blueprint and to conduct a think tank for voicing concerns as the project moves forward. Participants were provided with current statistics for port equipment, infrastructure, and emissions goals, as well as progress updates for current projects and cost forecasts. Furthermore, a brief questionnaire provided insights into industry opinions concerning operational change, equipment availability, and facility readiness in the face of the transition to zero emissions.

Key findings from this stakeholder workshop meeting encompassed concerns for fleet operators regarding the ZEV blueprint. Definitive results from the questionnaire were as follows:

- Price and availability of ZEVs from manufacturers are the primary concerns for fleet operators/owners;
- 100% of terminal operators state there is a requirement for significant training changes;
- Supervisors feel the mindset of operators needs to be changed from diesel combustion systems to the new alternative-fuels norm;
- No mechanics are considered ready to service ZEV equipment;
- Majority of respondents did not know if there is currently spare capacity for more ZEVs at the port;
- External funding for ZEVs is available on a limited basis; and
- 84% of respondents agreed there is a competitive advantage for "going green."

This discussion group served to create a dialogue for how the needs of fleet operators are being met and raised questions which could be addressed when CITT moves forward in deploying surveys and convening interviews with targeted industry stakeholders. Major questions left open for deliberation were as follows:

- How does the ZE transition impact the workforce?
    - What new skills are required and how will they be developed into a curriculum and taught?
- Where is the data on operations and maintenance? Do standards for maintenance need to be developed to gather this information and portray viability of ZEVs at the port?

6.3 Industry Professional Peer Exchange Webinars

In December 2018, two peer exchange webinars were hosted by CITT to discuss the topic "Workforce Impacts of Zero-Emission Technology." These webinars included industry professionals from the public transit industry, OEM representatives, educational partners, POLB Harbor Division, and workforce experts. Facilitated by CITT Executive Director Dr. Thomas O'Brien, participants were introduced to one another, provided with an overview of this study, and invited to discuss their experiences with ZEV technology and opinions regarding current and future workforce impacts.

These sessions largely outlined difficulties currently being managed by commercializing ZEV buses in the transit industry. Inherently, BEBs are causing a shift in operations and infrastructure management, and there is a growing need for expertise in efficient energy-use planning. Furthermore, there is a skills gap in utilities law/policy and an extensive need for electro-automotive technicians with experience and training working with high-voltage systems – findings which are applicable to the consensus that trade and technical certified jobs would be in the greatest demand for ZEVs.

6.3.1 12/17/28 Session

Participants from:

American Public Transit Exams Institute, APTREX

Northeast Transportation Workforce Center, NETWC

Foothill Transit

Center for International Trade and Transportation

Key Findings:

- Lack of sufficient operating and maintenance manuals from OEMs has hindered the development of standardized industry training thereby slowing down the upskilling of the current workforce to work with ZEVs. Safety awareness and familiarization training is needed for the ZEV workforce.

- Range of ZEVs creates a focus on efficient operating standards. Expertise in energy planning and conservation will allow for optimization of vehicle and infrastructure use.
- Standard electrical knowledge is a necessary new skill, and new training is required for existing operators and technicians.
- Senior management are finding they lack the necessary knowledge regarding legal and regulatory framework for energy planning.
- City maintenance workers will see an increase in work responsibilities as electric vehicle charging infrastructure grows, and those technicians will require standardized upskilling in order to work with the high voltage systems.

6.3.2 12/18/18 Session

Participants from:

City of Long Beach, Harbor Division

City of San Joaquin, Regional Transit

LA Metro Transit, Environment and Sustainability

Proterra, Inc

Center for International Trade and Transportation

Key Findings:

- Although a lot of the technology already exists for zero-emissions operations in the port environment, the trucking field will see a slower gradual transition regarding fuel type. Natural gas currently has a more viable efficiency because of its long range, as an alternative to diesel.
- New skills and expertise relating to ZEVs will likely be applicable both inside and outside of the port. Therein, new jobs are expected to be contractor-based in nature, while the existing longshoreman population will undergo upskilling.
- It is questionable as to whether it is worth upskilling the older workforce who will be retiring as California zero-emissions goals come to fruition in 2030 – 2040 (the majority age bracket of transit operators and significant portion of longshoreman). However, developing new training programs for the next generation of workers who will use zero-emission technology and upskilling the current younger workforce will be necessary.
- Technical trade expertise and skills obtained at 2-year community colleges will be more relevant for filling a larger quantity of positions; however, there will be some requirement for four-year college-educated professionals in the energy engineering/planning/management fields.
- Expertise in Information Technology and Geospatial Software may be required to manage infrastructure and plan vehicle routes, especially where automation is present.
- There is a shortage of high-voltage system knowledge and experience among electricians in the transit industry - a skill set which is essential to working with ZEVs and charging infrastructure. This may also be true for electrical professionals at POLB and is a major factor influencing an individual’s ability to safely work on ZEVs and infrastructure.

7. Training for Upskilling Incumbent Workers at POLB

The following courses of study outline training programs which have been identified as being particularly beneficial to both current and future workforce needs at POLB. Each of these programs are relevant to incumbent workers who already have technical skills in electrical, mechanical, or automotive disciplines. As a suggestive action item, this upskilling method has been highlighted as potentially critical to the ZEV technology transition.

Long Beach Community College's draft report for CEC's Zero-Emissions Terminal Equipment Transition Project identifies several competencies based on stakeholder-identified skill set needs: battery safety, battery theory, operating and maintaining charging components and electrical connections in corrosive environments, equipment maintenance, general electrical and mechanical aptitude, and skills in zero-emission technology (LBCC 2018). Many of these competencies are included in the training programs identified by CITT, as described below.

7.1 Electric Vehicle Infrastructure Training Program (EVITP)

This is a 24-hour class (completed over three days) addressing the requirements, regulations, products, and strategies which enable contractors and electricians to master professional customer relations, installations, and maintenance of electric vehicle and plug-in hybrid electric vehicle infrastructure. Graduates will have theoretical and practical application knowledge of the following EV infrastructure subjects:

- EV prospect/customer relations and experience
- Automobile manufacturer's charging performance integrity specifications
- EV battery types, specifications, and charging characteristics
- Utility interconnect policies and requirements
- Utility grid stress precautions including demand response integration technologies
- Role of electrical storage devices as charging intermediaries
- Installing, commissioning and maintaining electric storage devices
- Charging station fundamentals including brand/model-specific installation instructions for:
    - Level 1: 120 VAC 15 amps
    - Level 2: 120-240 VAC 60 amps
    - Level 3: 480 VAC 125 amps or 600 VDC 550 amps
- Service-level assessments and upgrade implementation
- Integration of electric vehicle infrastructure with distributed generation
- Understanding Internet Protocol (IP) networking of charging stations
- National Electrical Code (NEC) standards and requirements
- National Fire Protection Association (NFPA) 70E and OSHA regulations
- National Electrical Installation Standards (NEIS) for electrical equipment
- First responder safety and fire hazard measures
- Next generation charging
- EVSE troubleshooting, repair, and commissioning
- Facility based energy storage

This program is offered through various training agencies throughout Southern California, however it is most readily available at POLB through partnership with the IBEW's Local 11 union branch. Electrical workers and electricians at the port can take this 3-day course to gain the highest standard of certification for the installation of electric vehicle infrastructure and implement this training at POLB as new infrastructure is established.

7.2 Energy Storage and Microgrid Training and Certification (ESAM-TAC)

This is a program and credential which prepares electrical workers and electricians for the safe and effective assembly, testing, commissioning, maintenance, repair, retrofitting, and decommissioning of energy storage and microgrid (ESM) systems. ESAM-TAC consists of both theoretical and hands-on practical components. Modules include:

- Business drivers of microgrid and energy storage systems
- Microgrid systems and components (generation)
- Battery safety and arc flash protection
- DC power systems (DC theory)
- Battery enclosure, rack components and requirements
- Installation of batteries into racks and enclosures
- Connections between batteries
- DC power conductors and connections
- Grounding and bonding of ESM systems
- DC control conductors and connections
- Situational assessment of installed ESM systems

Offered through various training agencies throughout Southern California, electrical workers and electricians at the port can take this course in order to upskill and qualify for working on the various energy storage systems throughout the port and grid-connected plant at POLB.

7.3 Certified Electric Vehicle Technician (CEVT) Training Program

This 16-week certification program is designed to prepare automotive service technicians with the skills required to work in the production, repair, and maintenance of electric vehicles. It covers comprehensive advanced alternative fuel vehicle theory and practices:

- Introduction to advanced vehicle technologies
- Development of electric vehicles
- High voltage electrical safety
- High voltage vehicle safety systems
- Hybrid engines
- AC induction electrical machines
- Permanent magnet electrical machines
- Power inverter systems
- Electric circuit systems
- Electric propulsion sensing systems
- DC-DC converter systems
- Transaxles, gears, and cooling systems

- Energy management hardware systems
- Battery construction and technologies
- Latest development in battery technologies
- Nickel-metal hydride technologies
- Lithium ion battery
- Battery management systems
- Hybrid vehicle regenerative braking systems
- Electric car and hybrid climate control systems
- Computer aided design (SolidWorks software)
- Design and making an adapter for an electric motor (workshop)
- Design and making a fiber-glass battery box (workshop)
- Conversion of an internal combustion car into a 100% electric car (workshop)
- First responder safety for emergency situations
- Basic electric car maintenance

Although this course of study is much longer and more involved than the aforementioned programs, there are considerable POLB-applicable skill sets to be gained from completion of the courses outlined. This certification would be particularly beneficial to those mechanical and automotive maintenance technicians who are already proficient in combustion engines and wish to become fluent in working on alternative-fuel systems. Resulting expertise have applications across port operations, in retrofitting, electric battery vehicles, hybrid engines, and charging stations.

7.4 Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP)

Administered by the Energy Commission's Fuels and Transportation Division, the ARFVTP invests in a broad portfolio of transportation and fuel transportation projects throughout the state, leveraging public and private investments, and;

- Expedites development of conveniently-located fueling and charging infrastructure for low- and zero-emission vehicles.
- Accelerates advancement and adoption of alternative fuel and advanced technology vehicles, including low-and zero-emission medium- and heavy-duty vehicles;
- Expands in-state production of alternative, low-carbon renewable fuel from low-carbon pathways; and support manufacturing and workforce training to help meet the needs of the state's growing clean transportation and fuels market; and
- Supports manufacturing and workforce training to translate clean technology investments into sustained employment opportunities.

The Clean Energy Transportation Initiative (CETI), California Community Colleges Chancellor's Office (CCCCO), Employment Development Department, and Employment Training Panel (ETP) are public partners of this program.

7.5 Electrical Technology Programs through the California Community Colleges

The California Community Colleges offer Electrical Technology Programs in Construction Technologies and Construction & Maintenance, providing A.A. or A.S. degrees.

8. Top 5 Critical ZEV-Related Occupations

Narrowing down the top five critical occupations involved reconciling our shortlisted LMA results (Section 5.3) with findings from the peer-exchange webinars (Section 6.3). Our choices have been further validated by BLS literature and both historical and projected employment data. The following titles represent occupations with a range of prerequisite educational, professional, and experience relating to zero-emissions goals at POLB.

8.1 Electricians – (O*NET 47-2111.00)

Although this occupation title is encompassed by many fields of industry that may not be necessarily port-related, the expertise is directly applicable to many of the job titles that have been deemed critical to future operations within the POLB ZEV blueprint. Employment in this field is likely to increase in demand as a direct result of new green technology and economic activity (O*NET OnLine). At POLB in particular, this will relate to inspecting, troubleshooting, and testing the on-going continuity of new and existing infrastructure at the port such as charging stations, vehicle batteries, and renewable energy generating systems.

Fluency in working with high-voltage systems has been identified as critical knowledge when working with electric vehicle systems, so the expertise gained through an electrician apprenticeship pathway would be key to working with the latest POLB developments in ZEV technology. Additional knowledge and work experience may lead individuals down more specialized pathways (further elaborated upon below); however, the Electrician profession entails a set of skills that will be vital to working with ZEV systems on the whole. BLS statistics show a significant nationwide employment increase for this occupation (60,000 between 2016 and 2026).

Career Pathway (Figure 7)

In California, electricians must complete apprenticeship and certification requirements in order to become a qualified journeyman electrician. Beginning at the high school graduate level, job seekers can enroll in pre-apprenticeships and apprenticeships with the goal of attaining a certificate or associate's degree in Electrical Construction and Maintenance. Furthermore, they need to register as an electrician trainee with the California Department of Industrial Relations before applying for admission into an apprenticeship program. Commencing an apprenticeship can occur before attending trade/technical classes, however apprentices must be registered as trainees with the state and there must be a combination of both classroom and hands-on learning comprising the apprenticeship. Completion of sufficient education units in addition to at least 8,000 hours of apprenticeship work experience (within 5 years) qualifies an individual to sit for the journeyman certification exam. Passing this exam establishes the incumbent as a qualified electrician in California, and as such, requires demonstrable capability to interpret/implement technical diagrams, comply with National Electrical Code (NEC) local regulations, and install, repair, and maintain electrical systems and distribution equipment.

After journeyman certification, the qualified electrician decides which discipline of the profession to pursue. Pertaining to zero-emissions operations at POLB, the IBEW Local 11 offers the electric vehicle infrastructure training program (EVITP outlined in section 7.1) in addition to the traditional apprenticeship path. This is the state's highest standard in training and certification for installation, repair, and maintenance of electric vehicle infrastructure.

8.2 Solar Photovoltaic Installer – (O*NET 47-2231.00)

Expecting demand to grow rapidly in the next several years by over 100% (BLS, 2016) due to the impact of the developing green economy, this role and the on-going maintenance involved with it is directly related to POLB and the planned developments in solar energy generation projected for the coming years. Projects such as the 300kW solar carport at the POLB security center will require outside contractors for solar installation. This project may also engage consultants to optimize solar systems and locations of new projects, as well as to integrate solar energy generation with micro-grid infrastructure. This job may also involve electrician expertise in dealing with high-voltage systems. The BLS classifies this position as entry level, requiring a high school diploma or equivalent and accompanied by on-the-job training. This is a position which may also be specialized with additional credentials and work experience in other industries.

Career Pathway (Figure 8)

There are multiple pathways to this field of employment. Job-seekers with some background in construction or trade-related work can find work as a laborer or assistant in the solar installation industry. There are also sought-after skill sets and education pathways that can enhance a career in solar installation. Electricians or people with electrical technology certifications are highly desired in this industry, so completing an apprenticeship and specializing as a journeyman electrician for solar is a way to earn a higher salary. Furthermore, completing a bachelor's degree in engineering and having pertinent work experience can qualify a person to become a solar engineer, also taking advantage of a higher wage bracket and the demand for expertise in this field.

8.3 Automotive Specialty Technicians – (O*NET 49-3023.02)

This specialized role is applicable to automotive technicians who have enhanced skills in working with alternative fuel systems such as CNG, Electric-battery, Hydrogen Fuel Cell, and Hybrids. They will be able to troubleshoot, fix, replace, and retrofit vehicles with zero-emissions solutions (O*NET, 2018). This role requires trade/technical certification, on-the-job training experience, and is expected to see an increase of 45,900 of qualified individuals between 2016 and 2026. This is the only occupation the BLS included in their report of critical occupations in the EV industry pertaining to electric vehicle maintenance (Hamilton, 2011).

Career Pathway (Figure 9)

Becoming an automotive specialty technician requires an associate's degree in advanced transportation technology and electric vehicles at Long Beach City College (LBCC) which requires 20 units of major-specific courses, 19 units of G.E. courses, and 21 elective units to complete. This degree prepares students for a career working with hybrid, fuel-cell, and electric vehicles (LBCC, 2019). Graduates will be able to service, maintain, and repair light/medium and heavy duty vehicle systems, the latter of which is applicable to zero-emission CHE at POLB. Further certification through the CEVT program (Section 7.3) is also recommended for incumbent automotive technicians in order to become specialized in working with alternative fuel vehicle systems.

8.4 Electrical Engineer – (O*NET 17-2071.00)

This occupation is involved in designing, developing, testing, and supervising the manufacture of new electrical systems directly related to electricity use and efficiency and is in high demand. In the port environment, this position will address renewable energy generation, smart-grid development, retrofitting combustion engine equipment, and consulting on new green energy projects. This resonates with BLS statistics predictions of an 8.6% nationwide growth in electrical engineer positions by 2026, despite being highly specialized.

Career Pathway (Figure 10)

Prospective students must gain admission to an electrical engineering university program, wherein during the first two years, transfer requirement courses encompass mathematics, physics, and general education. In the third year of the bachelor program, students will complete core components of electrical engineering and prepare for specialization in their fourth year, when students choose a specific elective sequence pertaining to an area of specialization and complete a senior design project. Engineering graduates are encouraged to find internships and gain work experience as engineers. POLB offers engineering internships and has identified a current need for electrical engineering expertise. It is in the engineering candidate's best interest to specialize in a port-related elective sequence during their final years of higher education. After having gained sufficient work experience, a graduate engineer can get a professional engineering license and gain seniority in their field.

8.5 Electrical Power-line Installer and Repairer (Lineman) – (O*NET 49-9051.00)

The BLS has deemed electrical power-line installers and repairers as critical occupations in the infrastructure development for the EV industry (Hamilton, 2011). BLS Projected Employment data further substantiates this claim with a 13.9% projected growth rate of the profession from 2016-2026. These individuals are responsible for installing cable for electrical power distribution and maintaining grid efficiency, which will serve an instrumental role in POLB realizing their zero-emissions blueprint goals. Increased energy demand requires a vastly greater power grid to support electric CHEs and charging stations. A Proterra technical trainer expressed to CITT that they had noted a significant a shortage of workers comfortable working with high voltage systems in the public transit system. Therefore, we are keeping high voltage requirements in mind as we continue to develop educational pathways to critical occupations. The BLS states credentials required to attain this job are a high school diploma or equivalent, basic math and reading skills, and 1 to 5 years of on-the-job training.

Career Pathway (Figure 11)

To become a power-line installer and repairer, pathways are similar to that of the electrician. However, due to the strenuous physical demands and the high-risk nature of this work, the wage bracket is higher for linemen than any other electrical field. Entry to this apprenticeship program may be competitive, and there are a few highly desired prerequisites. To increase likelihood of being accepted into a lineman apprenticeship program, obtaining line school admission, first-aid/CPR certification, and flagging/traffic control certifications should be of high priority. Maintaining good physical fitness and gaining technical electrical work experience is also highly desirable. Apprentices must accumulate approximately 7,000 hours of work experience, progressing through the seven stages (increasing wage brackets) of the program. Completion of the journeyman certificate exam in California allows linemen to work in the highest-paying median wage bracket for electricians in the country. Growth of support infrastructure for electric vehicles and large initiatives such as the ZEV blueprint is pushing the demand for this skill set as charging infrastructure needs to be connected to the grid.

Appendices: Career Pathways

The following example diagrams represent essential education and experience requirements for entering the occupations outlined in section 7. These career pathways have been developed using data and research gathered from the BLS and not only depict the selected top five critical occupations, but also the prerequisites for developing those positions into more senior positions.

Entry level pathways and requirements for promotion to senior level positions were researched by examining job vacancies specific to large companies in California that are in the solar energy, alternative fuel vehicles, energy planning, or public utilities (electricity) industries.

Figure 7. Electrician (California)

	RELEVANT TRAINING, COURSEWORK, AND KNOWLEDGE	CAREER PATHWAY: Program of Study	CAREER PATHWAY: Work Experience	RECOMMENDED CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	**Trade Experiences:** • Read blueprints and technical diagrams for electrical plans. • Install, repair, and maintain electrical systems and distribution equipment. • Learn compliance with National Electrical Code and local regulations.	Electrician Journeyman Certification		EVITP[4] ESAM-TAC[5] CHEPVT[6]	**Advanced Level** • **Journeyman Electrician (Transportation)[3]** **Annual Salary:** $72,380 – 96,290[3]
INTERMEDIATE LEVEL	**Required Courses for Associate's Degree in Electrical Technology[1] (LATTC)** • Fundamentals of DC Electricity • Hand Tools and Wiring Practices • Elementary Circuit Practices • Industrial Control Systems • Fundamentals of Alternating Current • Principles of Industrial Electric Power • Industrial Power Application • Industrial Electric Control Systems • Applications of Electrical Devices • Construction Wiring • Introduction to Electrical Codes • Electrical Wiring Techniques • Installation of Electrical Wiring	Associate's Degree in Electrical Technology → Additional Specializations (Recommended) → Electrician Journeyman Certification	Begin electrician apprenticeship → Accumulate at least 8,000 hours work experience under an electrical contractor → Electrician Journeyman Certification	EVITP ESAM-TAC CHEPVT	**Intermediate Level** • **Apprentice Electrician[2]** **Annual Salary:** $32,870 – 61,190[2]
ENTRY LEVEL	**Obtained During High School** • Pass basic algebra with "C" or better • Enhance written and oral communication skills • Build mechanical knowledge • Develop manual dexterity and coordination • Maintain physical fitness **Work Experience** • Technical trade-based discipline	High School Diploma or Equivalent (One course titled "Algebra" required) → Associate's Degree in Electrical Technology	Up to two years work experience desired → Register as an electrician trainee with the California Department of Industrial Relations → Begin electrician apprenticeship	N/A	**Entry Level** • **Construction Helper/Worker** • **Electrician's Helper** **Annual salary:** $29,724 – 42,306[7]

[1] *Electrical Construction & Maintenance*. (2019). Retrieved from Los Angeles Trade-Technical College: http://college.lattc.edu/cmu/program/electrical-construction-maintenance/

[2] Electricians School Edu. (2015). Electrician Salaries in California. Retrieved from Electricians School Edu: https://www.electricianschooledu.org/california/california-salary/
Salary interpreted from 2015 BLS statistics for apprenticeship electricians in the Los Angeles-Long Beach-Glendale locality

[3] Electricians School Edu. (2015). Electrician Salaries in California. Retrieved from Electricians School Edu: https://www.electricianschooledu.org/california/california-salary/

Salary interpreted from 2015 BLS statistics for electrical and electronics repairers specializing in transportation equipment.

[4] Electric Vehicle Infrastructure Training Program (EVITP)

[5] Energy Storage and Microgrid Training/Certification (ESAM-TAC)

[6] Certificate of Hybrid and Electric Plug-in Vehicle Technology (CHEPVT)

[7] Salary obtained from 2nd and 3rd quartile ranges for Construction Helper/Worker in California on Burning Glass.

Figure 8. Solar Photovoltaic Installer

	RELEVANT TRAINING, COURSEWORK, AND KNOWLEDGE	CAREER PATHWAY: Program of Study	CAREER PATHWAY: Work Experience	RECOMMENDED CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	**Bachelor's Degree Courses[5] (CSULB):** • Digital System Design • Signals and Systems • Analog Electronic Circuits • Energy Conversion Principles • Electromagnetic Fields • Control Systems • Communication Systems I • Digital Signal Processing • Design of Power System Components • Power System Analysis • Protection of Power Systems • Solid State Electronic Devices • Fractals in Engineering	Professional Engineer License ↑ Bachelor's Degree in Engineering (or equivalent residential solar experience) →	6 years of qualifying experience → Professional Engineer License	Professional Engineer License	**Advanced Level** • **Solar Service Technician[2]** • **Solar Engineer[2]** **Annual Salary:** $79,700 – 127,600
INTERMEDIATE LEVEL	**Electrical Technology Courses[1] (LBCC):** - Electrical Mathematics - OSHA Standards for Construction Safety - Fundamentals of DC - Algebra & Trigonometry for Technicians - Introduction to Renewable Energy - Fundamentals of Motors/Generators - Introduction to the National Electrical Code - Solar 1 – Grid-Tied Solar Photovoltaics - Fundamentals of AC Electricity - Electric Motor Control 1 - Solar 2 – Advanced Solar Photovoltaics - AC Principles and practices - Electrical Code – Commercial, Industrial, and Grounding	If continuing toward engineering degree, complete transfer requirements ↑ Associate's Degree in Electrical Technology →	Electrician Journeyman Certification ↑ Accumulate at least 8,000 hours work experience under an electrical contractor ↑ Begin electrician apprenticeship	ESAM-TAC[6]	**Intermediate Level** • **Journeyman Electrician for Solar[2]** • **Solar Photovoltaic Installer[3]** **Annual Salary:** $39,490 – 61,580[3]
ENTRY LEVEL	**Obtained During High School** • Enhance written and oral communication skills • Build mechanical knowledge • Develop manual dexterity and coordination	High School Diploma or Equivalent	While it is desired for Solar Photovoltaic Installers to have an electrician background, relevant work experience will suffice.	CoA SPID[7]	**Entry Level** • **Solar Inspection Technician[2]** • **Solar Laborer[2]** **Annual salary:** $28,500 – 60,860[4]

[1] LBCC. (2019). *Electrical Technology: Curriculum guide for academic year 2018-2019*. Retrieved from Long Beach City College: https://www.lbcc.edu/sites/main/files/file-attachments/18-19-electrical-tech- curguide.pdf

[2] Semper Solaris. (2019). *Careers: Open Positions*. Retrieved from Semper Solaris Solar and Roofing: https://www.sempersolaris.com/careers/
These were job titles posted on solar company Semper Solaris' hiring page.

[3] Bureau of Labor Statistics. (2018). *Occupational Outlook Handbook: Solar Photovoltaic Installers*. Retrieved from United States Department of Labor - Bureau of Labor Statistics: https://www.bls.gov/ooh/construction-and-extraction/solar-photovoltaic-installers.htm
Job title derived from the BLS.

[4] Bureau of Labor Statistics. (2018). *Occupational Outlook Handbook: Construction Laborers and Helpers*. Retrieved from United States Department of Labor - Bureau of Labor Statistics: https://www.bls.gov/ooh/construction-and-extraction/construction-laborers-and-helpers.htm#tab-5
Wage derived from median to 90th percentile annual wage statistics for 2017.

[5] *Electrical Engineering, B.S.* (2019). Retrieved from California State University Long Beach University: http://catalog.csulb.edu/preview_program.php?catoid=2&poid=598

[6] Energy Storage and Microgrid Training/Certification (ESAM-TAC)

[7] Certificate of Achievement in Solar Photovoltaic Installation & Design (CoA SPID)

Figure 9. Automotive Specialty Technician

	RELEVANT TRAINING, COURSEWORK, AND KNOWLEDGE	CAREER PATHWAY	RECOMMENDED CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	**Incumbent Workforce:** Automotive technicians already in the industry will most-likely be able to upskill with zero emissions technology-specific technical certifications, particularly if they already have technical electrical expertise. This also provides current employees at POLB a way to upskill and stay fluent in all relevant vehicle drivetrains. **Training:** Qualified Electricians and Automotive Specialty Technicians will need to participate in CEVT in order to develop the skills specifically related to servicing, maintaining, and operating EV-CHE. These trainings offer a way for professionals currently working in related fields to upskill and join the POLB Labor Force. A full list of these trainings may be found in the report. Additionally OEMs also offer relevant training pertaining to their products.	**Program of Study** Industry-Specific Technical Certification	CEVT[3]	**Advanced Level** • **EV-CHE Specialty Technician** **Annual Salary:** $35,940 – 52,304[1]
INTERMEDIATE LEVEL	**Required Courses[2] (LBCC):** • Introduction to Hybrid and Electric Vehicles • Introduction to Alternative Fuels • Advanced Hybrid & Electric Vehicles • Advanced Hybrid Diagnosis & Repair **Recommended Electives[2] (LBCC):** • Heavy Equipment Electrical Systems • General Engines • Auto Emission Controls • Forklift Safety & Operation • Introduction to Metal Working • Introduction to Welding	Associate's Degree in Advanced Transportation Technology – Electric Vehicles	CEVT	**Intermediate Level** • **Automotive Specialty Technician** **Annual salary:** $35,940 – 52,304[1]
ENTRY LEVEL	**Obtained During High School** • Enhance written and oral communication skills • Build mechanical knowledge • Develop manual dexterity and coordination	High School Diploma or Equivalent (or aged 18 or older)	N/A	**Entry Level**

[1] Salary obtained from 2nd and 3rd quartile ranges for Automotive Service Technician/Mechanic California on Burning Glass.

[2] LBCC, (2019) Curriculum Guide for Academic Year 2018-2019. *Advanced Transportation Technology, Electric Vehicles*. Long Beach, California, United States of America: Long Beach City College.

[3]Certified Electric Vehicle Technician Training Program (CEVT)

Figure 10. Electrical Engineer (EE)

	RELEVANT TRAINING, COURSEWORK, AND KNOWLEDGE	CAREER PATHWAY: Program of Study	CAREER PATHWAY: Work Experience	RECOMMENDED CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	**Engineering Demonstrable Knowledge** • Work experience in field(s) of engineering with sustainability-motivated projects. • Wield the ability to "prepare, sign and seal, and submit engineering plans and drawings to a public authority for approval, or seal engineering work for public and private clients."[6] • Perform work with an emphasis towards sustainable planning and environmentally conscious practices. • Demonstrate understanding of new technology, working towards zero emissions future, such as electric vehicles and charging infrastructure.	Professional Engineer License	6 years of qualifying experience	Professional Engineer License	**Advanced Level** • **Principal Electrical Engineer** • **Senior Project Manager** **Annual Salary:** $100,000+
INTERMEDIATE LEVEL	**Bachelor's Degree Courses[3] (CSULB)** • Digital System Design • Signals and Systems • Analog Electronic Circuits • Energy Conversion Principles • Electromagnetic Fields • Control Systems • Communication Systems I • Digital Signal Processing • Design of Power System Components • Power System Analysis • Protection of Power Systems • Solid State Electronic Devices • Fractals in Engineering	Appropriate certifications to meet personal career goals Bachelor's Degree in electrical engineering	Some supervisory experience preferred for Planner III/Senior Planner positions Up to six years planning experience required	Fundamentals of Engineering Exam Energy Efficiency Practitioner Certification from AEE	**Intermediate Level** • **Electrical Engineer** • **Energy Efficiency Specialist[6]** **Annual Salary:** $52,528 – 110,258[1]
ENTRY LEVEL	**Transfer Requirements[5] (ASSIST.org)** • EE Circuits • Calculus I, II, and III • Applied Math/Differential Equations • Physics (Mechanics, Electricity & Magnetism, and Modern) • Oral Communication • Reading & Composition • Critical Thinking • Life Science • Arts & Humanities • Social Sciences • Lifelong Learning & Self-Development	Complete transfer requirements at a community college or first two years of a Bachelor's Degree program at a university.	Up to two years work experience desired	N/A	**Entry Level** N/A

[1] Salary obtained from 2nd and 3rd quartile ranges for Electrical Engineer and Energy Efficiency Specialist in California on Burning Glass.

[2] Occupation title from Burning Glass.

[3] *Electrical Engineering, B.S.* (2019). Retrieved from California State University Long Beach University: http://catalog.csulb.edu/preview_program.php?catoid=2&poid=598

[4] 2018-2019 General Education Requirements California State University General Education-Breadth. (2019). *Long Beach City College 2018-2019 Course Catalog*. Long Beach, California, United States of America: Long Beach City College.

[5] *ASSIST Report: LBCC 16-17 CSULB Articulation Agreement by Major*. (2019). Retrieved from ASSIST: http://web2.assist.org/web-assist/report.do?agreement=aa&reportPath=REPORT_2&reportScript=Rep2.pl&event=19&dir=1&sia=LBCC&ria=CSULB&ia=LBCC&oia=CSULB&aay=16-17&ay=16-17&dora=EE

[6] *Advantages of Licensure*. (2019). Retrieved from National Society of Professional Engineers: https://www.nspe.org/resources/licensure/why-get-licensed/advantages-licensure

Figure 11. Electrical Power-Line Installer and Repairer (EPIR)

	RELEVANT TRAINING, COURSEWORK, AND KNOWLEDGE	CAREER PATHWAY: Program of Study	CAREER PATHWAY: Work Experience	RECOMMENDED CERTIFICATION	JOBS & WAGES
ADVANCED LEVEL	**Apprentice Program Coursework[2] (CNJATC)** Saturday classes once per month, plus week-long intensive training courses throughout the apprenticeship program: • Work Methods Training • Underground Training • Rubber Glove Training • Hot Sticks Training • Crane Certification Class	Lineman Journeyman Certification		ESAM-TAC[5] First Aid/CPR (CNJATC) OSHA[6] (CNJATC)	**Advanced Level** • **Journeyman Lineman** **Annual Salary:** $104,140 – 123,160[3]
INTERMEDIATE LEVEL	**Skills Developed During Powerline Mechanic Training Program[4] (LATTC)** • Overall safety considerations • Power pole climbing skills • Knowledge of the basic tools and materials involved with the electrical line crafts • General construction standards • Basic rigging principles • Basic electrical theory	Additional Specializations (Recommended) Power Lineman Certification (Recommended)	Accumulate approximately 7,000 required hours and pass through 7 stages of the apprenticeship program[1] Begin lineman apprenticeship	First Aid/CPR (CNJATC) Flagging/ Traffic Control (CNJATC)	**Intermediate Level** • **Apprentice Lineman** **Annual Salary:** 60%-90% of Journeyman Salary. Pay increases 5% roughly every 6 months.[1]
ENTRY LEVEL	**Obtained During High School** • Pass basic algebra with "C" or better • Enhance written and oral communication skills • Build mechanical knowledge • Develop manual dexterity and coordination • Maintain physical fitness **Work Experience** • Technical trade-based discipline	High School Diploma or Equivalent (One course titled "Algebra" required)	Apply to lineman apprenticeship program Up to two years work experience desired	First Aid/CPR (CNJATC) Flagging/ Traffic Control (CNJATC)	**Entry Level** • **Construction Helper/Worker** • **Electrician's Helper** **Annual salary:** $29,724 – 42,306

[1] CNJATC. (2019). *The Apprenticeship Process*. Retrieved from California / Nevada Joint Apprenticeship Training Committee: http://www.calnevjatc.org/templates/template12/?page=130

[2] CNJATC. (2019). *Lineman Program Description*. Retrieved from California / Nevada Joint Apprenticeship Training Committee: http://www.calnevjatc.org/templates/template5/?page=45

[3] Electrician School Edu. (2015). *Electrician Salaries in California*. Retrieved from Electrician School Edu: https://www.electricianschooledu.org/california/california-salary/
Median to 90th percentile annual range of salaries for journeyman EPIR positions in California.

[4] *Powerline Mechanic Training Program*. (2019). Retrieved from Los Angeles Trade-Technical College: http://college.lattc.edu/cmu/program/electrical-lineman-training-program/

[5] Energy Storage and Microgrid training and Certification (ESAM-TAC)

[6] Occupational Safety and Health Administration (OSHA)

Bibliography

Berkeley Engineering. (2019). *Energy Engineering*. Retrieved from UC Berkeley Collage of Engineering: https://engineering.berkeley.edu/academics/undergraduate-guide/degree-requirements/engineering-science/energy

Bureau of Labor Statistics. (2018). *Occupational Outlook Handbook: Construction Laborers and Helpers*. Retrieved from United States Department of Labor - Bureau of Labor Statistics: https://www.bls.gov/ooh/construction-and-extraction/construction-laborers-and-helpers.htm#tab-5

Bureau of Labor Statistics. (2018). *Occupational Outlook Handbook: Solar Photovoltaic Installers*. Retrieved from United States Department of Labor - Bureau of Labor Statistics: https://www.bls.gov/ooh/construction-and-extraction/solar-photovoltaic-installers.htm

BurningGlass. (2018). *Labor Insight/Jobs*. Retrieved from Burning Glass Technologies (Accessed: November 21st, 2018).

California Community Colleges. (2019). Californiacommunitycolleges.cccco.edu/collegePrograms.

California Energy Commission. (2019). *Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP). www.every.ca.gov/transportation/arfvtp/workforce-development.html.*

Cohn, L. (2018, July 2). *Port of San Diego to Demonstrate How Microgrids Benefit Ports Worldwide*. Retrieved from Microgrid Knowledge: https://microgridknowledge.com/microgrids-benefit-ports-san-diego/

CNJATC. (2019). *The Apprenticeship Process*. Retrieved from California / Nevada Joint Apprenticeship Training Committee: http://www.calnevjatc.org/templates/template12/?page=130

CNJATC. (2019). *Lineman Program Description*. Retrieved from California / Nevada Joint Apprenticeship Training Committee: http://www.calnevjatc.org/templates/template5/?page=45

Dekker, N. & Port of Rotterdam. (2016, April 25). *50 Years of Containers: The Robot is Coming*. Retrieved from Port of Rotterdam: https://www.portofrotterdam.com/en/doing-business/logistics/cargo/containers/50-years-of-containers/the-robot-is-coming

Draper, M., Rodriguez, E., Kaminsky, P., Sidhu, I., & Tenderich, B. (2008). *Economic Impact of Electric Vehicle Adoption in the United States.* Berkeley: U.C. Berkeley.

Electrician School Edu. (2015). *Electrician Salaries in California*. Retrieved from Electrician School Edu: https://www.electricianschooledu.org/california/california-salary/

Elkind, E. N. (2017). *Plugging Away: How to Boost Electric Vehicle Charging Infrastructure.* Berkeley: Berkeley Law/UCLA Law.

Ercan, T., Mehdi, N., Zhao, Y., & Tatari, Y. (2016). *On the Front Lines of a Sustainable Transportation Fleet: Applications of Vehicle-to-Grid Technology for Transit and School Buses.* Energies.

Eudy, L., Prohaska, R., Kelly, K., & Post, M. (2016). *Foothill Transit Battery Electric Bus Demonstration Results.* Los Angeles: National Renewable Energy Laboratory.

Evarts, E. C. (2018, September 10). *Toyota enters $82 million partnership to roll out hydrogen trucks in Los Angeles port.* Retrieved from Green Car Reports: https://www.greencarreports.com/news/1118877_toyota-enters-82-million-partnership-to-roll-out-hydrogen-trucks-in-los-angeles-port

Farrell, B., & McKie, R. (2016). *Designing a Battery Exchange Building for Automated Guided Vehicles.* Oakland: American Society of Civil Engineers.

Green Port. (2018, April). *Asia switches its focus to green initiative*. Retrieved from Green Port: https://www.greenport.com/news101/asia/asia-switches-its-focus-to-green-initiatives

Hamilton, J. (2011, September). *Careers in Electric Vehicles.* Retrieved from U.S. Bureau of Labor Statistics: https://www.bls.gov/green/electric_vehicles/electric_vehicles.pdf

Long Beach Business Journal. (2015, October 12). *Technology Will Inevitably Change Labor's Role At Local Ports But With Long-Term Benefits, Experts Say*. Retrieved from Long Beach Business Journal: http://www.lbbizjournal.com/single-post/2015/10/12/Technology-Will-Inevitably-Change-Labor%E2%80%99s-Role-At-Local-Ports-But-With-LongTerm-Benefits-Experts-Say

LBCC, (2019) Curriculum Guide for Academic Year 2018-2019. *Advanced Transportation Technology, Electric Vehicles*. Long Beach, California, United States of America: Long Beach City College.

LBCC. (2019). *Electrical Technology: Curriculum guide for academic year 2018-2019*. Retrieved from Long Beach City College: https://www.lbcc.edu/sites/main/files/file-attachments/18-19-electrical-tech- curguide.pdf

LBCC. (2018). *Zero-Emissions Terminal Equipment Transition Project, 2018.*

Marine Terminals Coporation. (2017). *Automated Marine Container Terminal System.* San Francisco: United States Patent.

Miller, A., & Hye-Jin, K. (2018). *Electric Buses: Clean Transportation for Healthier Neighborhoods and Cleaner Air.* Frontier Group, U.S. PIRG, Environment America.

North-east Advanced Vehicle Consortium (NAVC). (2005). *Analysis of Electric Drive Technologies for Transit Applications: Battery-Electric, Hybrid-Electric and Fuel Cells.* Boston: U.S. Department of Transportation, Federal Transit Administration.

Port of Long Beach. (2018). *Careers: Electrician - Wire the World*. Retrieved from Port of Long Beach, Academy: https://academy.polb.com/career/electrician/

Roberts, D., & Chang, A. (2018, May 24). *Meet the microgrid, the technology poised to transform electricty*. Retrieved from Vox: Energy and Environment: https://www.vox.com/energy-and-environment/2017/12/15/16714146/greener-more-reliable-more-resilient-grid-microgrids

Semper Solaris. (2019). *Careers: Open Positions*. Retrieved from Semper Solaris Solar and Roofing: https://www.sempersolaris.com/careers/

The Port of Metro Vancouver. (2017). Retrieved from https://www.portvancouver.com/wp-content/uploads/2016/06/2016-05-18-Shore-Power-Container-Qs-and-As-for-website.pdf

The Port of Rotterdam. (2017). *The Port of Rotterdam- CO2 Neutral*. Retrieved from The Port of Rotterdam: https://www.portofrotterdam.com/sites/default/files/port-of-rotterdam-co2-neutral.pdf

UC Davis. (2019). *Energy Graduate Group: For Prospective Students*. Retrieved from UC Davis Energy and Efficiency Institute: https://energy.ucdavis.edu/education/energy-graduate-group/for-prospective-students/

UNCTAD. (2017). *Review of Maritime Transport 2017.* Retrieved from UNCTAD: https://unctad.org/en/PublicationsLibrary/rmt2017_en.pdf

University of San Francisco (2019). *Energy Systems Management: Program Details*. Retrieved from University of San Francisco: College of Arts and Sciences: https://www.usfca.edu/arts-sciences/graduate-programs/energy-systems-management/program-details

U.S Department of Energy. (2014, June 17). *How Microgrids Work*. Retrieved from Energy.Gov: https://www.energy.gov/articles/how-microgrids-work

San Francisco State University (2019). *Coursework: Energy Systems*. Retrieved from Graduate School of Engineering: http://engineering.sfsu.edu/academics/graduate/engineering/coursework_es.html

Stanford University (2019). *Energy Resources Engineering*. Retrieved from Stanford Bulletin: ExploreDegrees 2018-19: https://exploredegrees.stanford.edu/schoolofearthsciences/energyresourcesengineering/#bachelorstext

Vujicic, A., Zrnic, N., & Jerman, B. (2013). *Ports Sustainability: A Life Cycle Assessment of Zero Emission Cargo Handling Equipment.* Journal of Mechanical Engineering.