THE NORTHWEST SEAPORT ALLIANCE
SEATTLE + TACOMA

Port of Tacoma

South Harbor Electrification Roadmap

Executive Summary

Through the Northwest Ports Clean Air Strategy (NWPCAS), The Northwest Seaport Alliance and Port of Tacoma (together "the port") have embraced the vision of "phasing out" seaport related emissions by 2050, including both air pollutant and greenhouse gas emissions. This vision seeks to both reduce air pollution impacts on near port communities, particularly those that have been historically disproportionately impacted, as well as reduce contributions to climate change. Achieving this vision will require a holistic transition to clean energy. Electrification is a key strategy for this transition in Tacoma, where the Tacoma Power, the local utility, grid is currently 97% supplied by clean energy resources.

The South Harbor Electrification Roadmap (SHERM) is a collaborative planning effort between the port and Tacoma Power, that assesses the infrastructure needs associated with electrification at port facilities in Tacoma and presents a roadmap for developing this required infrastructure. The SHERM seeks to establish a baseline understanding of port-wide energy use, project future energy demand associated with electrification, assess infrastructure upgrades needed on port facilities and in the utility grid to support electrification, develop high level cost estimates for the necessary infrastructure upgrades, and provide strategic action recommendations to guide electrification.

Analytical Findings

The following is a summary of key analytical results from energy baseline, demand forecast, and infrastructure needs assessments. These results are the foundation for the infrastructure development roadmap and will provide baseline data for future studies and engineering designs.

- **Port-wide coincident peak electrical demand is projected to increase 4-fold if port facilities are fully electrified.** Peak electrical demand is projected to increase from the baseline of approximately 30 megawatts (MW) to 125 MW of peak usage on the highest demand days. Typical daily peak demand is projected to be around 100 MW.
- **Significant upgrades to the utility distribution grid will be needed to serve this increased electrical demand, with an estimated cost of $78 million (in 2023 dollars).** This includes projects, such as electrical distribution line (feeder) improvements, substation improvements, and transmission line improvements.
- **An estimated $153 million (2023 dollars) in electrical infrastructure upgrades will be needed on major port terminal facilities to support full electrification.** This estimate only includes major terminal facilities prioritized in the analysis and may not include all civil upgrades needed to support charging installation.

Therefore, actual costs may be significantly higher than estimated. This excludes investments, likely in the hundreds of millions, in electric equipment.

- **Non-wires solutions are currently not independently cost effective, but may be useful in the future for avoiding or deferring grid upgrades.** When analyzed purely based on electricity bill cost reductions, non-wires solutions, such as battery energy storage, have negative net present value over their typical useful lives. These technologies should be evaluated as alternatives to grid upgrades when additional electrical capacity is required.

Action Recommendations

The following steps are recommended to begin electrification of port operations in Tacoma. The analytical results and recommendations of this study should be periodically revisited as conditions change.

- **Conduct detailed zero emission master planning for terminals and port authority owned fleets.** Develop master plans for the transition to zero emission technologies at the port's major marine terminals and for the port's own fleets. These plans should include schedule for zero-emission (ZE) equipment purchases, assessment of existing infrastructure conditions, assessment of optimal parking/charging locations, site-wide electrical system layout, and preliminary design of infrastructure projects to support near term equipment electrification.
- **Implement a technology demonstration program.** Enable operators to purchase ZE equipment to build familiarity and confidence that the equipment can accomplish operational requirements. Prioritize a diverse suite of equipment types, including heavier equipment (like top handlers) if possible.
- **Implement priority infrastructure projects.** The following infrastructure projects are identified as highest priority to maximize near term emission reductions and begin the transition to full adoption of ZE technology by 2050. These should be implemented in the next 5-10 years.
    - Utility upgrades necessary to support shore power and near-term cargo-handling equipment electrification at Husky, Washington United (WUT), and Pierce County (PCT) terminals.
    - Install shore power infrastructure at Husky Terminal (completed in 2025), WUT, and PCT.
    - Infrastructure installations identified as near-term priorities through terminal master planning work, to enable ZE cargo handling equipment adoption.
    - Explore the feasibility and business case for drayage truck charging hubs on port properties.

- **Workforce development.** Invest in workforce development programs to assist labor partners with the skills to service the next generation of cargo handling equipment. Workforce development/training should focus on both battery electric equipment and associated charging equipment.
- **Operational Adjustments.** The modeling conducted to estimate peak electrical loads assumed current practice of all terminals operating on the same break and shift change schedules. As a result, charging peaks at all of the terminals occur at the same time. Staggering break-times could reduce the total peak demand on the utility grid and therefore, could reduce grid upgrade costs. The ports should engage with labor partners to explore this concept.

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Acknowledgements

- Tacoma Power, for providing critical data for developing the baseline energy use inventory, performing the utility upgrades assessment, and reviewing analytical work.
- Burns and McDonnell for research and technical analysis that form the foundation of the SHERM.

List of Abbreviations

AACE: Association for the Advancement of Cost Engineering
CHE: Cargo-handling equipment
EVSE: Electric vehicle supply equipment, charger
GHG: Greenhouse Gas
kW: Kilowatt, a unit of power
kWh: Kilowatt-hours, a unit of energy
MVA: Megavolt Ampere, a unit of apparent power in electrical circuits
MW: Megawatt, a unit of power
NWPCAS: Northwest Ports Clean Air Strategy
NWSA: The Northwest Seaport Alliance
PoT: Port of Tacoma
SHERM: South Harbor Electrification Roadmap (This Study)
The port: combination of the Port of Tacoma and the NWSA's South Harbor properties
UTR: Utility tractor, otherwise known as yard tractors or terminal tractors
ZE: Zero Emission

1. Introduction

The Port of Tacoma (the PoT) and the Northwest Seaport Alliance (NWSA) (henceforth, "the port" refers to the combination of NWSA and PoT managed facilities) are committed to reducing air pollutant and greenhouse gas (GHG) emissions from port operations at the Port of Tacoma. The Northwest Ports Clean Air Strategy[1] established a vision to phase out emissions from seaport operations no later than 2050, and the NWSA's 2017 Greenhouse Gas Resolution targets a 50% reduction by 2030. Accomplishing these goals will require the transition of the energy used to power goods movement operations from fossil fuels to low or zero carbon energy sources.

Established in 1918, the Port of Tacoma is one half of the NWSA, a marine cargo operating partnership of the ports of Tacoma and Seattle, which is one of the largest container gateways in North America, and serves as a major center for container cargo, bulk, break-bulk, automobiles, and heavy-lift cargo. In addition to marine cargo facilities managed by the NWSA, PoT owns a grain terminal and a commercial/industrial real estate portfolio. The cargo handling equipment (CHE), vehicles, and vessels currently operating at the Port are predominantly powered by diesel, marine fuel oil, and gasoline. Additionally, PoT buildings and facilities are powered and heated by a combination of electricity and natural gas. Achieving the vision of zero-emissions (ZE) operations will involve a combination of electrification and incorporation of zero-carbon fuels.

Electrification involves the replacement of internal combustion engine CHE with battery-electric or grid-electric technologies. Other zero and low carbon technologies that are being developed and evaluated for port operations include hydrogen fuel cells for CHE and trucks; green methanol and ammonia for cargo vessels; and drop-in fuels such as biodiesel, renewable diesel, and renewable natural gas that can be used for CHE, vehicles, and vessels. Deployment of many of these technologies will require significant investments in fuel supplies and supporting infrastructure both on and off the Port. Electrification of port facilities will require close collaboration and coordination with Tacoma Power, the local utility that provides electrical service to all port facilities in Tacoma. Tacoma Power's generation resource mix is 97% carbon free[2], representing a major opportunity to reduce emissions by switching from conventional fuels to electricity. Given the need for close collaboration, Tacoma Power was directly engaged in the development of this study and provided critical data, insight, and analysis for the baseline energy inventory and grid capacity and investments assessment.

[1] Northwest Ports Clean Air Strategy | The Northwest Seaport Alliance

[2] Clean & Renewable Energy - Tacoma Public Utilities

The South Harbor Electrification Roadmap (SHERM) is an energy infrastructure planning study that assesses the infrastructure investments that will be required to support the transition to ZE operations at port facilities in the Tacoma harbor, with a focus on electrification. This includes the deployment of shore power for vessels; charging infrastructure for battery-electric CHE, trucks, and harbor craft; and hydrogen generation, storage, and fueling infrastructure for hydrogen fuel cell equipment and vehicles. The primary foci of the SHERM were to inventory current (baseline) energy use, project future energy use and peak demand associated with electrification, assess infrastructure required to meet these projected demands, and provide strategic recommendations for beginning to develop the necessary infrastructure.

2. Roadmap Analysis Methodology

The foundation of the SHERM study is quantitative analyses to assess electrical demands associated with electrification of port operations and planning level engineering analyses to assess infrastructure needs. The following summarizes the analyses conducted.

2.1. Baseline Energy Use Inventory

A detailed, bottom-up energy inventory for all port properties was developed, based on electricity usage data provided by Tacoma Power, equipment and vehicle inventories provided by terminal operators and the ports, vessel call logs, and other facility information, such as building square footage and type. Direct energy usage data was used where directly available and was estimated based on available information where direct usage was not available. For example, in most cases, fuel usage by cargo handling equipment was estimated based on hours of operation and engine specifications and building natural gas usage was estimated based on square footage and building type. The baseline energy inventory was performed for calendar year 2022, for all port owned properties in the Tacoma Harbor, as depicted in Figure 1[3].

[3] Facilities and services guide (digital) 20240923

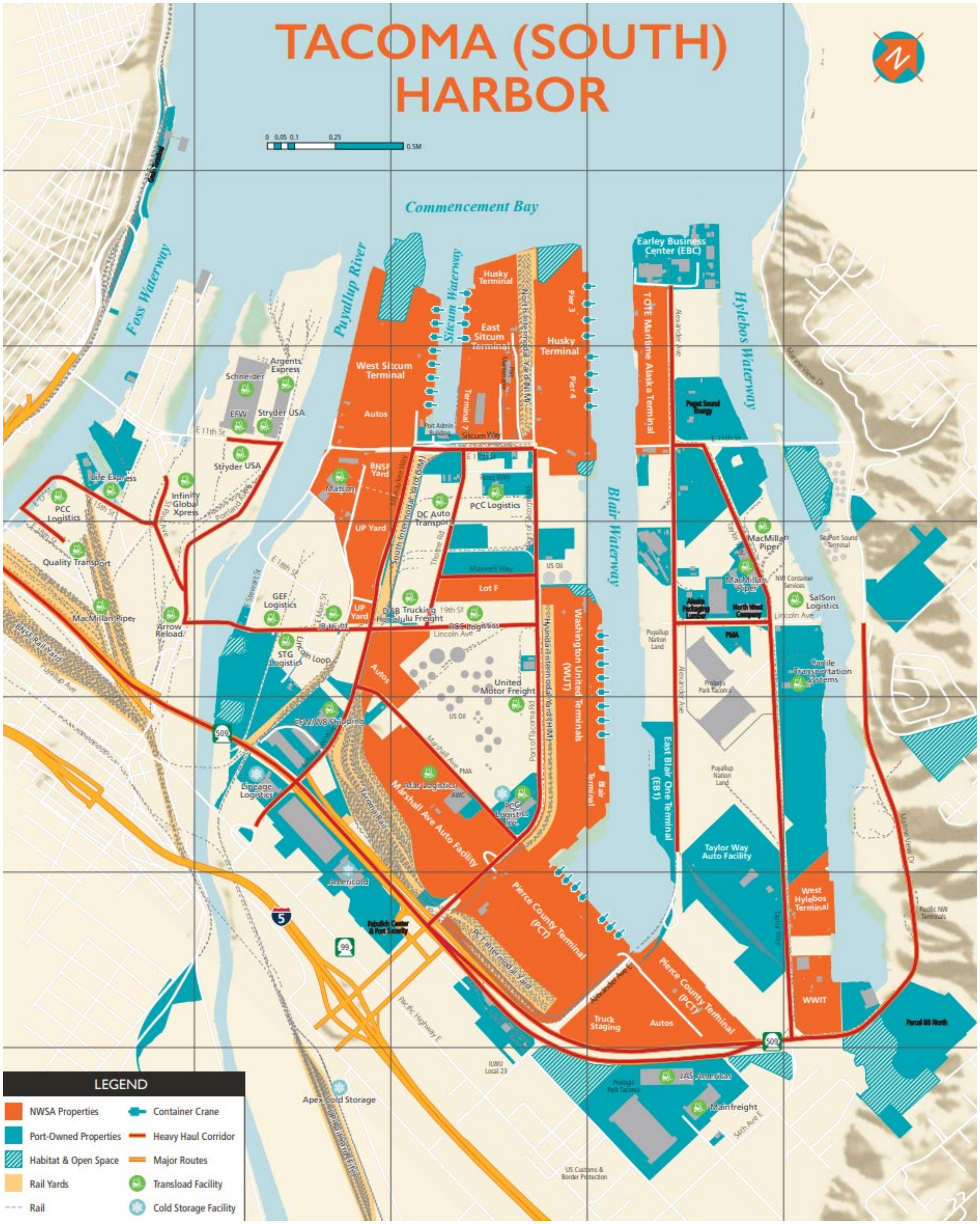

Figure 1. Map of Port of Tacoma and NWSA properties.

2.2. Energy Forecast

Building on the baseline inventory, detailed energy modeling was conducted to estimate future total energy usage (kWh) and peak energy demand (kW) across port properties. Peak demand is particularly important for assessing infrastructure needs, as it is the metric used to determine how much utility capacity is needed and sizing of on-site electrical gear.

A bottom-up approach was used to develop the forecast, relying on operational data and information. Interviews were conducted with terminal operators to understand typical and peak operating patterns, including utilization of equipment and vehicle fleets. Terminal operators were also asked about their fleet replacement plans and plans to transition to electric vehicles and equipment. Detailed equipment and vehicle fleet inventories were also key inputs to the energy modeling process, critical for estimating charging demand. In total, there were 567 pieces of CHE operating at port facilities in the Tacoma harbor and 493 on-road fleet vehicles. About half of the CHE were yard tractors (utility tractors, UTRs), with the remaining half a combination of top handlers, side handlers, reach stackers, straddle carriers, rubber-tired gantry cranes, and forklifts. Most of the on-road fleet vehicles were light duty, i.e. gross vehicle weight rating of less than 10,000 lbs.

Energy demands were forecasted for “typical operations”, “peak operations” with managed charging, and “peak operations” with unmanaged charging. Typical and peak operations reflected operational and equipment utilization characteristics reported by terminal operators in the interviews conducted. Managed charging refers to calibrating equipment and vehicle charging speed to the minimum necessary to fully charge when the next needed, while unmanaged charging assumes charging at maximum speed whenever plugged in. Managed charging can reduce electrical demand, especially during longer charging periods, like overnight. Slower charging speeds can also improve life of lithium-ion batteries. For the purpose of estimating port-wide peak demand, “coincident” peak demand is modeled, which assumes the highest demand for each facility. This is assumed representative of worst-case electrical demand across the port, as peak demand occurs for most facilities over the lunch hour, when equipment and vehicles would need to fast charge.

2.3. Priority-Site Infrastructure Needs Assessment

Based on the energy forecast and equipment and vehicle inventories, an infrastructure needs assessment was conducted for key priority sites where electrification associated electrical demand increases were expected to be the greatest. These sites were the primarily the largest marine terminals where the largest concentrations of cargo-handling equipment is stationed and vessel calls occur. The following priority facilities were included.

- Husky Terminal
- Pierce County Terminal
- Washington United Terminal
- TOTE Terminal
- West Sitcum terminal
- East-Blair One Terminal
- Terminal 7/East Sitcum

The assessment included high-level engineering assessment of the infrastructure needed for cargo-handling equipment charging, vehicle charging, building electrification, and in one case, class 8 truck charging. This was a planning level engineering assessment, meaning that significant additional work would be required for complete design of any of the infrastructure elements identified. Cost estimates were considered AACE Class 5, or in other words "order of magnitude" estimates carrying significant uncertainty and meant primarily for project screening and long-range planning. Only electrical infrastructure elements were considered, excluding any civil or other upgrades that may be needed. Given the uncertain implementation timelines, estimates are priced in 2023 dollars without any escalation applied.

2.4. Utility Upgrades Assessment

In addition to the assessment of "behind the meter" (i.e. on port facility) upgrades, an analysis of utility grid upgrades required to serve the electrical demand projected in the forecast analysis was performed. This analysis focused on serving the projected demands in 2050, i.e. the peak demand associated with full electrification of major port facility. Tacoma Power performed this analysis, using energy forecast data from the SHERM as inputs. This analysis focused on local energy distribution infrastructure (i.e. local distribution circuits and substations).

2.5. Innovative Energy Technologies Assessment

To inform the development of an energy infrastructure development strategy a screening assessment of innovative energy technologies, or "non wires" solutions, was performed. This analysis sought to analyze the business case for key commercially available "non wires" solutions based on net present value of investment (solar energy generation and battery energy storage) and levelized cost of energy (on-site hydrogen production via electrolysis and stationary fuel-cell power generation). These analysis were to provide base-line information on the current business-case for these technologies, but did not compare cost of "non wires" solutions against cost of potential grid upgrades. Those alternatives analyses will need to be performed as part of future, more detailed planning work, and as part of the engineering design process for future projects.

3. Analytical Results

3.1. Energy Baseline and Forecast

The baseline assessment determined that approximately 20% of the port-wide energy consumption is in the form of grid electricity provided by Tacoma Power. The remaining 80% is in the form of diesel, gasoline, or marine fuel oil, with vessels at berth accounting for ~40% of the total energy use, fossil fueled CHE and building natural gas using approximately ~15% each, and vehicles accounting for ~5%. The major marine terminals were the biggest energy users, accounting for 66% of total energy consumption.
Figure 2 depicts the baseline energy use (2022) and forecasted energy use out to 2050, assuming full electrification of port facilities by 2050. Total electricity use is projected to more than double by 2050, with the largest contributors to growth in electricity use being shore power (~100 GWh) and cargo-handling equipment charging (30 GWh). Transitioning to electricity is projected to significantly decrease the energy inputs used across the port, driven by the greater efficiency of electric drivetrains and shore power when compared with internal combustion engines. This is reflected in Figure 2 by the decrease in total energy use from greater than 450 GWh in 2022 to less than 250 GWh in 2050.

The port's coincident peak demand is projected to increase four-fold, from the currently estimated 30 MW to approximately 125 MW by 2050. Figure 3 shows the diel pattern in projected peak demand across the port for typical and peak operations, with managed and unmanaged charging. Based on the forecasted demand for peak operations, during the lunch hour (12-1 PM), 10 PM shift change, or at 2 AM if charging is not managed. The biggest driver of increased peak demand is vessel shore power, followed by CHE charging, as shown in Figure 4. In addition to the core peak demand growth associated with electrification, additional "alternative scenarios" were included in the modeling, to reflect the potential demand growth associated with less certain potential sources of demand growth. These alternative scenarios are summarized in Figure 5. For some of these alternative scenarios, the higher degree of uncertainty is associated with location (i.e. to what degree will class 8 truck charging occur on port property vs. elsewhere) while for others there is more uncertainty associated with whether electrification will be feasible (electric tug-boats and locomotives). The class 8 truck charging captured by the SHERM represents only potential charging installations on port property, a very small proportion of the total amount of charging necessary regionally to serve the entire drayage fleet. If all of these alternative scenarios were to be implemented, peak demand would increase by an additional 60 MW.

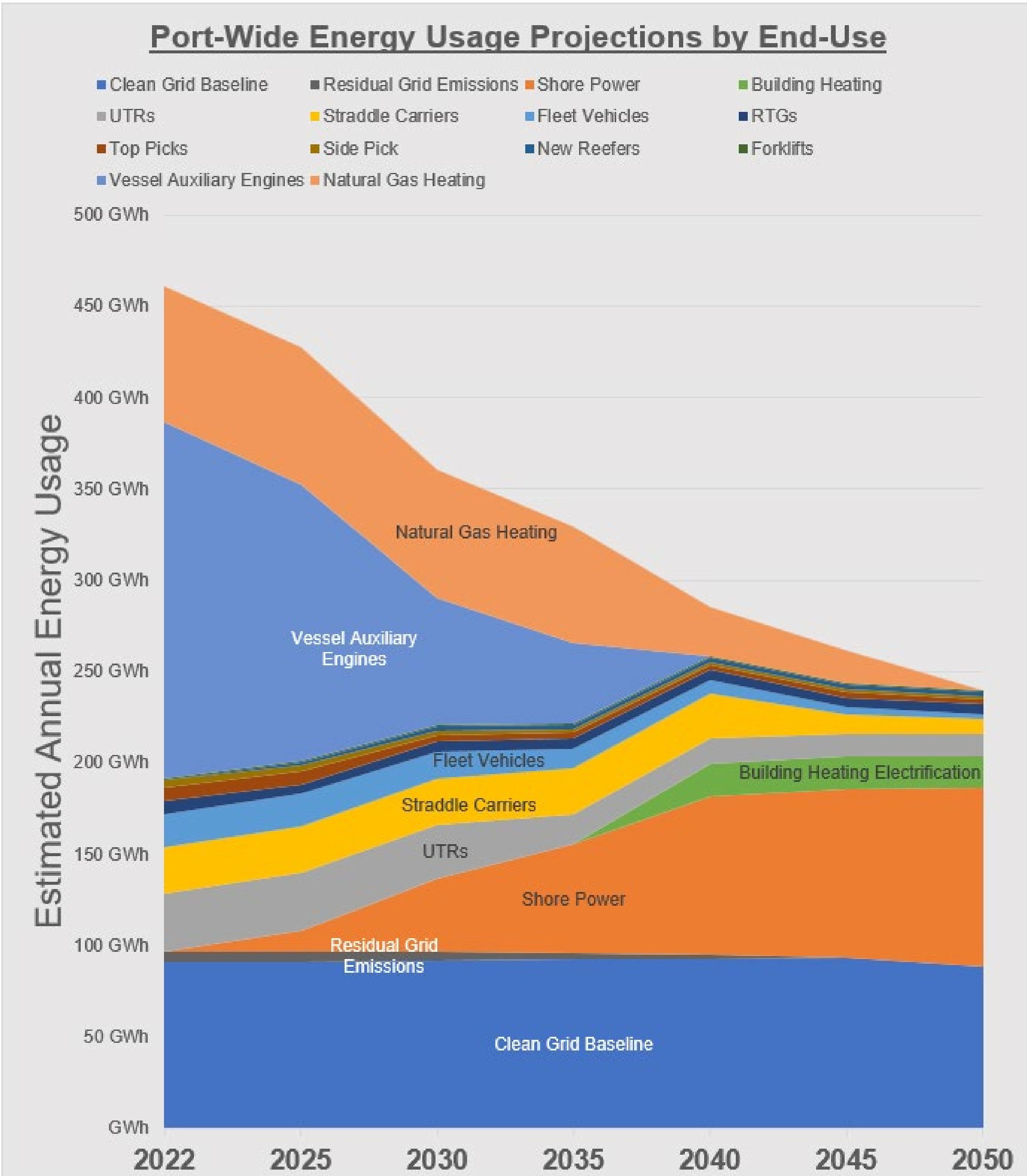

Figure 2. Port-Wide Baseline and Forecasted Energy Use

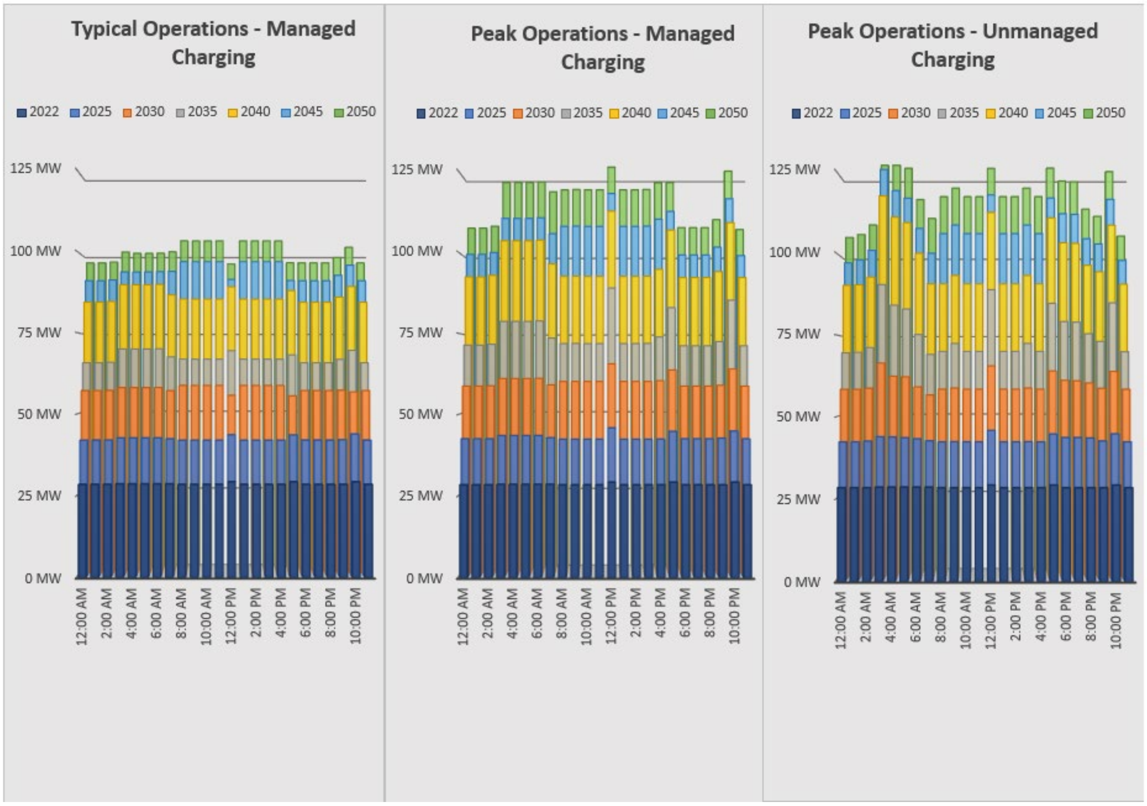

Figure 3. Port-Wide Forecasted Diel Coincident Peak Electrical Demand.

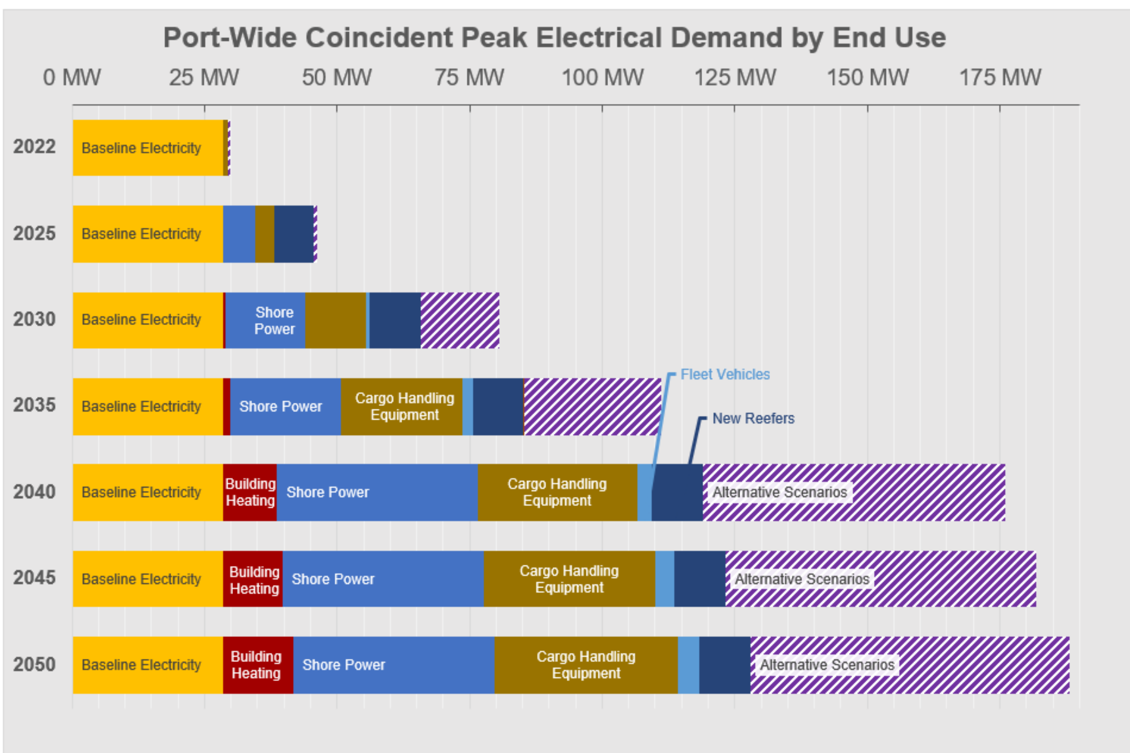

Figure 4. Port-Wide Forecasted Peak Electrical Demand by End Use

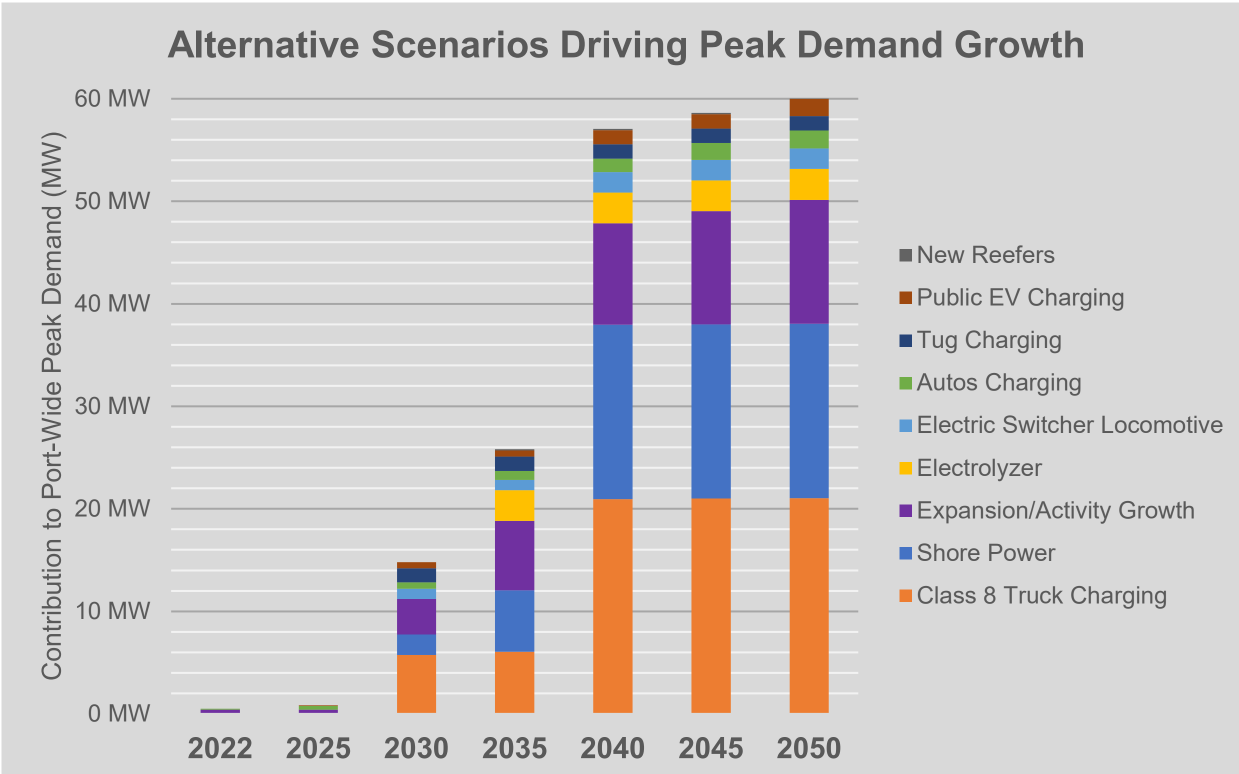

Figure 5. Alternative Scenarios Driving Peak Demand Growth.

3.2. Priority Facility Infrastructure Needs

The priority facility infrastructure needs assessment identified $157 million in electrical infrastructure upgrade needs to enable electrification at the port's largest 7 terminals in the Tacoma harbor. This is meant as a **rough order of magnitude estimate only** and likely underestimates the total investment needed since the estimate was performed in 2023 dollars without escalation to actual construction year, does not include civil upgrades that may be needed to accommodate charging, and does not include the port's administrative costs to manage these projects. This only includes infrastructure and does **not** include the hundreds of millions likely needed to purchase electric equipment and vehicles. These assessments and cost estimates will need to be further expanded and refined via future planning and design work. Non-wires technologies were not included in the solution set for which costs were estimated, as they were not deemed to have a positive net present value based on local utility rates. As implementation of electrification progresses, these solutions should be re-evaluated against required grid upgrades to determine whether they may be a cost-effective alternative to conventional grid upgrades.

Table 1. Summary of Estimated Costs for Electrical Upgrades by Terminal

Terminal	Electrical Upgrade Needs	Estimated Cost
Husky	Building Heating; Shore Power; Reefers; Electric Vehicle Service Equipment (EVSE) for Fleet Vehicle Electrification, Forklifts, Picks, RTGs, and UTRs; and New Electrical Service	$39.5M
PCT	Shore Power; EVSE for Forklifts, Side Picks, Top Picks, UTRs, Class 8 Trucks, Straddle Carriers; and New Electrical Service	$42.6M
TOTE	Building Heating; EVSE for UTRs, Forklifts, Top Picks, and Fleet Vehicles; New Reefers; and New Electrical Service	$8.2M
Terminal 7	Building Heating; Shore Power; EVSE for Forklifts and UTRs; Expansion Growth; and New Electrical Service	$10.6M
West Sitcum	Building Heating; Shore Power; EVSE for Fleet Vehicles, Forklifts, Side Picks, Top Picks, and UTRs; and New Electrical Service	$21.1M
East Blair One	Building Heating; EVSE for Forklifts, Side Picks, and UTRs; and New Electrical Service	$2.4M
WUT	Building Heating; Shore Power; EVSE for Fleet Vehicles, Side Picks, Top Picks, Forklifts, and UTRs; and New Electrical Service	$32.7M
TOTAL		**$157.1M**

3.3. Utility Grid Upgrade Needs

The analysis conducted by Tacoma Power holistically assessed the electrical system requirements to serve the projected demands, while maintaining reliability and resiliency. Tacoma Power conducted an analysis of their system using their distribution modeling software to identify overloads and potential mitigations. For example, many of the terminals currently require less than the 10 MW of power a distribution circuit can supply. Utilities take advantage of this by servicing multiple customers from a single distribution feeder. As power requirements escalate above this 10-MW threshold, there will be a need for additional feeds. Today, multiple terminals are fed by the same distribution feeder. In the future, this will likely not be possible for terminals with the highest power demands. Typically, utility upgrades are made incrementally, as new capacity is requested by utility customers, to meet immediate needs. Rather than approaching upgrades in an incremental fashion as individual terminal upgrade needs are identified, it will be more cost efficient and less operationally disruptive for the Port to coordinate with Tacoma Power on a strategic long-term grid upgrade plan to accommodate the Port's future power needs. The analysis performed for the SHERM is the first step towards enabling this greater collaboration.

Significant upgrades to the utility's distribution grid will be needed to serve the forecasted 2050 power demand, including upgrades to infrastructure serving each of the port's priority terminals. Table 2 provides a summary of the upgrades identified by substation service area. In total, the rough, order of magnitude cost estimates for the identified upgrades is $78 million, of which ~$49 million is substation upgrades, ~$26 million is feeder (local electrical line) upgrades, and $6 million is transmission line upgrades. Costs identified should be considered rough order of magnitude only and are presented in 2023 dollars. Further planning and design work will be needed to estimate actual costs.

Table 2. Tacoma Power System Upgrades Identified

Substation Area	Upgrade Type	ROM Cost ($M)
Alexander	Substation	$12.1
	Feeder	$10.2
Blair	Feeder	$3.4
East F	Feeder	$2.6
Lincoln	Substation	$9.5
	Feeder	$7.6
Northeast	Substation	$9.1
	Feeder	$2.3
New Substation	Transmission line and substation installation	$15.0
Transmission Grid	Transmission line upgrades	$6.0
TOTAL		**$77.8M**

4. Infrastructure Development Strategy

While the port's 2050 ZE goal is still decades away, it can be argued that now is the most critical time for the port to lay the groundwork to successfully meet the goal. This section outlines a multi-faceted plan to guide the port in identifying, prioritizing, and pursuing the most impactful action-steps toward an electrified future. The strategy identifies utility and on-Port infrastructure upgrades required to support electrification, as well as supportive planning. Investments are prioritized based on the probability of near-term use due to operational needs and technology viability.

4.1. Zero Emission Transition Master Planning

The SHERM provides a high-level assessment that allows the Port to engage with its tenants and Tacoma Power to begin the process of planning for a net zero future at the port. The next recommended step is to work closely with marine terminal operators to develop ZE master plans for each major terminal. These plans can be used to assess the feasibility of different ZE technologies to meet the specific terminal's individual operational requirements; identify desired technologies, manufacturers, and models; identify preferred charging / fueling locations; and develop preliminary designs and cost estimates for the on-terminal infrastructure upgrades necessary to power CHE, vehicles, and vessels. This detailed planning process will allow the Port and tenants to have more informed conversations with Tacoma Power regarding the timing and amount of power needed; begin the capital investment program planning process; and have concept designs and estimates that will support pursuit of outside project funding, as well as initiation of the project development process, which will include design, procurement, construction, and deployment. It is important to note that full-scale electrification at terminals will result in large demand increases that could justify planning for the deployment of batteries, or other methods of energy storage to avoid or defer utility grid upgrades. The port should also undertake similar planning efforts for the facilities and fleets it manages. ZE Transition Master Planning should include making key near-term infrastructure projects to grant-ready status, to position these projects well to apply for funding to support their implementation.

4.2. Technology Demonstration Program

One of the most powerful steps the Port can take to encourage terminal operators to accelerate their electrification efforts is to perform demonstration projects to create case studies on their operational capabilities and cost savings. Accordingly, it is recommended that the Port prioritizes demonstration projects at its own Port-controlled facilities and with tenants who have corporate goals or interests in decarbonization. Pilot projects can provide valuable insights to operators and original equipment manufacturers that help inform operations and refine technologies to optimize cargo handling operations with ZE technologies. Real-world, local data that proves operational cost savings can also be used to make the business case for adopting electrification, on a total cost of ownership basis. The commercial availability and operational viability of grid-electric and battery-electric CHE continue to improve. Grid-tied RTGs are commercially available and both operationally economically viable. The most recent generations of yard tractors, top handlers, and large-capacity forklifts being deployed in 2024-2025 are now able to complete 10-16 hours of continuous operations on a single charge. Initially, equipment and vehicle deployments may need to stay smaller in scale as the necessary charging and infrastructure upgrades are put into place and functionality is proven under various operating conditions. Once the operational viability of ZE equipment and vehicles are demonstrated at the Port and economics improve or funds can be acquired, large-scale deployments can be initiated, including the buildout of supporting charging infrastructure.

4.3. Priority Electrification Projects

4.3.1. Shore Power

As part of the NWPCAS, the ports have embraced the goal of installing shore power for ocean-going vessels at major international container terminals by 2030. This includes Husky, Washington United, and pierce County terminals in the Tacoma harbor. To date, shore power has been installed at the TOTE domestic terminal and Husky Terminal.

Projects to install shore power at Washington United are being planned for implementation, pending availability of external funding needed to enable them. Installation of shore power is a high priority given the maturity of the technology and significant emission reduction benefits. The port should continue working with relevant stakeholders, including Tacoma Power, to make shore power capabilities broadly available.

4.3.2. Fleet Vehicle Electrification

The nearly 500 fleet vehicles operating at PoT should be prioritized for conversion to EVs. There are numerous light-duty EVs that are commercially available, economical, and capable of meeting port and terminal operational requirements. Additionally, these vehicles will only require level 1 or 2 chargers, which are less likely to require substantial utility upgrades to support their deployment. These vehicles can be transitioned in alignment with fleet replacement schedules for the Port and its tenants. There are fewer EV options for medium and heavy-duty trucks commonly used for maintenance activities. These vehicles can be prioritized for replacement as commercial EVs become available based on replacement schedules.

4.3.3. Cargo Handling Equipment Electrification

Master planning and installation of key enabling infrastructure are pre-requisites for large, transformational deployment of electric cargo handling equipment, as significant electrical infrastructure will be needed to support charging of electric CHE. In addition, further analysis and planning is needed to determine phasing plans for transition to zero emission technologies at each terminal. In the near term, it is recommended that the port focus on equipment deployments through the technology demonstration program and fleets directly owned and operated by the port, in order to demonstrate efficacy of the technology and build the business case. In parallel, detail master planning and scoping of highest priority infrastructure projects should be conducted to enable installation of the enabling infrastructure and subsequent equipment purchases.

4.3.4. Drayage Truck Charging

Transitioning the approximately 5000 class 8 on-road trucks (drayage trucks) that move cargo to and from port terminals to zero emission will be a critical, yet extremely challenging component of phasing out emissions by 2050. While it is yet uncertain where charging for battery electric trucks will take place, it is likely that charging will be needed across the region, including in the vicinity of the port. Building on the SHERM and work of the Puget Sound Zero Emission Truck collaborative[4], the port should perform a detailed

[4] Puget Sound Zero-Emission Truck Collaborative

assessment of opportunities to host truck charging on port properties. The NWSA is also already running its own ZE Drayage Incentive Program, which will help catalyze early deployments of ZE trucks.

4.4. Priority Utility Upgrades and Coordination

The port and Tacoma Power should continue to coordinate on planning and implementation of electrification projects at port facilities to ensure efficient and timely delivery of necessary capacity upgrades. In the near term (i.e. 2026-2030) the biggest electrification-related demand increase will be associated with container vessel shore power installation at Washington United and Pierce County Terminals. The port should work with Tacoma Power on the following grid infrastructure upgrades, as needed by near term projects.

- Install 40 MVA Transformer upgrades at the Lincoln substation to support shore power and other electrification projects.
- Install feeder upgrades to support near-term shore power projects.

The following utility upgrades have been identified to support longer term fleet electrification at the major terminals. The port should continue to coordinate with Tacoma Power throughout ZE Transition Master Planning process, to assess the need for and/or timing of the following upgrades.

- Install new dual circuit crossing under the Blair waterway to connect distribution circuits on both sides, to maximize utilization of existing substation capacity.
- Replace transformers at Alexander and Northeast substations, which are nearing end of life. Consider increasing transformer capacities as part of these projects.
- Upgrade a portion of the transmission system on the Tideflats to handle additional load.

4.5. Workforce Development

By investing in workforce development programs, the Port can better equip its labor partners with the skills needed to effectively service the next generation of ZE CHE and its associated infrastructure. Training can include programs led by original equipment manufacturers, local colleges, unions, and trade associations. Specifically, these trainings should focus first and foremost on battery-electric equipment / vehicles, EVSE, and supporting electrical infrastructure since this is the technology most likely to deployed widely at the Port. Safety protocols, infrastructure deployment and maintenance, electric vehicle/equipment maintenance, charging procedures, and vehicle/equipment operations are all topics that should be included in the workforce development programs.

4.6. Operational Adjustments

A key assumption made in this study's electric demand modeling was that all terminals' shift schedules would remain unchanged in an electrified future. This assumption was made to minimize friction in the transition to electric CHE and avoid disruptions to terminal operator's well-established schedules. However, substantial cost savings may be realized by the Port and its tenants alike if agreements can be reached with organized labor to stagger their operating schedules at each major marine terminal by +/- 1 hour to lower the coincident peak demand at the Port as seen by Tacoma Power. This is because equipment must "opportunity charge" at full power during the lunch hour and shift breaks to ensure that it can maintain state of charge across all shifts. Staggering operating schedules can therefore reduce coincident peak demand by staggering charging, which may reduce the need for grid upgrades to serve harbor-wide peak demands.