The Port of Hueneme
Oxnard Harbor District

The SPARC Blueprint Project

SUSTAINABLE POWER ADVANCEMENT & RESILIENCY FOR OUR COMMUNITY

THE CALIFORNIA ENERGY COMMISSION ARV-21-024

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Executive Summary

The Sustainable Power Advancement and Resiliency for our Community (SPARC) Blueprint Project grew from the Port of Hueneme's (Port) commitment to protecting their community's health and ensuring the Port's long term energy viability for the future. The Port partnered with Zero Emission Advisors, Breathe Southern California and the Coalition for Clean Air to explore clean energy options for Port operations. The SPARC Blueprint examined holistically with great operational resolution the equipment and fuel infrastructure technologies to enable a conversion to zero emission of all cargo handling equipment (CHE) operations at the Port. In these analyses of how energy is and will be used for Port operations, hydrogen fuel cell and battery electric alternatives were explored and evaluated against the operational requirements at the Port, in addition to commercial readiness, costs and technology readiness considerations.

Operational data suitable for the required analyses were limited, necessitating the development of a utilization model based on vessel call and cargo throughput data and operator input. This allowed the project team to determine the energy usage of equipment over time and identify infrastructure requirements accordingly. Equipment utilization is driven by cargo volume, which is driven in part by vessel size. The Port's entrance size and turning basin constrain the vessel sizes that can make calls to those in the 200-300 meter size.

Analyzing these variables in the constructed energy model built for this project helped the Project team conclude that operators in the Port will be able to perform cargo operations using battery electric power sources, which are commercially available, already being deployed on the property, and may offer operational cost savings. Hydrogen fuel cell powered CHE alternatives are not required or recommended at this time due to their significantly lower commercial readiness and higher relative deployment cost. The exception to this is leveraging fuel cell technology for stationary power, rail, and maritime applications, which though not immediately needed on Port could provide operational flexibility and resilience in the near future as this technology evolves and sources of hydrogen fuel become more available and cost effective.

The Port can feasibly transition to zero emission (ZE) CHE operations by 2030 if they take a lead in developing charging infrastructure to support current and future Port equipment fleets. Due to the unique nature of operations at the Port, it is recommended that the Port own and deploy the proposed charging infrastructure to ensure fair, timely access to infrastructure for all commercial partners. It is important that the Port control infrastructure siting and technology selection to avoid stranded asset risk and establish clear standards for use. Additionally, the integration of climate change adaptation considerations such as stormwater intrusion and sea level rise are suggested for future infrastructure deployments.

Current electrical service may not be sufficient for all future charging infrastructure requirements. The Port is prioritizing engagement with Southern California Edison Company (SCE) to support electrical service upgrades necessary for planned infrastructure implementation. In parallel, the implementation of new policies and commercial incentives will help align the Port with its commercial partners to support adoption and commercial-scale deployment. It is recommended that on the longer scale the Port leverage both battery electric and hydrogen-based energy storage systems to improve resiliency, provide stationery power, enable load shifting and support charging systems.

Harborcraft were not examined closely in this report as the best commercially available emissions control technology is currently Tier 4 diesel and the Port's commercial partners are seeking to transition to Tier 4 during their future repowers. Fuel cell alternatives are promising for ZE harborcraft but successful demonstration projects are scarce and infrastructure is lacking and technology is still under development. Ocean going vessel (OGV) emission control technologies including an emissions capture barges and shore power are already currently deployed or in planning phases for upcoming deployment.

MD/HD Vehicle Landscape

Regional Environmental Context

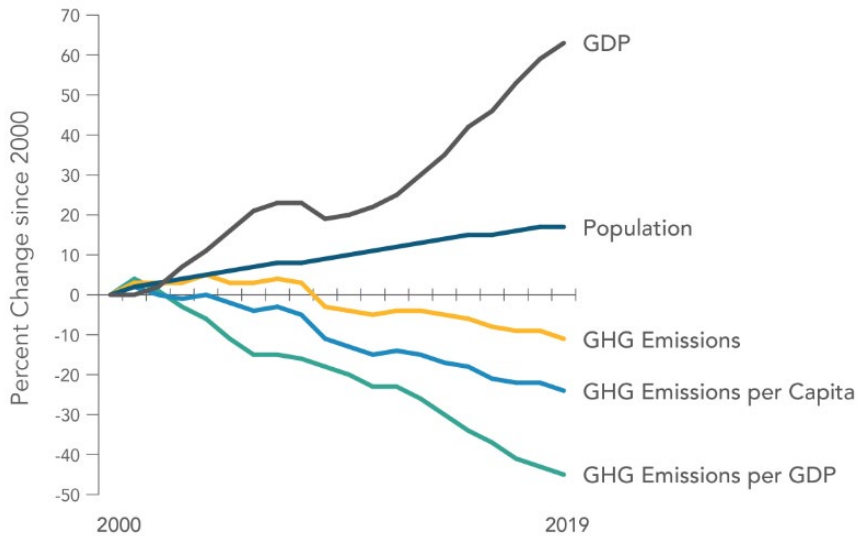
Regional Environmental Goals

The State of California has set several aggressive environmental goals that are relevant to the Port's operations and planning efforts. These goals help shape policy on a state level and are important to consider as the Port sets its own environmental goals and policies. The California Air Resources Board (CARB) is the "clean air agency" for the government of California[1]. Its programs and goals address harmful air pollutants ranging from toxic air contaminants to greenhouse gas (GHG) emissions.

California's Global Warming Solutions Act of 2006 (AB 32) is a key policy measure California enacted to reach 1990 greenhouse gas levels by 2020 (15% reduction from "business as usual" scenario). CARB instituted a number of key policies and programs including mandatory reporting for large emitters, the Air Toxics Program, Diesel Risk Reduction Plan, and many others that have set a consistent pace for ramping up air quality standards. CARB updates its scoping plan on a 5-year basis, outlining the state's strategy for meeting its goals. Below is a graph showing the percent change in GHG emissions, Gross Domestic Product (GDP), and population growth from 2000 to 2019.

Figure 1.1: Percent Change of GHG Emissions in Correlation to GDP and Population Growth; 2000-2019

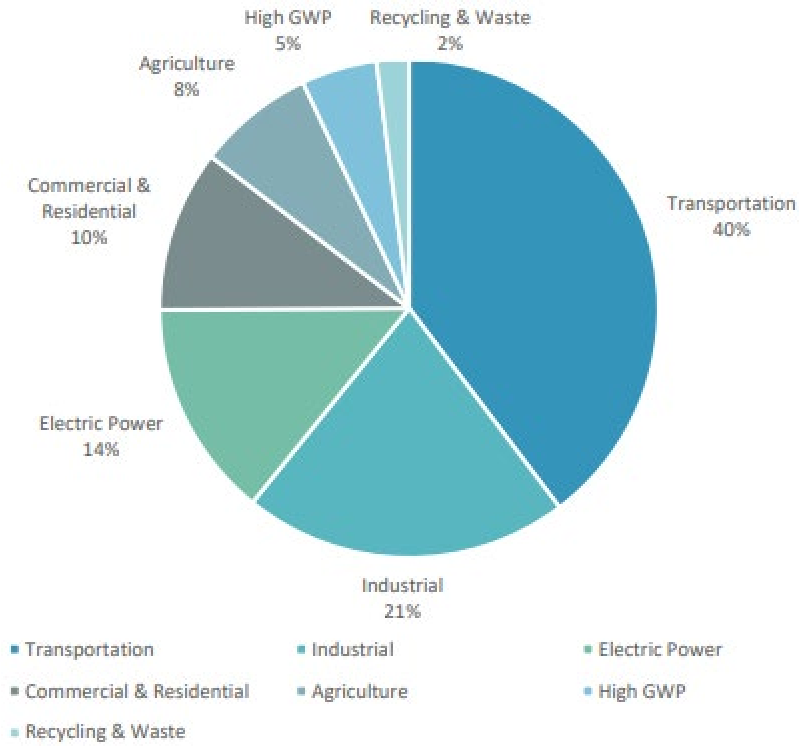
[1] C*alifornia Air Resources Board: Homepage*



Source: "GHG Emission Inventory Graphs 2022." *California Air Resources Board*

The 2017 scoping plan outlined the state plan to reach its 2030 climate target to reduce greenhouse gas (GHG) emissions by 40 percent from 1990 levels and advance toward the 2050 goal to reduce GHG emissions by 80 percent below 1990 levels. CARB published its draft scoping plan for 2022 on May 10, 2022, highlighting a carbon neutrality goal of 2045. Special emphasis is placed on the Industrial, Electric Power, and Transportation sectors as they constitute a combined 75% of State GHG emissions in the 2019 year (see chart below).

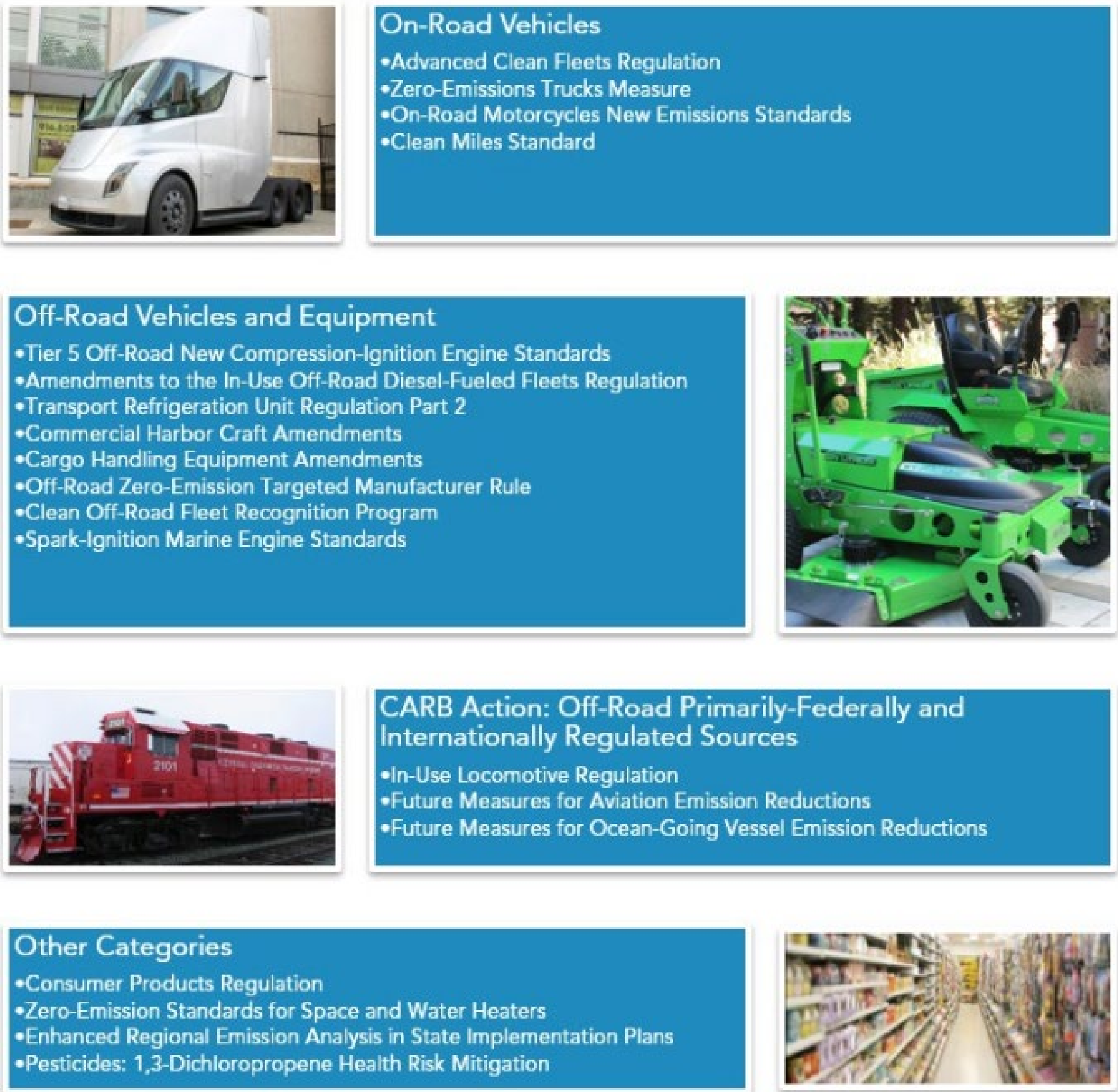
Figure 1.2: Apportioned emissions by sector.



Source: "Draft 2022 Scoping Plan Update." *California Air Resources Board*

Federal clean air laws require the development of State Implementation Plans (SIPs) for all areas with unhealthy levels of ozone, inhalable particulate matter, carbon monoxide, nitrogen dioxide, and sulfur dioxide. A SIP describes how a region will meet national ambient air quality standards (NAAQS). Ventura County has been struggling to achieve Federal NAAQS goals for ozone in recent years. The State's 2022 SIP highlights increasing commitments to target air quality issues that present health risks to disadvantaged communities. Below is a summary of the key strategy measures proposed by the state.

Figure 1.3: Summary of key strategy measures proposed by state.



Source: "2022 State SIP Strategy." *California Air Resources Board*

Below is a list of proposed State and Federal measures listed in CARB's 2022 SIP. All areas of Port operation are facing increasingly stringent air quality regulations in upcoming years, the full extent of which is still unknown as several of the rules are still in development.

Figure 1.4: CARB 2022; Proposed Measures

Proposed Measure	Agency	Action	Implementation Begins
On-Road Heavy-Duty			
Advanced Clean Fleets Regulation	CARB	2023	2024
Zero-Emissions Trucks Measure	CARB	2028	2030
On-Road Light-Duty			
On-Road Motorcycle New Emissions Standards	CARB	2022	2025
Clean Miles Standard	CARB	2021	2023
Off-Road Equipment			
Tier 5 Off-Road Vehicles and Equipment	CARB	2025	2029
Amendments to the In-Use Off-Road Diesel-Fueled Fleets Regulation	CARB	2022	2024
Transport Refrigeration Unit Regulation Part 2	CARB	2026	2028
Commercial Harbor Craft Amendments	CARB	2022	2023
Cargo Handling Equipment Amendments	CARB	2025	2026
Off-Road Zero-Emission Targeted Manufacturer Rule	CARB	2027	2031
Clean Off-Road Fleet Recognition Program	CARB	2025	2027
Spark-Ignition Marine Engine Standards	CARB	2029	2031
Other			
Consumer Products Standards	CARB	2027	2028
Zero-Emission Standard for Space and Water Heaters	CARB	2025	2030
Enhanced Regional Emission Analysis in State Implementation Plans[39]	CARB	2025	2023
Pesticides: 1,3-Dichloropropene Health Risk Mitigation	DPR[40]	2022	2024
Primarily-Federally and Internationally Regulated Sources – CARB Measures			
In-Use Locomotive Regulation	CARB	2023	2024
Future Measures for Aviation Emissions reductions	CARB	2027	2029
Future Measures for Ocean-Going Vessel Emissions reductions	CARB	2027	TBD
Primarily-Federally and Internationally Regulated Sources – Federal Action Needed[41]			
On-Road Heavy-Duty Vehicle Low-NOx Engine Standards	U.S. EPA	2022	2027
On-Road Heavy-Duty Vehicle Zero-Emission Requirements	U.S. EPA	TBD	TBD
Off-Road Equipment Tier 5 Standard for Preempted Engines	U.S. EPA	TBD	TBD
Off-Road Equipment Zero-Emission Standards Where Feasible	U.S. EPA	TBD	TBD
More Stringent Aviation Engine Standards	U.S. EPA/ICAO[42]	TBD	TBD
Cleaner Fuel and Visit Requirements for Aviation	U.S. EPA	TBD	TBD
Zero-Emission On-Ground Operation Requirements at Airports	U.S. EPA	TBD	TBD
Airport Aviation Emissions Cap	U.S. EPA	TBD	TBD
More Stringent National Locomotive Emission Standards	U.S. EPA	TBD	TBD
Zero-Emission Standards for Locomotives	U.S. EPA	TBD	TBD
Address Unlimited Locomotives Remanufacturing	U.S. EPA	TBD	TBD
More Stringent NOx and PM Standards for Ocean-Going Vessels	U.S. EPA/IMO[43]	TBD	TBD
Cleaner Fuel and Vessel Requirements for Ocean-Going Vessels	U.S. EPA	TBD	TBD

Source: "2022 State SIP Strategy." *California Air Resources Board*

Regional Air Quality & Environmental Regulations

The tables provide a summary of the regional air quality regulations relevant to current planning efforts and Port of Hueneme's operation.

Table 1: Cargo Handling Equipment Emission Regulations, Standards, and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
EPA	Emission Standards for Non-Road Diesel Powered Equipment	All	2008 - 2015	All non-road equipment
CARB	Cargo Handling Equipment Regulation	All	2007 through 2017; Opacity test compliance starting in 2016	All Cargo handling equipment
CARB	New Emission Standards, Test Procedures, for Large Spark Ignition (LSI) Engine Forklifts and Other Industrial Equipment	All	2007 - first phase 2010 - second phase	Initial IMO Strategy on reduction of GHG emissions from ships by 50% in 2050 from 2008 level. Goal is to phase out GHG
CARB	Fleet Requirements for Large Spark Ignition Engines	All	2009 through 2013	More stringent emissions requirements for fleets of large spark ignition engines equipment

Source: Starcrest Consulting Group. *Port of Hueneme Inventory of Air Emissions CY 2020 and 2019*. 2022.

Table 2: OGV Emission Regulations, Standards, and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
International Maritime Organization (IMO)	NO_x Emission Standard for Marine Engines	NO_x	2000 - Tier I 2011 - Tier II 2016 - Tier III for ECA only	Auxiliary and propulsion engines over 130 kW output power on newly built vessels
IMO	Emissions Control Area, Low Sulfur Fuel Requirements for Marine Engines	DPM, PM, and SO_x	2012 ECA - 1% Sulfur	Significantly reduce emissions due to low sulfur content in fuel by

			2015 ECA - 0.1% Sulfur	creating Emissions
IMO	Initial IMO Strategy on Reduction of GHG emissions from ships - Resolution MEPC.304(72)	GHG	2050 - 50%	Initial IMO Strategy on reduction of GHG emissions from ships by 50% in 2050 from 2008 level. Goal is to phase out GHG
IMO	Energy Efficiency Design Index (EEDI) for International Shipping	CO_2 and other pollutants	2013	Increases the design efficiencies of ships relating to energy and emissions
Environmental Protection Agency (EPA)	Emission Standards for Marine Diesel Engines above 30 Liters per Cylinder (Category 3 Engines); Aligns with IMO Annex VI marine engine NO_x standards and low sulfur requirement	DPM, PM, NO_x, and SO_x	2000 - Tier I 2011 - Tier II 2016 - Tier III	Auxiliary and propulsion category 3 engines on US flagged new built vessels and requires use of low sulfur fuel.
California Air Resources Board (CARB)	Control Measure for Ocean Going Vessels at Berth	DPM, PM, NO_x, SO_x, and CO_2	2023 - Additional requirements for container, reefer, and cruise vessels. 2025 - New requirements for auto carriers / RoRos 2025 - New requirements for Tanker vessels	Shore power (or equivalent) requirements for all regulated vessel visits.
CARB	Ocean-going Ship Onboard Incineration	DPM, PM, and ROG	2007	All vessels cannot incinerate waste within 3 nm of the California coast

Source: Starcrest Consulting Group. *Port of Hueneme Inventory of Air Emissions CY 2020 and 2019*

Table 3: Harbor Craft Emission Regulations, Standards, and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
EPA	Emission Standards for Harbor Craft Engines	All	2009 - Tier III 2014 - Tier IV for 800 hp or greater	Commercial marine diesel engines with displacement less than 30 liters per cylinder
CARB	Low Sulfur Fuel Requirements for Harbor Craft	DPM, PM, NO_x, and SO_x	2006 - 15 ppm in SCAQMD area	Use of low sulfur diesel fuel in commercial harbor craft
CARB	Regulation to Reduce Emissions from Diesel Engines on Commercial Harbor Craft	DPM, PM, and NO_x	2009 to 2020 - schedule varies depending on engine model year	Most harbor craft must meet more stringent emissions limits according to a compliance schedule

Source: Starcrest Consulting Group. *Port of Hueneme Inventory of Air Emissions CY 2020 and 2019*

Table 4: Heavy-Duty Vehicles Emission Regulations, Standards, and Policies

Agency	Regulation/Standard/Policy	Targeted Pollutants	Years Effective	Impact
CARB / EPA	Emission Standards for New 2007+ On-Road Heavy-Duty Vehicles	NO_x and PM	2007 2010	All new on-road diesel heavy-duty vehicles
CARB	Heavy-Duty Vehicle On-Board DIagnostics (OBD and OBDII) Requirement	NO_x and PM	2010+	All new on-road heavy-duty vehicles
CARB	ULSD Fuel Requirement	All	2006 - ULSD	all on-road heavy-duty vehicles
CARB	Drayage Truck and Bus Regulation (amended in 2011 and 2014)	All	Phase-in started in 2009	All drayage trucks operating at California ports

CARB	Low NO_x Software Upgrade Program 2007	NO_x	Started in 2005	1993 to 1998 on-road heavy-duty vehicles that operate in California
CARB	Heavy-Duty Vehicle Greenhouse Gas Emission Reduction Regulation	CO_2	Phase I started in 2012	Heavy-duty tractors that pull 53-foot+ trailers in California
CARB	Assembly Bill 32 requiring GHG reductions targets and Governor's Executive ORder B - 30-15	CO_2	GHG Emissions reduction goals in 2020	All operations in California

Source: Starcrest Consulting Group. *Port of Hueneme Inventory of Air Emissions CY 2020 and 2019*

Port of Hueneme Environmental History

The Port has enacted several policies and programs throughout its history to advance its environmental goals. Implemented in 2012, the Port's Environmental Management Framework (EMF) marked the beginning of the Port's strong push to become a national leader in maritime sustainability. This robust environmental document sets strategic action plans in these core areas:

- Air Quality Management
- Marine Resources Management
- Soil and Sediment Management
- Water Quality Management
- Energy Management
- Climate Change Adaptation

In 2016 the Port became the first port in California to become certified by Green Marine, the pre-eminent international environmental certification program for maritime facilities. Green Marine helps to guide the integration of sustainability into the Port's day-to-day operations.

In recent years the Port has focused on addressing the challenge of the climate crisis and the intersection between air quality, energy management and climate change adaptation, and has become a regional leader in industrial decarbonization and community air quality. Central among those efforts are its air quality monitoring and emissions inventory efforts. These provide critical data to measure the effectiveness of emissions mitigation efforts such as the electrification of Port equipment.

Starting in 2018, the Port has produced regular emissions inventory reports to track its progress, using emissions estimates for 2008 as its baseline. Over the twelve-year period from 2008 to 2020, the Port has seen a 85% reduction in DPM, a 37% reduction in NOx, a 97% reduction in SOx, and a 7% reduction in carbon dioxide equivalent (CO2e), all while experiencing a 25% growth in cargo volume.

Source: Starcrest (2022) Inventory of Air Emissions for CY 2020 and 2019

Table 5: Summary of 2020 and 2019 Port-Related Emissions

2020								
Harbor Craft	0.35	0.33	0.35	17	0.02	3.5	0.9	1,860
Cargo Handling Equipment	0.24	0.22	0.24	13	0.03	9.1	1.0	2,775
Locomotives	0.12	0.11	0.12	4	0.00	0.5	0.2	165
Wheeled Vehicles	0.03	0.03	0.03	4	0.03	3.4	1.2	2,491
2019								
Ocean-going Vessels	2.49	2.29	1.67	121	6.17	10.6	4.9	9,334
Harbor Craft	0.64	0.61	0.64	32	0.03	6.4	1.6	3,200
Cargo Handling Equipment	0.26	0.24	0.26	13	0.03	7.2	0.9	2,222
Locomotives	0.12	0.11	0.12	4	0.00	0.5	0.2	165
Wheeled Vehicles	0.04	0.03	0.03	4	0.03	6.4	1.4	2,983
Total	**3.55**	**3.28**	**2.72**	**174**	**6.26**	**31.0**	**9.0**	**17,905**

Source: Starcrest Consulting Group. *Port of Hueneme Inventory of Air Emissions CY 2020 and 2019*

In 2019 the Port commenced its community air quality monitoring program, with the installation of Environmental Protection Agency (EPA) reference grade monitoring equipment at local Haycox Elementary School located 1.7km east of the Port. The monitoring station measures particulate matter and black carbon as a surrogate for diesel particulate matter, providing community-specific air quality data to local stakeholders.

The Port's EMF defined several key long-term strategies relevant to the blueprint that are in preliminary development. The first of note being the Green Lease Program, intended to incorporate new language to support periodic review of new technologies, and assess the cost, technical feasibility, and operational feasibility of new technologies. The second is a Technology Advancement Program to provide incentive funding for accelerating the implementation of zero emissions equipment and infrastructure. Air quality key performance indicators (KPIs) identified in the Port's EMF are a reduction in criteria pollutants (carbon monoxide, oxides of nitrogen, particulate matters 10 & 2.5, oxides of sulfur, total hydrocarbon, carbon dioxide, methane, and nitrous oxide.

An electrical master plan for the Port was produced in 2019 by industry-leading electrical engineering firm H3 Engineering. The plan, which is a living document updated on a regular basis, takes a close look at the Port's electrical infrastructure and estimates future loads based on electrification scenarios. The plan highlights opportunities for the potential deployment of electric top handlers, 10 additional electric utility tractor rigs (UTRs), and the possible deployment of a rack system to support refrigerated containers which would necessitate an increase in container handlers (reach stackers). Additionally, the report explores the electrification of up to six (6) dock cranes, each with an estimated power requirement of 720 kW.

The Port's investments and leadership in environmental stewardship to date have earned it several awards and recognition over the years. In 2016, the Port of Hueneme became the first Port in the State of California to receive a Green Marine Certification. The Port was also given high accolades during the 2017 US Green Shipping Summit as the Greenest Port of the Year. Additionally, the Ventura County Board of Supervisors presented the Port with an Award for Excellence in Environmental Stewardship in 2017 on Earth Day.

The Port has also proactively begun the development of a clean air action plan in partnership with the local air quality regulatory agency, the Ventura County Air Pollution Control District (VCAPCD). The Port of Hueneme, Reducing Emissions, Supporting Health (PHRESH) plan will be the first time in the State that a port and its air quality regulator have teamed up to write a clean air plan together. PHRESH will assess and address the Port's emissions, air quality requirements and goals for the Port, future growth scenarios, emission control strategies, community involvement, strategy funding, implementation, and monitoring.

In 2021, the Port's Board of Harbor Commissioners unanimously approved a resolution committing to the decarbonization of its operations. A goal has been set for all Port trucking to be zero emission by at least 2035 for short haul/drayage and at least 2045 for long haul. Additionally, the Board made a commitment to additional reductions of ocean-going vessel emissions via the at-berth regulations by 2025 or sooner, including auto carrier and roll-on, roll-off (RORO) vessels.

Equipment Inventory

The Port's inventory of equipment consists of a diverse range of cargo handling equipment, Ocean Going Vessels (OGVs), harbor craft, light duty vehicles, and Class 8 trucks. Most of the equipment operated on the Port property is not owned or operated by the Port but by commercial partners and tenants. Alternatives were assessed for the equipment listed below in the Port's provided equipment inventory. This subset of equipment represents the cargo handling equipment and tugboats.

Table 6: Port Equipment; Inventory and Specifications

Port Equipment Inventory			Equipment Specifications				
QTY	Engine Year	Model	Equipment Type	Engine Type	Name Engine Index	Engine Model	Horse Power (Hp)
1	2015	4x2 DOT EPA	Utility Tractor Rig (UTR)	Diesel	Utility Tractor Rig (UTR), Diesel	B6.7 200	200
3	2019	4x2 DOT EPA	Utility Tractor Rig (UTR)	Diesel	Utility Tractor Rig (UTR), Diesel	B6.7 200	200
13	2013	4x2 DOT EPA	Utility Tractor Rig (UTR)	Diesel	Utility Tractor Rig (UTR), Diesel	B6.7 200	200
1	2015	YT223	Utility Tractor Rig (UTR)	Diesel	Utility Tractor Rig (UTR), Diesel	B6.7 225	225
1	2019	YT223	Utility Tractor Rig (UTR)	Diesel	Utility Tractor Rig (UTR), Diesel	B6.7 225	225
4	2020	YT223	Utility Tractor Rig (UTR)	Diesel	Utility Tractor Rig (UTR), Diesel	B6.7 225	225
1	2009	TJ6000	Utility Tractor Rig (UTR)	Diesel	Utility Tractor Rig (UTR), Diesel	QSBT4F 6.7L 225	225
2	2020	T2E+	Utility Tractor Rig (UTR)	Electric	Utility Tractor Rig (UTR), Electric	Power Drive 8000	244
1		H300	Forklift - Class V	Diesel	Forklift - Class V, Diesel	QSB 6.7L 156	156
1		H190-280XD	Forklift - Class V	Diesel	Forklift - Class V, Diesel	QSB 6.7L 156	156
1	2005	H50FT	Forklift - Class V	Propane	Forklift - Class V, Propane	PSI 2.4L	59
1	2003	LMH320	Mobile Harbor Crane	Diesel	Mobile Harbor Crane, Diesel	D 444.901-505	677
1	2016	LMH420	Mobile Harbor Crane	Diesel	Mobile Harbor Crane, Diesel	D 2842 LE	1085
1	2020	LMH420e	Mobile Harbor	Hybrid	Mobile Harbor	D 9512 A7	765

			Crane		Crane, Hybrid		
1		HTC-238H	Truck Mounted Crane	Diesel	Truck Mounted Crane, Diesel	6SD1TQB	207
1		HC-238A	Truck Mounted Crane	Diesel	Truck Mounted Crane, Diesel	6V-92TAC	260
2	1991	DC25-1200	Forklift - Class V	Diesel	Forklift - Class V, Diesel	TD71AW	200
2	1996	DC13-600XL	Forklift - Class V	Diesel	Forklift - Class V, Diesel	P-1006	129
1	2013	RS 46XD	Container Handler	Diesel	Container Handler, Diesel	X12 380	380
1	2015	RS 46XD	Container Handler	Diesel	Container Handler, Diesel	X12 380	380
1	2018	RS 46XD	Container Handler	Diesel	Container Handler, Diesel	X12 380	380
1	2017	Unknown	Towing Vessel	Diesel	Towing Vessel, Diesel	3512C	2375
1	2013	Unknown	Towing Vessel	Diesel	Towing Vessel, Diesel	3512C	2000

Technical and Economic Feasibility for Battery and Fuel Cell Technologies

Methodology - General

Port equipment quantitative analysis methodology is discussed below for each of the equipment categories and referred to as simply, “Methodology.” Our methodology in general terms is discussed here. All Port equipment and electricity use was viewed as energy load in terms of kW, kWh, and kg of H_2, including gas and diesel engines. Emissions were derived as a function of energy use: emissions = fnc (kWh). To find this relationship, energy use and emissions were used from the Starcrest report and then a constant (*C) was created and solved to formulate: emissions = *C x kWh. Then, when varied solutions are presented to decrease energy use (kWh) from hydrocarbon fuels, the quantity of reduced emissions is found easily.

The emissions tracked were CO_2 equivalents (CO_2e), particulate matter (PM_{10}), and the family of nitrous oxides or NO_x’s. CO_2e was considered an imperative to quantify our climate impact with PM_{10} being a close second. On a global scale, particulate matter lands on glaciers making them darker, decreasing their albedo, and making them melt faster. PM also has grave effects on human health as a local pollutant. Finally, NOx is another important local pollutant and is the only pollution product of burning ammonia in an internal combustion engine. Given that OGVs may someday run on ammonia, and that ammonia (NH3) is a hydrogen carrier molecule, NOx was tracked. Below, is a discussion of each equipment type and the energy use and emissions metrics of each; the methodology specific to each equipment type is also detailed.

Core Technologies Examined

Battery Electric Technologies

Battery electric medium-duty/heavy-duty (MD/HD) equipment is a rapidly growing market, with demonstration projects and commercial scale deployments in port applications all around the world. In many cases these technologies are slightly more mature in commercialization compared to hydrogen alternatives, though can struggle where weight, available infrastructure capacity, or energy storage become an issue.

The global demand for battery electric technologies is growing at an exponential rate, driven mainly by the demand for electric mobility and energy storage solutions. Government and commercial stakeholders have committed to deploying battery-electric zero-emission vehicles to perform a range of activities, though initial growth in battery manufacturing capacity was driven by light-duty vehicles. Historically, Wright's law has been an accurate indicator of battery cell cost decline, seeing a 28% reduction in cell cost for every cumulative doubling of units produced.

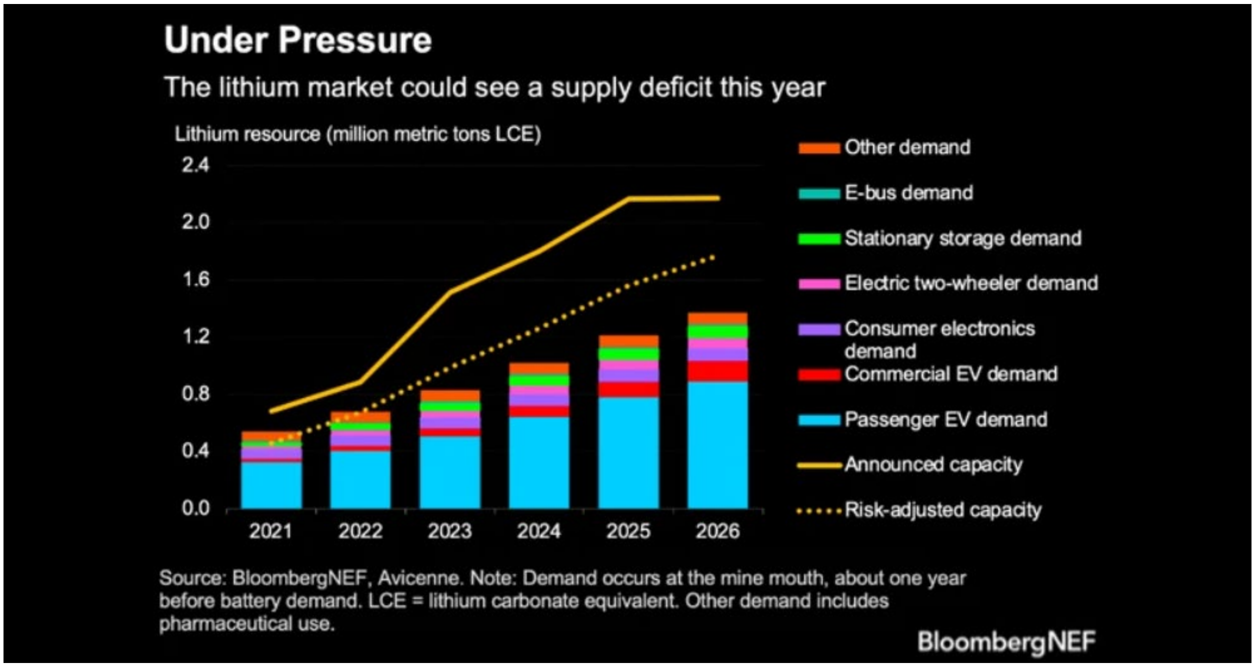
“Global battery demand doubled in 2021, driven by electric car sales in China,” according to a 2022 IEA report on the Global EV market[2]. Pressures on the supply chain present serious bottlenecks for meeting global demand. Metal commodity price surges are expected to have an adverse impact on battery prices while promoting greater diversification in battery chemistries. The International Energy Agency (IEA) estimated that if metal prices remained consistent with Q1 2022 for the remainder of the year, battery pack prices could increase by up to 15% from 2021 figures.

Source: Global Electric Vehicle Outlook 2022 - *IEA*

A recent report from Bloomberg New Energy Finance (NEF) cited issues with the Lithium supply chain attributed to COVID-19 and the war in Ukraine. Substantial investments are required into new mining capacity to meet this surge in demand. Chemistries will continue to adapt, lessening reliance on cobalt in exchange for more readily available materials like nickel.

[2] **Source:** Global Electric Vehicle Outlook 2022 - *IEA*

Figure 1.5: (Lithium Cost Trends)



Source: "Race to net zero: Pressures of the battery boom in five charts | Insights." *Bloomberg.com*

Hydrogen Fuel Cell Technologies

Another zero emission powertrain option is the hydrogen fuel cell. Originally invented over 100 years ago, and largely developed by the National Aeronautics and Space Administration (NASA) for use in the Apollo space missions of the 1960s, hydrogen fuel cells are today used to provide zero emission electricity on applications that typically require a large amount of onboard energy storage and fast refueling options.

The most common type of fuel cell utilized in mobility applications is a proton exchange membrane (PEM) fuel cell, which offers the best combination of power density, efficiency, and efficiency for medium- and heavy-duty equipment like cargo handling equipment, commercial marine vessels and trucks. These systems are ideally suited for applications in environments with limited grid capacity for charging, or where the limitations of battery-energy storage prohibit sufficient endurance. They often utilize compressed gas tanks at a fill pressure of up to 700 BAR.

As a diversity of applications for fuel cell systems emerge in the decarbonization of global energy systems, the cost of fuel cell vehicles and equipment is expected to decline dramatically. Major equipment original equipment manufacturers (OEMs) like Taylor and Hyster are developing and testing heavy lift fuel cell electric vehicles (FCEVs) all around the world. Ballard Power Systems, a leading manufacturer of proton-exchange membrane (PEM) fuel cells for several markets, reported a 65% reduction in the price of fuel cell vehicles over the last ten years. Major truck OEMs are developing Class

8 FCEVs and promoting the development of infrastructure for the market. Companies like Zero Emission Industries are building fuel cell power systems for commercial maritime applications.

Access to fuel is essential for supporting early demonstration projects and commercial-scale deployments. For many heavy duty applications, the fuel cost represents a significant portion of the overall operating cost and total cost of ownership. The reduction in the cost of producing green hydrogen has been forecasted to drop below $1 by 2050 according to BloombergNEF[3]. *Ballard Blog* Alternative production pathways are available that include various waste streams and natural gas.

Cargo Handling Equipment

There have been several recent advancements in the development of zero emission alternatives for cargo handling equipment. Multiple demonstration projects and commercial scale deployments have been completed or are presently underway. There is a range of technologies being explored as alternatives to diesel by OEMs including battery-electric, hybrid, propane, hydrogen fuel cells, and natural gas based solutions. Due to the increasing availability of zero emission alternatives at an adequate Technology Readiness Level (TRL) within the planning horizon, bridge fuels or near zero alternatives were not considered, only zero emission technologies.

Methodology - CHE

Technologies were assessed along several factors to determine suitability for adoption. The first is the TRL, originally developed by NASA and presently utilized by the U.S. Department of Energy. TRL provides a standard metric from 1-9 used by governments and commercial entities to determine the maturity of a given technology (see Table 1 below). Generally, technologies will only be considered in near term planning if they have achieved a TRL of 6-7 or greater.

[3] **Source:** Pocard, Nicolas. “Fuel Cell Price to Drop 70-80% as Production Volume Scales.”

Figure 1.6: (Technology Readiness Breakdown)

Technology Readiness Levels

Relative Level of Technology Development	Technology Readiness Level	Definition
System Operations	TRL 9	Actual system operated over the full range of expected conditions.
System Commissioning	TRL 8	Actual system completed and qualified, through test and demonstration.
	TRL 7	Full-scale, similar (prototypical) system demonstrated in relevant environments.
Technology Demonstration	TRL 6	Engineering/pilot-scale similar (prototypical) system validation in relevant environments.
	TRL 5	Laboratory scale; similar system validation in relevant environment.
Technology Development	TRL 4	Component and/or system validation in laboratory environment.
Research to Prove Feasibility	TRL 3	Analytical and experimental critical function and/or characteristic proof of concept.
	TRL 2	Technology concept and/or application formulated.
Basic Technology Research	TRL 1	Basic principles observed and reported.

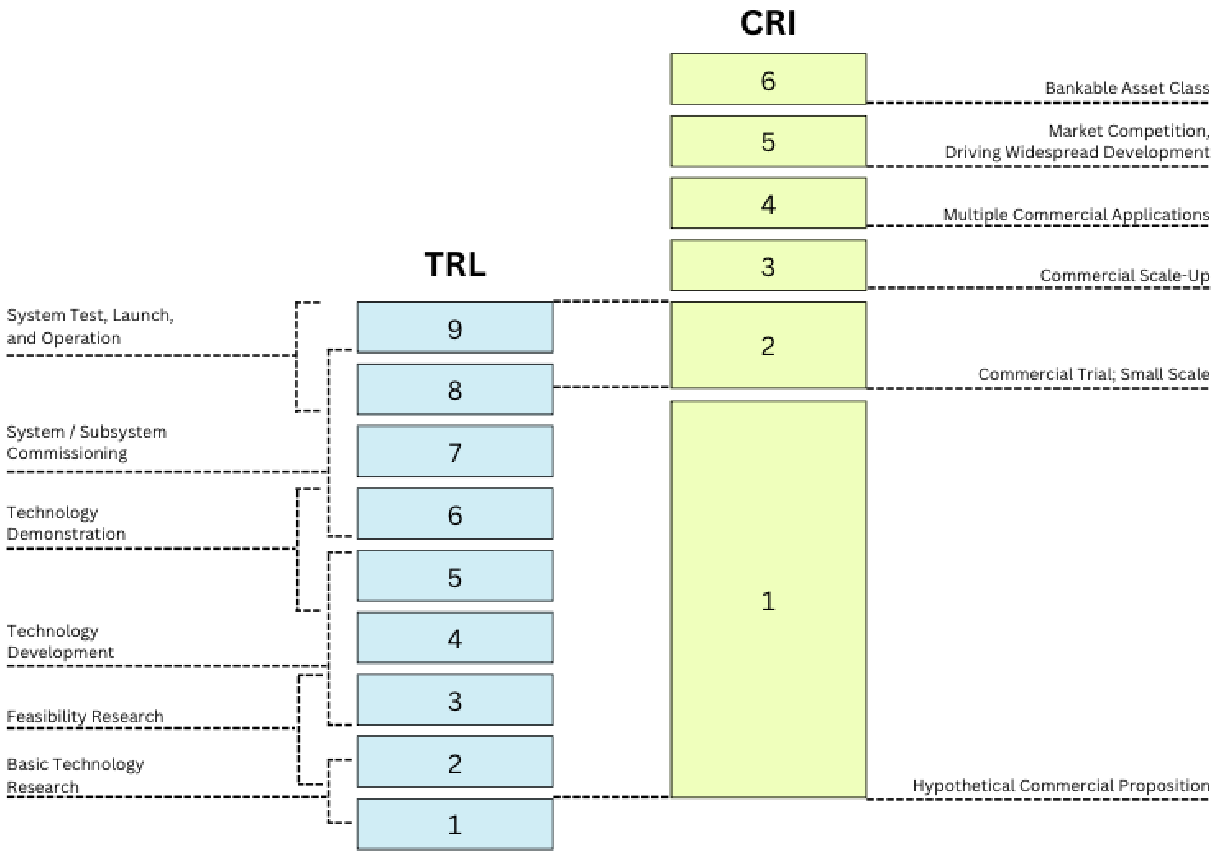
The second metric used is the Commercial Readiness Index (CRI), operating on a scale of 1-6, and addresses various factors influencing commercial market factors as opposed to the maturity of a given technology. CRI presents an evolution from a highly subsidized, but technically viable solution, to a fully bankable and underwritable asset (see Table 2 below). Because many of the technology adoption at the Port are made by operating tenants, not the Port Authority itself, CRI provides a more valuable framework for evaluating the considerations of tenant adoption. Technologies with a CRI as low as 1 and 2 can be considered for early-stage demonstration projects, but are unlikely to see rapid adoption by tenants for several years.

Figure 1.7: (Commercial Readiness Breakdown)

Commercial Readiness Index

Relative Level of Commercial Readiness	Commercial Readiness Index Level	Definition
Bankable Grade Asset	6	Considered a "bankable" grade asset class with known standards and performance expectations. Market and technology risks not driving investment decisions.
Market Competition, Driving Widespread Deployment	5	Competition emerging across all areas of the supply chain. Verifiable data on technical and financial performance in the public domain
Multiple commercial applications.	4	Becoming evident locally; still subsidized. Verifiable data on technical and financial performance in the public domain, driving interest from a variety of debt and equity sources. Still requires government support, and faces regulatory challenges which are addressed in multiple jurisdictions.
Commercial Scale-Up	3	Small scale: first of a kind project funded by equity and government project support.
Commercial Trial	2	Commercial proposition backed by evidence of verifiable data; typically not in the public domain.
Hypothetical Commercial Proposition	1	Technically ready; commercially untested and unproven. Subsidized by the government.

Figure 1.8: (TRL & CRI)



These two metrics combined provide valuable indicators of the stage of technical development and testing, as well as the readiness of the industry to support said technology with a robust, reliable supply chain. Together they provide a useful model for assessing the evolution from research and development to full commercialization. These two initial screening criteria are used to screen zero emission technologies and alternatives to ensure that considered technologies are commercially available and capable of performing CHE operations at the Port of Hueneme.

It's important to note that these two metrics do not constitute final feasibility, rather serve as initial acceptance criteria for further analysis. Additional criteria are considered for final recommendation including Operational Impact, Infrastructure Availability and Commercial Viability.

Capital cost estimates are based on markup factors calculated by taking the average capital expenditure (CAPEX) from listed studies and creating an average markup price factor per CHE category from a base diesel unit. Operational expenditure (OPEX) was calculated using average hours per year provided by the Port multiplied by operation and maintenance (O&M) costs per hour. Fuel costs were derived from current commercial quotes specific to the Port of Hueneme region for the various fuel types (see table 7). Fuel costs, especially hydrogen are subject to change based on volume, offtake agreement term and other factors. The hydrogen supply chain is still immature and not to be considered a full commodity, resulting in a high variance in cost per kg. This is expected to improve, driving down the cost of hydrogen and reliability issues associated with the supply chain over the next five years. Shift schedules and utilization assumptions were also informed by data published by the International Longshore and Warehouse Union (ILWU)[4].

Table 7: Fuel Cost Inputs

Fuel Type	Cost[5]
Diesel	$5.69
Electricity (Commercial Rate)	$0.12
Hydrogen	$7.00
Propane	$2.34
CNG	$2.33
Gasoline	$3.25
LNG	$3.16

Utility Tractor Rig "UTRs" Overview

The Utility Tractor Rig market is highly mature with over twenty OEM's providing a UTR for port terminal use. A majority of units in the market utilize diesel as a fuel source, though significant progress has been made towards the commercialization of near zero and zero emissions alternatives. Near zero emission (NZE) hybrid-electric yard tractors are also available, at approximately TRL 7 along with NZE natural gas internal combustion engines (ICE) yard tractors. There are also liquid natural gas (LNG) units operating commercial service at the San Pedro Bay Ports, though it is expected that compressed natural gas (CNG) be utilized over LNG. While these technologies are expected to reach TRL 9 in the next couple of years, they were not analyzed in further detail in this report as they do not support a fully zero emission operation.

Maximize Market Research Group updated a report in 2022 forecasting the growth of the hybrid and battery segments within the yard tractor market (data shared below). While there are fuel cell options in development, the TRL is closer to 6, with early pilots and pre-commercial testing underway.

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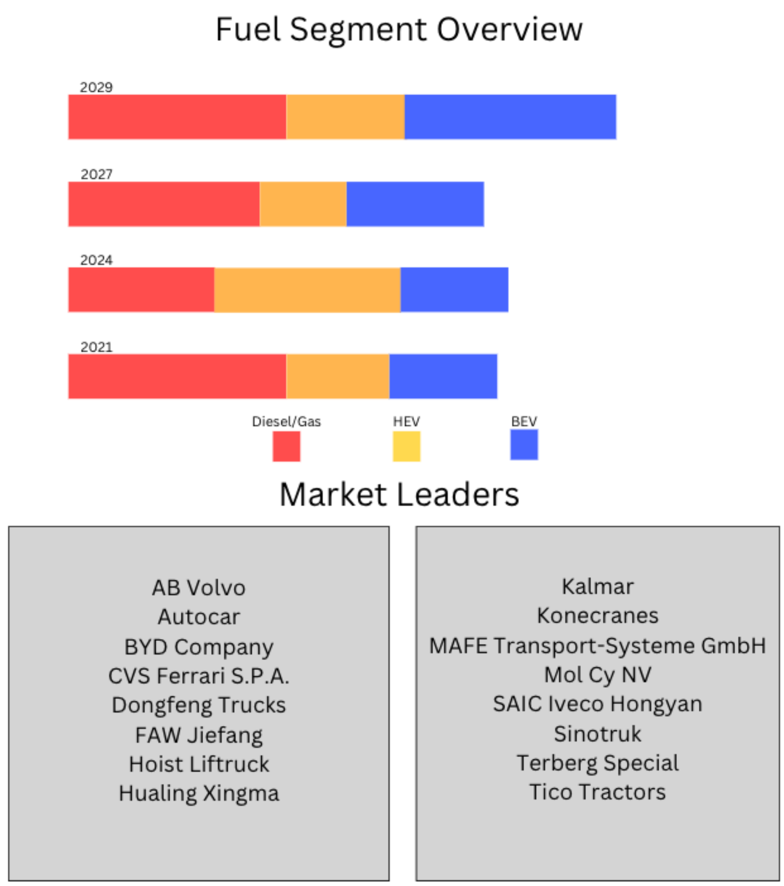
[4] **Source**: 2019 AECOM, 2019 Tetra Tech, 2017 CAAP, 2022 Northwest Seaport, 2022 ICCT, 2022 NREL"

[5] Fuel costs derived from current commercial quotes specific to the Port of Hueneme region for various fuel types. Confirmed with local suppliers under the pretext of large scale commercial offtake agreement. Time period: First quarter 2023, Jan - Feb.

Figure 1.9: (UTR Fuel Segment Overview)



Source: "Terminal Tractor Market - Global Industry Analysis and Forecast 2029." *Maximize Market Research*

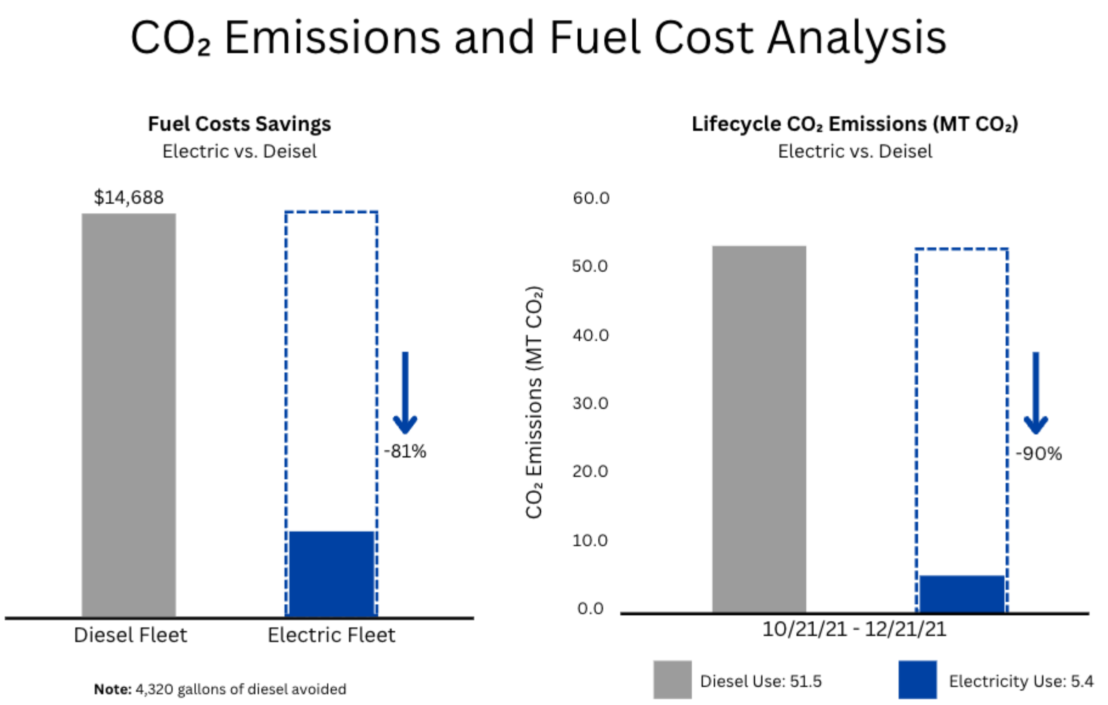
Battery Electric Powered Yard Tractors

Battery-electric technology is the most developed zero emission technology offered today for the UTR market. Currently available from several OEMs as early commercial products, battery electric UTRs are well on their way to full commercialization and maturity. There are three CHE OEM's selling battery-electric yard tractors certified by CARB and thus eligible for incentive funding through California's Clean Off-Road Equipment Project (CORE). The three models available are the Kalmar Ottawa T2E 4x2, the BYD 8Y and the Orange EV T-Series. OEM's TICO and Autocar are introducing battery-electric offerings to the market. Battery-electric UTRs are presently at a CRI of 2-3, experiencing growing utilization on a commercial trial and expanded basis.

Expected to reach TRL 9 and CRI 6 before 2024, battery-electric UTRs are in service in multiple port terminals throughout the globe and offer a viable alternative to diesel within the current planning horizon. Many demonstration projects were delayed due to Covid 19, but several projects have produced initial findings for consideration. The 2021 Cargo Handling Equipment Feasibility Assessment Report released by the San Pedro Bay Ports (SPBP) shared feedback from marine terminal operators operating battery-electric yard tractors. Operator feedback stated success in completing single shifts, but two shift operations involving 16 hours or more of run time per day have not been successfully demonstrated.

Red Hook Container Terminals Port Newark, New Jersey deployed 10 BYD units. Their initial operating data recorded an 81% reduction in fuel costs and a 90% decline in C02 emissions with 100% uptime (see chart below).

Figure 1.10: (C02 Emissions & Fuel Cost Analysis)



Source: *Redhook Container Terminal*

The Port of Hueneme deployed two Kalmar units as part of a $3 million USD Zero- and Near Zero Emission Freight Facilities (ZANZEFF) grant sought in partnership with the Port of Los Angeles (POLA). Data is currently being collected and analyzed by National Renewable Energiy Laboratory (NREL). During the deployment of the two charging points, additional conduit was laid to support the future adoption of ten additional units.

Figure 1.11: (Battery Electric UTRs at the Port of Hueneme)

Stevedoring Services of America (SSA) reported in 2021 they have electrified 64% of their CA fleet operating at Matson terminals to the effect of 38 total eUTRs. These units were produced in partnership between Kalmar and Transpower and offset an estimated 152,000 gallons of diesel/year (4,000 gallons/unit) resulting in a total CO2 reduction/yr of 1,533 MT (35MT/unit). 33 units were deployed in the Port of Long Beach and an additional 5 units in the Port of Oakland. This constituted the largest global deployment of electric yard tractors to-date and was 90% funded by CARB[6].

Hydrogen Fuel Cell Powered Yard Tractors

While progress is being made, fuel cell electric yard tractors are behind commercialization and technical development than battery electric alternatives. At a TRL of approximately 7 and CRI of 1-2, first generation test units are rolling out in several locations. As advancements are made in other heavy-duty off-road applications and Class 8 trucking, these developments are translating to increasing maturity in

[6] **Source:** "SSA Sustainability Report FYE 2021." *SSA Marine*

MD/HD market. In some cases, capacity constraints limiting EV charging deployments have led some port operators to consider hydrogen as an increasingly attractive alternative.

Atena is working in partnership with Ballard to develop its yard tractor, which will be put into service at the Valencia Terminal Europa in Spain for a two-year test period. Deployed in the greater context of the H2 Ports initiative, the unit is expected to be able to perform at least a six-hour shift and store an estimated 12kg of hydrogen at 350 bar along with 25kWh in on-board battery storage.

Figure 1.12: (Atena//Ballard - Hydrogen UTR Development)

Source: "The Hydrogen Terminal Tractor Within The Framework of The H2PORTS Project is in Full Development." *Hydrogen Central*

In 2019 Toyota tested its yard tractor prototype called "UNO" with Fenix Marine Services in the POLB. The UNO unit utilized the same fuel cell from the Mirai and Project PORTAL electric semi-truck prototypes. The test period was 2.5 hours, though the configuration was not optimized to maximize energy storage; additional tank capacity can easily be added in future models.

Figure 1.13: (Toyota UNO - Hydrogen UTR)

Source: "Toyota and Fenix Demonstrate First Hydrogen Fuel Cell Electric UTR." *Toyota USA Newsroom*

Ongoing development will be needed to support larger volumes of onboard storage at higher pressures (up to 700 bar) and improve endurance. Further advancements in fueling technologies to support higher flow rates and fill volumes will also be needed to support these units in operation beyond pilot deployments.

Cost Considerations

A recent AECOM report examining the feasibility of zero mission cargo handling equipment explored the capital cost of diesel versus battery-electric UTRs. In 2019 a new diesel yard tractor will cost $115,000. With 12% tax and fees included, the new diesel UTR costs approximately $129,000 to purchase. A new off-dock electric yard tractor currently costs about $274,000 including tax but with a CORE voucher the purchase price can be reduced by 80%. This yields a voucher value of $104,000 in 2019, for a net retail price of $170,000 compared to $129,000.

Source: AECOM (2019) Zero-Emission Cargo-Handling Equipment Feasibility Assessment

Figure 1.14: (Capital Expense for Utility Tractor Rigs)

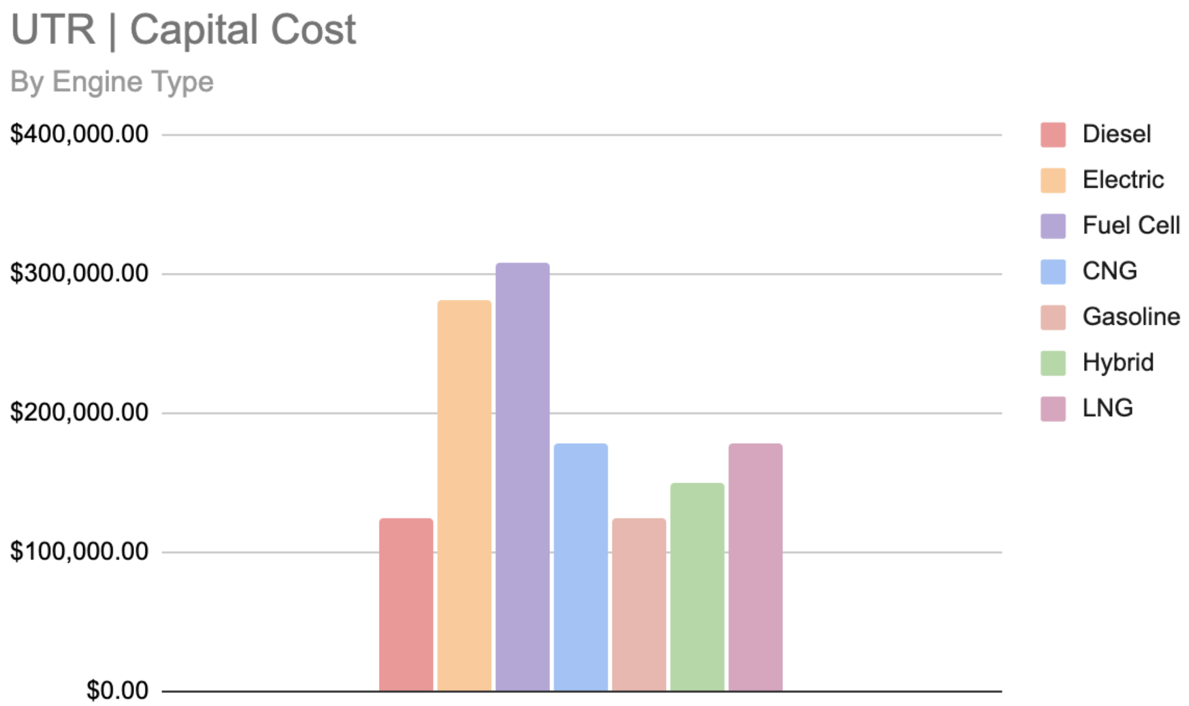


Figure 1.15: (Annual Fuel Expense for Utility Tractor Rigs)

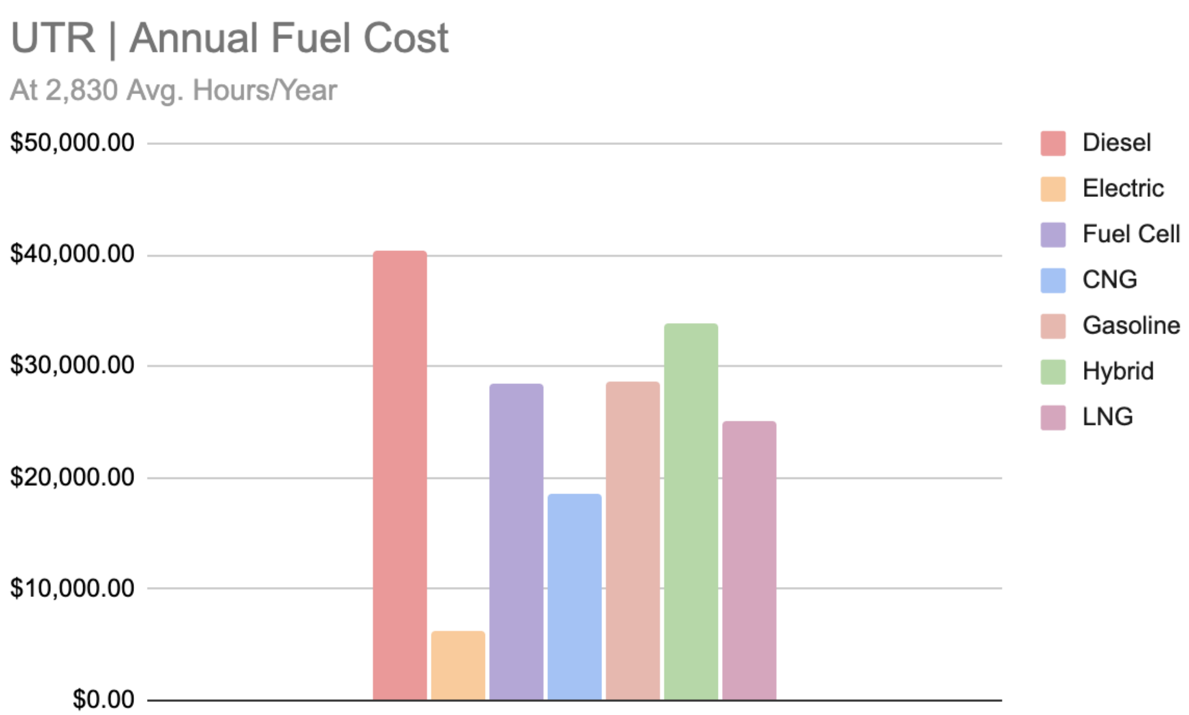
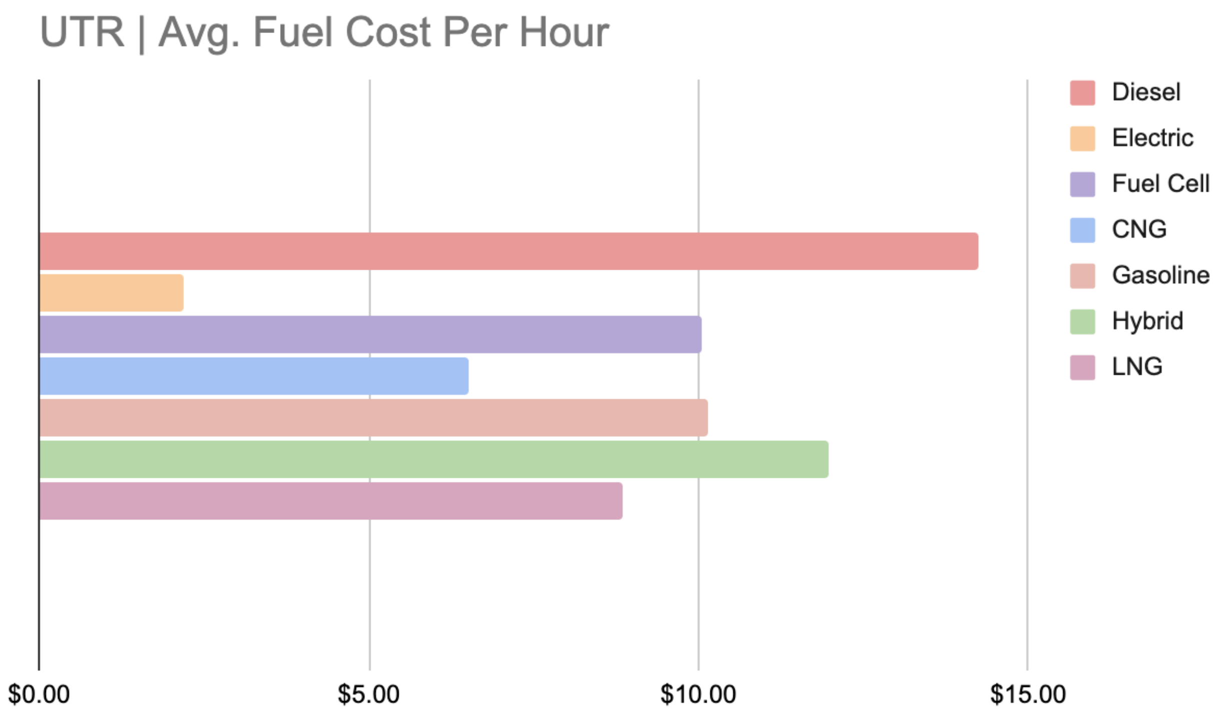


Figure 1.16: (Average Fuel Cost Per Hour for Utility Tractor Rigs)



<u>Mobile Harbor Crane Overview</u>

Mobile harbor cranes are a highly mature segment with over 10 established OEM's providing equipment to the market. Mobile harbor cranes come in several configurations, with the most common being a gantry-based configuration. Due to the variability of equipment this report will address the equipment category in general terms with an emphasis on technologies most relevant to the equipment in the Port of Hueneme's inventory. The Port of Hueneme listed three Liebherr mobile harbor cranes in its inventory that support container and bulk cargo operations on its south terminal. The Port also listed two truck mounted, lattice boom cranes from Link-Belt in its inventory.

Mobile harbor cranes as a category of CHE are one of the more mature CHE segments when it comes to commercially available ZE and NZE alternatives. Hybrid-electric models are at a TRL of 9 and CRI of approximately 6. All-electric models are similarly at a TRL of 9, with a CRI of approximately 6. Multiple OEM's currently offer commercially available models in various configurations; however, we will focus on two that offer models most similar to the cranes currently in use at the Port of Hueneme, Liebherr and Konecranes. Fuel cell mobile harbor cranes are presently at a TRL of 5 and CRI of 2, with limited trials and development to-date. Due to commercial availability of fully electric cranes supported by shore power, it is likely that further R&D on alternative fuel types will be halted or limited by comparison to all-electric pathways.

All-Electric Mobile Harbor Cranes

In January 2022 the Port of San Diego's Board of Commissioners authorized an approximately $14 million USD purchase for 2 all-electric, battery-supported cranes from a Germany based OEM, Konecranes. The Gottwald Generation 6 Mobile Harbor Cranes are expected to go into operation sometime in mid 2023, marking the first North American deployment despite their commercial availability as of 2021.

Figure 1.17: (All-Electric Mobile Harbor Crane Rendering Port of San Diego)

Source: "Purchases All-Electric Mobile Harbor Cranes, First in North America | Port of San Diego." *Port of San Diego*

In 2021 Euroports Germany initiated an order for a LPS 420 E, Liebherr's all-electric portal crane first launched in 2018[7]. The all-electric gantry crane is designed to be plugged into the Port's electrical infrastructure supporting all crane movements (luffing, lifting, slewing and traveling) by electric motors rather than hydraulics. The LPS 420 E has a maximum lifting capacity of up to 124t and up to a 48m outreach. While there have been several deployments of the LPS 420 E all-electric portal cranes to customers internationally the Euroports Germany unit is now the first in Europe. Liebherr also offers the option to integrate energy storage to take advantage of regenerative energy and mitigate peak-loads.

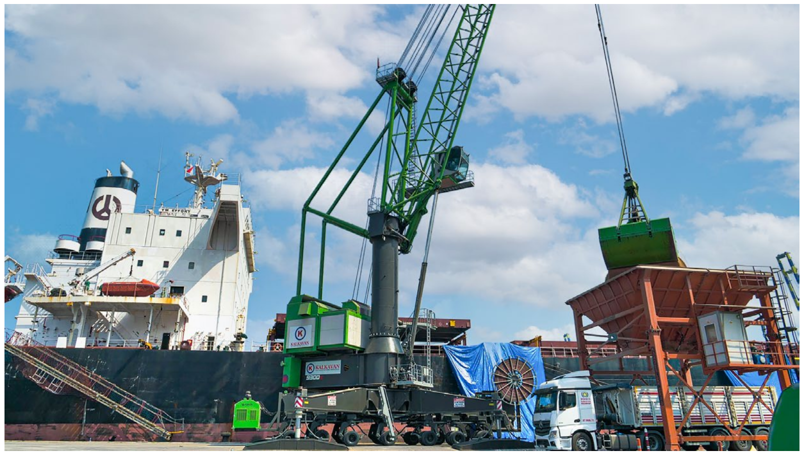
Figure 1.18: (Euroports Liebherr LPS 420 E)

Source: "Euroports invests in emission-free LPS 420 E." Liebherr

[7] **Source:** "Euroports Germany to Add a Liebherr LPS 420 E Portal Crane at the Rostock Overseas Port – Heavy Lift News." *Heavy Lift News*

In 2019 Sennebogen finished commissioning the 9300 E mobile harbor crane at the Port of Iskenderun. The 9300 is capable of a 90t load and has a 615 kW electric motor installed that powers work movements.

Figure 1.19: (Sennebogen Mobile Harbour Crane with Electric Drive)



Source: "SENNEBOGEN 9300 E mobile harbor crane with electric drive for bulk cargo handling in the port of Iskenderun." *SENNEBOGEN*

Hybrid-Electric Mobile Harbor Cranes

An order was placed in February of 2022 for a new, eco-efficient Generation 6 Konecranes Gottwald Mobile Harbor Crane, to be operated by Oy M. Rauanheimo Ab (Rauanheimo) in the Port of Röyttä Finland. The crane was delivered in July of 2022 and offers an unplugged operation off its onboard stage V compliant diesel genset, as well as a plug-in option supported by the harbor's main power supply.

Figure 1.20: (Hybrid-Electric Mobile Harbor Crane at the Port of Röyttä)

Source: "Konecranes hands over first Generation 6 Mobile Harbor Crane in Finland." *Port Technology*

In July 2019 the Port of Hueneme announced the arrival of the base of its new hybrid mobile harbor crane. The crane is one of the listed Liebherr mobile harbor cranes in the Port's inventory and part of a $3 Million ZANZEFF grant with $7 million additional investment by stevedoring company Ports America. The crane can operate on diesel or grid power affording additional operational flexibility.

Figure 1.21: (Base of new hybrid mobile harbor crane arrives on board the NYK Line Cassiopeia Leader)

Source: "Port Welcomes First Zero Emission Crane." *Port of Hueneme*

Figure 1.22: (Capital Expense for Mobile Harbor Crane)

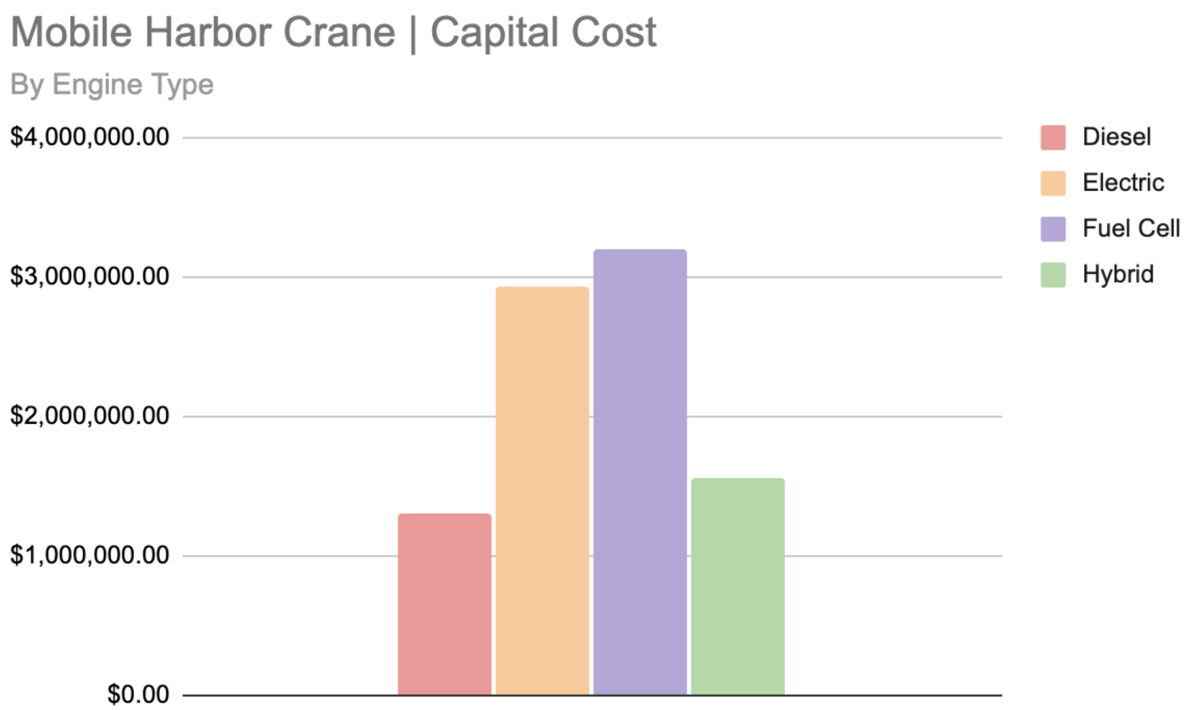


Figure 1.23: (Annual Fuel Expense for Utility Tractor Rigs)

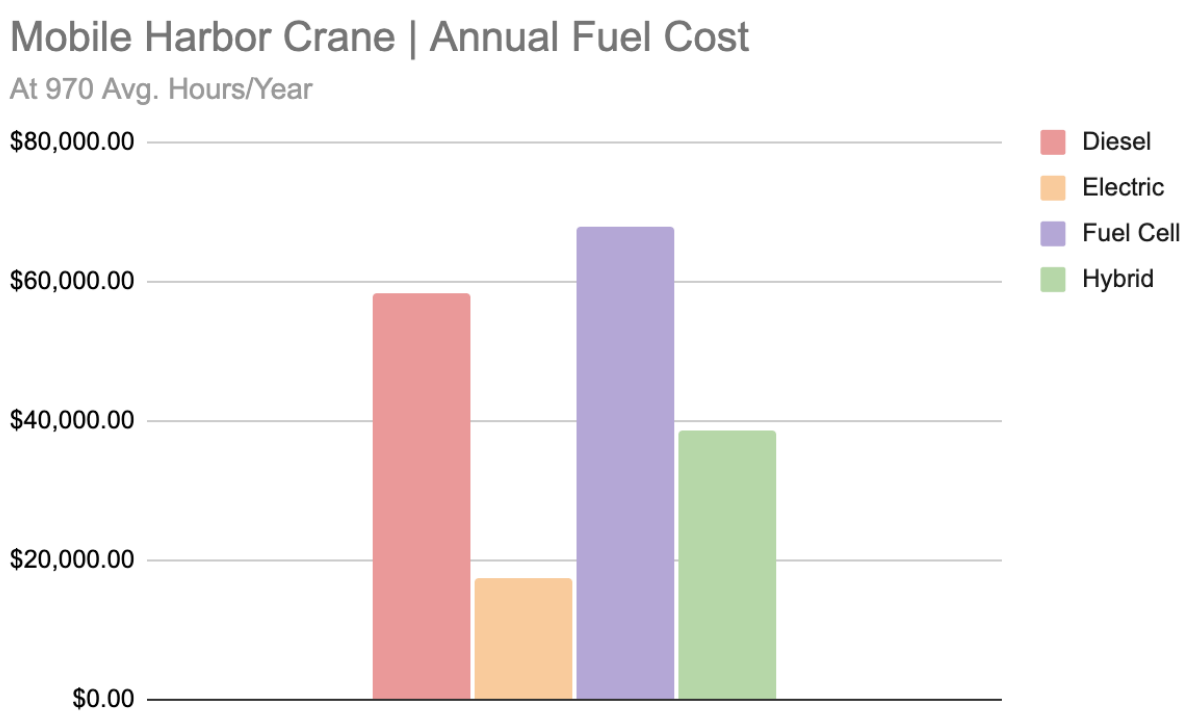
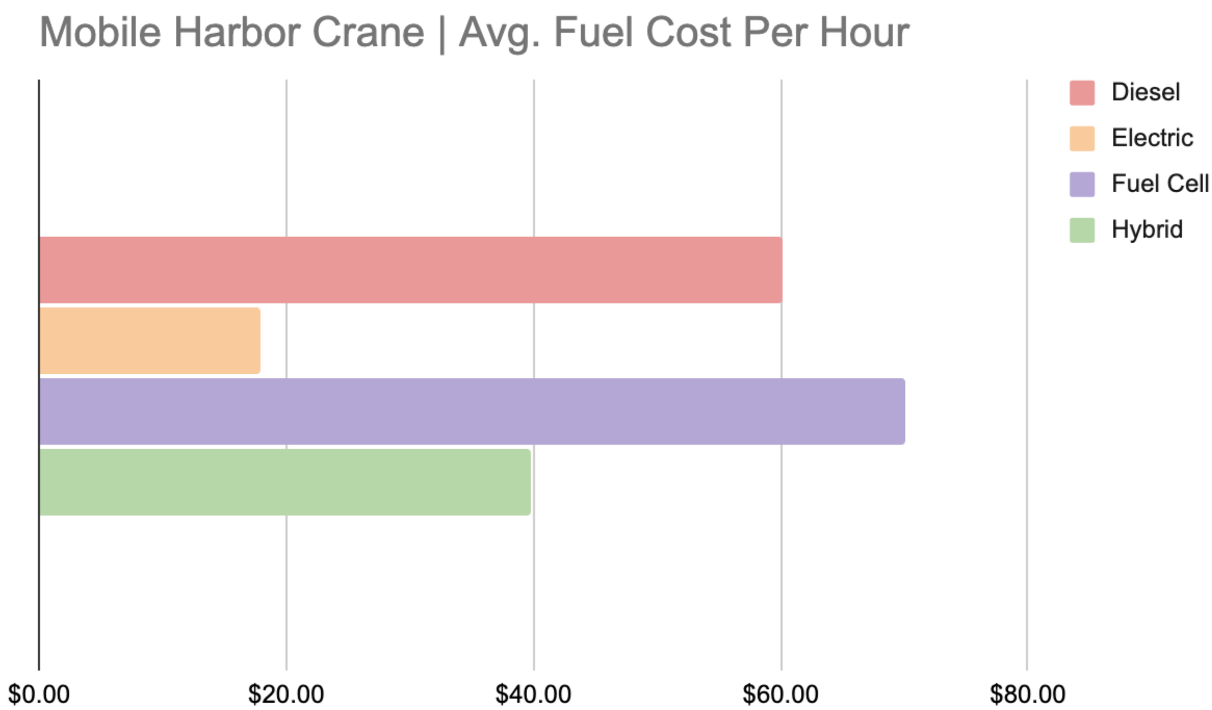


Figure 1.24: (Average Fuel Cost Per Hour for Mobile Harbor Cranes)



<u>Container Handler Overview</u>

The Container Handler market is a highly mature segment with over a dozen OEM's providing equipment to the marketplace in several configurations. Container handlers are typically distinguished by their ability to handle loaded vs. empty containers as well as their ability to stack containers multiple rows deep vs. in a single row. The Port of Hueneme reported three diesel powered Hyster Reach Stackers in its inventory, which will be the focus of this report. This report will also address developments in laden container handlers, also referred to as "Top Handlers," given advancements in technical and commercial maturity of the Reach Stacker market are correlated.

Due to the intense duty cycle, movement and high vertical stacking of fully loaded containers, container handlers are behind other equipment segments such as UTRs and mobile harbor cranes in their progress towards commercial and technical readiness. Empty container handlers are the exception, with commercially available electric alternatives available today due to the simpler technical and operational requirements.

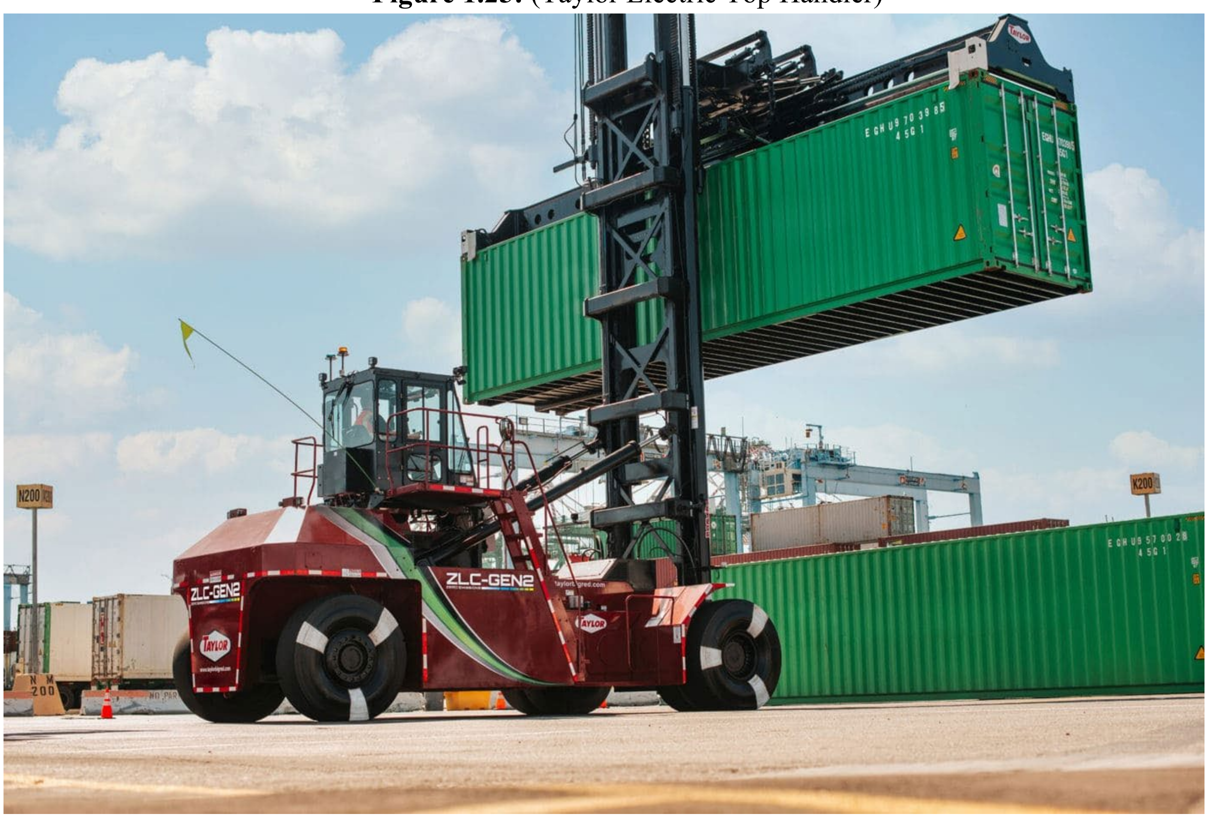
Most container handlers are powered by Diesel with moderate progress towards the development of ZE and NZE alternatives, specifically in the last 5 years. Battery electric and hybrid alternatives are the most mature in development at a TRL of 8 and 7 respectively and a CRI of approximately 3. Hydrogen fuel cell (HFC) alternatives are at a TRL of 6 and CRI of 1, with several early pilot projects at various stages in development. Developments towards viable hybrid alternatives, while dating as far back as 2013, are not likely to see significant additional advancement as ZE alternatives get prioritized. LNG alternatives have been investigated but never reached maturity beyond TRL 5 or 6, despite a prototype reach stacker being developed and tested in Italy by Kalmar back in 2014. Multiple demonstration projects are currently underway for ZE container handlers and are expected to conclude some time in 2023-2024. The conclusion of these initial trials will result in a drastically improved operational dataset on the performance of pre-commercial units. It is expected that HFC alternatives will see rapid advancement in the next two years as OEM's struggle to meet the intense duty cycle requirements of laden container handlers with batteries alone due to the energy intensity of the operation. Additionally, grid capacity issues and long lead times for expanding utility service to support charging will have an influence on operator technology selection.

Battery Electric Container Handlers

Battery Electric Container Handlers are at a TRL of 8 and CRI of 3, with the completion of successful demonstration projects and testing, though market adoption is limited.

In 2018 Taylor initiated a project to develop four electric top handlers for use at the SPBP, with funding support from the Ports and several CA agencies (CEC, CARB & SCAQMD). The project sought deployment for testing in 2019 and was delayed due to issues related to certification of the charging infrastructure. Despite these delays, the four units became operational in 2020 and successfully performed an equivalent work shift to that of a diesel unit. The units were data logged and performance was analyzed by the University of California Riverside.

Figure 1.25: (Taylor Electric Top Handler)



Source: "Electric Equipment for Industrial Material Handling." Proterra

Hyster has made investments towards the development of ZE top handler and reach stacker alternatives. Hyster's first electric top handler deployment was in POLA and is powered exclusively by lithium-ion batteries. The unit is reported to be designed for operations with smaller fleets, working a medium duty cycle in an area with sufficient electrical infrastructure to support fast charging. For operations with a heavier duty cycle and larger fleets, Hyster is developing a model with a fuel cell to charge the on-board batteries for increased endurance.

Figure 1.26: (Hyster ZE Container Handlers)

Source: "Hyster® Electric and Fuel Cell Electric Container Handlers Make Progress." *FuelCellsWorks*

Sany has deployed several electric reach stackers in China, with a recent delivery of their Lithium-ion battery-powered unit to Auckland in late 2022. The on-board battery pack supports all-electric operation and has a capacity of 269 kWh. The unit is also reported to have an independent diesel power supply unit to serve as a range-extender if charging is unavailable.

Figure 1.27: (Sany Electric Reach Stacker)

Source: Champion, Vincent. "WorldCargo News - News - Sany electric reach stacker." World Cargo News

Kalmar currently offers an electric reach stacker for marine terminal operators (MTOs). In 2019 they announced an initial pilot deployment in Germany as a part of the Venlo logistics hub, scheduled for 2021.

Figure 1.28: (Kalmar Electric Reach Stacker)

Source: “Kalmar Unveils First Electric Reachstacker.” *Port Technology*

Hydrogen Fuel Cell Container Handlers

HFC container handlers are at a TRL of 6 and CRI of 2. While less developed than battery-electric alternatives, rapid progress is being made to support longer operation in heavier duty cycles where battery alternatives are not sufficient. At present Hyster has made the most public progress in developing hydrogen fuel cell based container handlers for the marketplace, but it is expected that other OEM's will announce pilot projects with similar prototype offerings over the next two years.

As part of the H2 Ports initiative in Europe, a hydrogen reach stacker is under development for deployment and testing at the MSC Terminal in the Port of Valencia. The unit is designed to support a full day of operation and be refueled in under 15 minutes. The fuel cell system mitigates what would be a prohibitively large battery pack to support a full day of operation, more in line with capabilities of diesel versions.

Figure 1.29: (Rendering of Hyster Hydrogen Reach Stacker)

Source: *The hydrogen Reach Stacker within the framework of the H2PORTS project is in full development at Hyster - Valenciaport*

A hydrogen fuel cell powered Top Handler manufactured by Hyster is announced to be deployed at the Fenix Marine Services at POLA. Like their reach stacker, the fuel cell alternative is designed to support longer continuous operation and eliminate the need to stop or refuel mid-shift. The unit is powered by two 45 kW Nuvera fuel cells along with lithium-ion batteries.

Figure 1.30: (Hyster Hydrogen Top Handler)

Source: Currie, Charlie. "Hydrogen-powered top-pick container handler trials at the Port of Los Angeles." *H2 View*

Figure 1.31: (Capital Expense for Container Handlers)

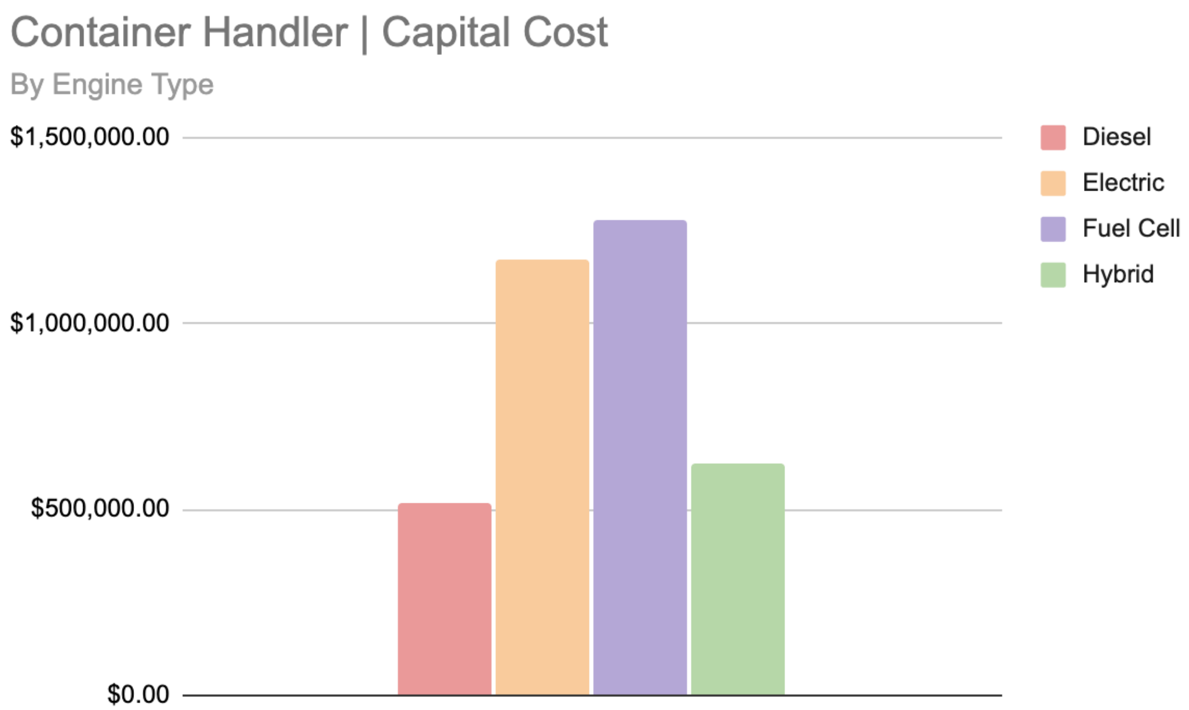


Figure 1.32: (Annual Fuel Expense for Container Handlers)

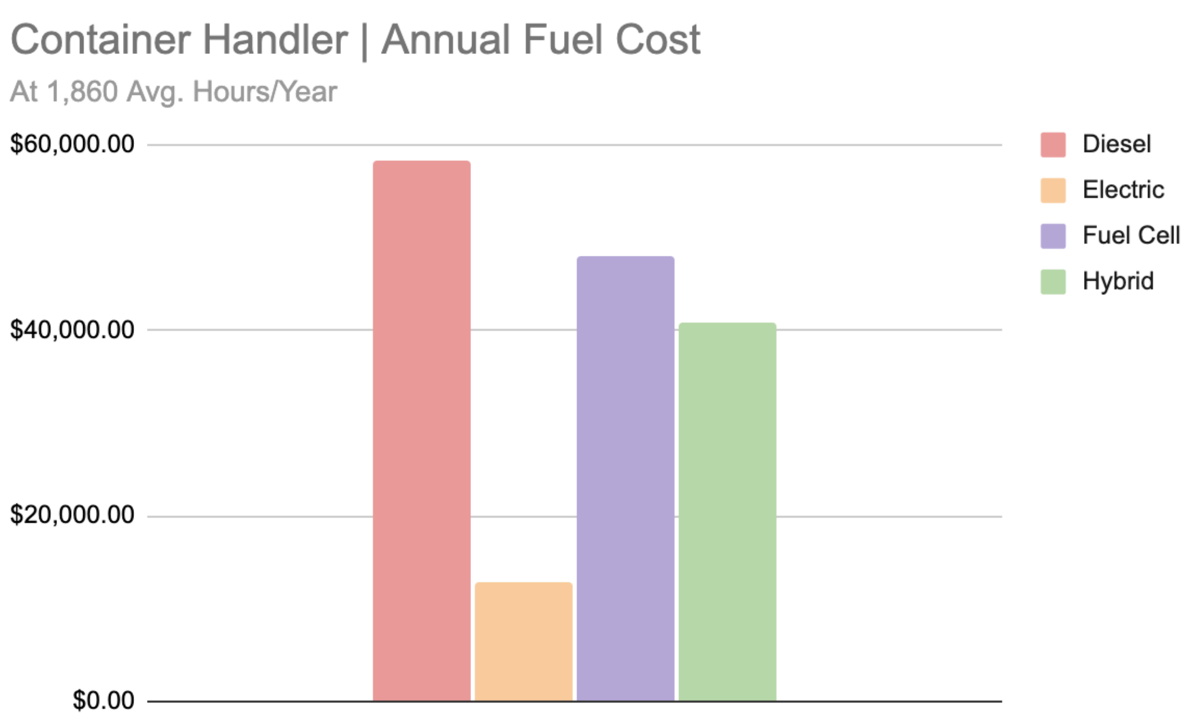
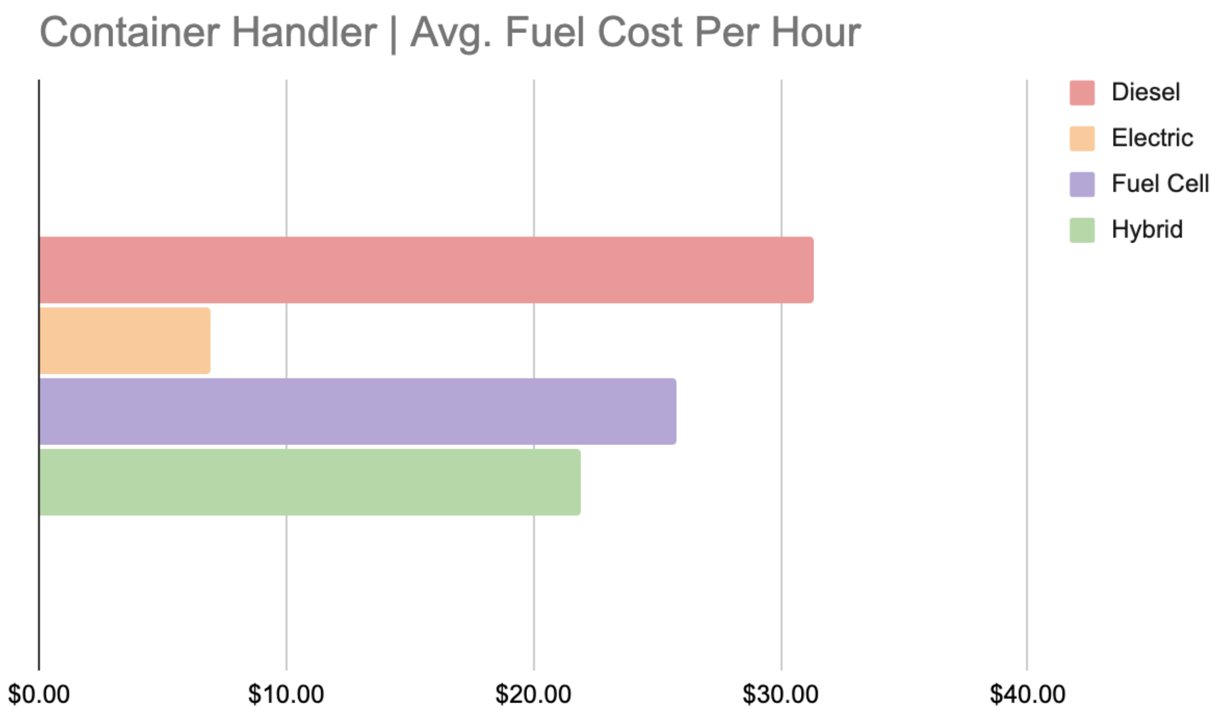


Figure 1.33: (Average Fuel Cost Per Hour for Container Handlers)



Ocean Going Vessels (OGV's)

The primary emission control methods the Port has influence over for OGVs is grid power based Shore Power, and in the future potentially bonnet capture and treatment systems. The Port has no direct influence over primary propulsion technologies and fuels utilized by the OGVs. These emissions control technologies and their impact on Port infrastructure will be analyzed in the following infrastructure section of this report.

Harborcraft

The two tugboats operating out of the port plan to deploy Tier 4 engines as the best commercially available emissions control technology during an upcoming repower. The vessels will not require a repower for some time allowing further commercialization of ZE alternatives.

Charging and Fueling Technology Evaluation

Purpose

To evaluate and determine the best mix of charging and fueling technologies to support the Port of Hueneme.

Background – Current Fueling Infrastructure

TracTide supplies all current fuels for visiting vessels via pipeline. TracTide does offer renewable diesel as an option, but it is also supplied via pipeline at each berth. Current MTO's use mobile diesel fueling direct to units.

Key Considerations

a. The port collaborates closely with partners but does not have direct control over equipment selection decisions unless they elect to own and lease equipment.

b. The port plays a role in providing the infrastructure needed by tenants.

c. The port has the ability to directly influence adoption through enabling infrastructure availability.

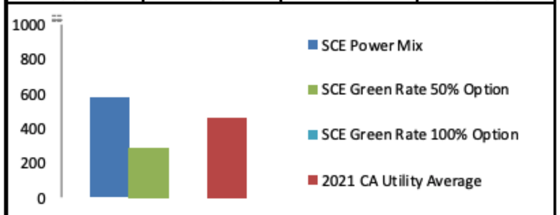
d. Electricity should be supplied via fixed electrical infrastructure. Using anything but underground infrastructure will impact the flexibility of port operations and reduce commercial growth opportunities, as the land space is needed for potential vertical expansion. It is also recommended that any solar initiatives be roof mounted or mounted to long-standing storage or real estate assets to avoid any impact on future POH commercial expansion.

e. Electricity is currently supplied by Southern California Edison and electrical capacity is severely limited. Grid power will become increasingly renewable over time.

Figure 2: (2021 Power Content Labels)

2021 POWER CONTENT LABEL
Southern California Edison
www.sce.com

Greenhouse Gas Emissions Intensity (lbs CO_2e/MWh)			
SCE Power Mix	SCE Green Rate 50% Option	SCE Green Rate 100% Option	2021 CA Utility Average
580	290	0	456



Energy Resources	SCE Power Mix	SCE Green Rate 50% Option	SCE Green Rate 100% Option	2021 CA Power Mix
Eligible Renewable[1]	**31.4%**	**65.7%**	**100.0%**	**33.6%**
Biomass & Biowaste	0.1%	0.0%	0.0%	2.3%
Geothermal	5.7%	2.8%	0.0%	4.8%
Eligible Hydroelectric	0.5%	0.3%	0.0%	1.0%
Solar	14.9%	57.5%	100.0%	14.2%
Wind	10.2%	5.1%	0.0%	11.4%
Coal	**0.0%**	**0.0%**	**0.0%**	**3.0%**
Large Hydroelectric	**2.3%**	**1.1%**	**0.0%**	**9.2%**
Natural Gas	**22.3%**	**11.1%**	**0.0%**	**37.9%**
Nuclear	**9.2%**	**4.6%**	**0.0%**	**9.3%**
Other	**0.2%**	**0.1%**	**0.0%**	**0.2%**
Unspecified Power[2]	**34.6%**	**17.3%**	**0.0%**	**6.8%**
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**
Percentage of Retail Sales Covered by Retired Unbundled RECs[3]**:**	**3%**	**2%**	**0%**	

[1]The eligible renewable percentage above does not reflect RPS compliance, which is determined using a different methodology.

[2]Unspecified power is electricity that has been purchased through open market transactions and is not traceable to a specific generation source.

[3]Renewable energy credits (RECs) are tracking instruments issued for renewable generation. Unbundled renewable energy credits (RECs) represent renewable generation that was not delivered to serve retail sales. Unbundled RECs are not reflected in the power mix or GHG emissions intensities above.

For specific information about this electricity portfolio, contact:	**Southern California Edison** **1-800-655-4555**
For general information about the Power Content Label, visit:	http://www.energy.ca.gov/pcl/
For additional questions, please contact the California Energy Commission at:	Toll-free in California: 844-454-2906 Outside California: 916-653-0237

Source: *Southern California Edison - SCE*

Methodology

After reviewing all available research on CHE equipment and related fueling infrastructure availability, the Zero Emission Advisors (ZEA) team discovered that both the "2017 San Pedro Bay Ports Clean Air Action Plan – Framework for developing feasibility assessments" and the "2021 Feasibility Assessment for Cargo-Handling Equipment (CHE)" align with CEC guidelines and provide a sturdy framework and initial dataset to create a forward-looking blueprint for the Port of Hueneme.

As with the 2021 Feasibility Assessment, the following five parameters were applied to collectively assess overall feasibility for each of the charging and fueling technologies, per the 2017 Framework:

1. Commercial Availability
2. Technical Viability
3. Operational Feasibility
4. Infrastructure Availability
5. Economic Workability (Key Economic Considerations and Issues)

In this Assessment, tables present ratings regarding the feasibility level of different fuel-technology platforms for CHE, as assessed presently. The ratings are based on five key feasibility parameters: Commercial Availability, Technical Viability, Operational Feasibility, Infrastructure Availability, and Economic Workability. The tables display Bar Rating in quarter increments for each parameter and the individual criteria that define them. These ratings range from "little/no achievement" of a particular feasibility criterion to "fully achieved" presently. It should be noted that the Bar ratings are not intended to convey exact percentages of achievement for each feasibility criterion. Rather, they summarize the relative degrees of progress towards full or near-full achievement.

Table 8: Example Technology Table

Technology	Fuel Technology	Fuel Interface	TRL - Rating	CRI - Rating	Technical Viability	Operational Viability	Infrastructure Availability	Economic Workability
Example Technology	Battery Electric	Manual	6	2	25%	50%	75%	100%

Figure 2.1: (Technology Bar Rating Example)

0%	Little/No Achievement
25%	Partial Achievement
50%	Anticipated Halfway Point
75%	Major Achievement
100%	Fully Achieved

When reviewing each technology for each of the key feasibility parameters, the following criteria were applied and evaluated:

Evaluation Criteria

As with MD/HD equipment, TRL & CRI (See **Figure 1.8:** (TRL & CRI) on Page 21), along with other key criteria were used to evaluate potential infrastructure technologies.

Technical Viability Criteria:

- Technology performance equivalent to the in-use equipment
- Regulatory and jurisdiction of authority approval for commercial deployment
- Technology meets or exceeds performance metrics for the port.
- Technology is currently manufactured at comparable rates as in-use equipment.
- Technology carries similar warranty support as in-use technology.

Operational Viability Criteria:

- Basic Performance
- Fuel Economy and Endurance
    - Specifically, the durability of the component equipment was reviewed.
- Speed and Frequency of Fueling / Charging
- Operator Comfort, Safety, and Fueling Logistics
- Availability of replacement parts and support for Maintenance and training

Infrastructure Availability Criteria:

- Time required for fueling/charging.
- Infrastructure location and footprint
- Infrastructure buildout timeline

- Regulatory and Compliance Standards Exist

Economic Workability Criteria:

- Initial CAPEX
- Initial OPEX
- Infrastructure CAPEX
- Infrastructure OPEX
- Potential workforce development efforts (training, certification) necessary to make the transition.
- Existence and sustainability of financing to improve cost of ownership, cost recovery or financial performance.

Technology Evaluations

Technology Reviewed and Determined Not to be Feasible

Table 9: Unfeasible Technology Evaluation

Technology	Fuel Technology	Fuel Interface	TRL - Rating	CRI - Rating	Technical Viability	Operational Viability	Infrastructure Availability	Economic Workability
Robotic Chargers	Battery Electric	Manual	6	2	25%	25%	25%	25%
Mobile Chargers	Battery Electric	Manual	8	3	25%	25%	25%	25%
Individual Solar Chargers	Direct Solar	Manual	9	6	25%	25%	25%	25%
Overhead Catenary Systems	Grid Tied Electric	Automated	9	6	60%	25%	100%	100%
Curbside Chargers	Grid Tied Electric	Manual	9	6	25%	25%	25%	25%
Streetlamp Chargers	Grid Tied Electric	Manual	6	5	25%	25%	25%	25%
Interoperable MD/HD Chargers	Grid Tied Electric	Manual	2	1	0%	0%	0%	0%
Autonomous Garages	Grid Tied Electric	Automated	9	4	25%	25%	25%	25%
Vehicle-to-grid Integration	Grid Tied Electric	Manual	4	1	0%	0%	0%	0%

- **Robotic/Mobile EV Chargers**
    - Not available on a commercial scale

Figure 2.2: (EV Safe Charge Ziggy Portable Charger)

Source: *EV Safe Charge | Electric Vehicle Charging Stations*

Figure 2.3: (TU Graz Autonomous Charging Robot)

Source: Randall, Chris. "TU Graz presents autonomous charging robot (video)."

Figure 2.4: (Volkswagen EV Charging Robot Concept)

Source: Ackerman, Evan. "Volkswagen's Concept Robot Would Bring Mobile EV Charging to Any Garage."

Individual Solar Chargers

- Did not meet basic performance needs for MD/HD charging metrics and is currently being developed primarily for light-duty vehicles.

Figure 2.5: (Envision Solar EV Charger)

Source: Davies, Alex. "An Easy-to-Install Solar Charger That Juices Your EV Off the Grid." *WIRED*

- **Overhead Catenary Systems (OCS)**
  - The technology is very mature and meets or exceeds several performance criteria. The technology is not being considered because current port operations require tremendous flexibility, and the OCS system, once deployed, will not support the needed flexibility[8].
- **Curbside/Streetlamp Chargers**
  - Did not meet basic performance needs for MD/HD charging metrics and is currently being developed primarily for light-duty vehicles

Figure 2.6: (Blink Charging Street Light / Utility Pole Charger)

Source: "Blink Charging Introduces New Product Allowing Street Light or Utility Pole to Become a Charging Destination." *Blink Charging*

- **Interoperable MD/HD chargers**

[8] **Source:** Siemens Industry Inc. *SCAQMD Contract 14062 FINAL REPORT; Construction of a 1 Mile Catenary System and Develop & Demonstrate Catenary Hybrid Electric Trucks*

- Did not pass commercial availability as there is significant regulatory and compliance work remaining.
    - New federal rule effective March 30, 2023 will need to be reviewed and adopted by each jurisdiction with authority.[9]

- **Autonomous garages**
  - Core components of the technology are proven and commercially available however, the integration of charging and fueling technologies within the autonomous garage space is still in very early stages and will require significant regulatory and compliance work to be completed before it reaches technical viability for an MD/HD commercial application.
  - Determined not suitable due to desire to avoid automation in support of local labor.\

- **Vehicle-to-grid integration**
  - Did not pass commercial availability as there is significant regulatory and compliance work remaining. Notice on CEC website:
    - "To responsibly integrate these vehicles into California's electricity system, the CEC continues to prepare for widespread VGI through funding solicitations, planning and analysis, reporting, and EV charger deployment block grants."
    - Status of CA VGI can be tracked via the CEC website.[10]:

Electric Technology

Technology: DC Fast Charging

Key Findings:

The average CAPEX for DCFS will exceed $100K per charger well into 2030. The 150kW DCFS will satisfy most charging requirements during the Hoot shift, except for the 1MW batteries needed for the top handlers. The 150kW DCFS should be the commercial norm for most ports' CHE requirements, and a larger DCFS will only be needed if Port Partners select battery-powered Top Handlers.

Table 10: DC Fast Charging Assessment

Technology	Fuel Technology	Fuel Interface	TRL - Rating	CRI - Rating	Technical Viability	Operational Viability	Infrastructure Availability	Economic Workability
Direct current fast charging	Grid Tied Electric	Manual	9	6	95%	100%	100%	100%

[9] **Source:** "National Electric Vehicle Infrastructure Standards and Requirements." *Federal Register*
[10] **Source:** "Vehicle-Grid Integration Program | California Energy Commission." *California Energy Commission*

Assessment Table Review:

- DCFS meets or exceeds all assessment criteria, and only a small amount of progress is still needed regarding a larger than 150kW charger.

Technology Deployment Examples:

Port Advanced Vehicle Electrification, PAVE Project (Port of Long Beach)[11]

Figure 2.7: (Cavotec Megawatt Charging System (MCS)

Source: "Megawatt Charging System (MCS)." *Cavotec*

Technology: Wireless Inductive Charging

Key Findings:

While wireless charging has seen 98% efficiency, we only see that the technology and standard still have not been published in the level 2 charging and for 250kW to 500kW. The opportunity charging is still 5-10 years away for development and mainstream adoption. It will also be necessary for OEMs to adopt the technology as a mainstay so you can include the wireless charging equipment needed during manufacturing instead of the current deployment method of retrofit.

[11] **Source:** "Port of Long Beach awarded $8 million grant." *Baird Maritime*
Source: "Port Advanced Vehicle Electrification (PAVE) Project." *World Port Sustainability Program*

Table 10: Wireless Inductive Charging Assessment

Technology	Fuel Technology	Fuel Interface	TRL - Rating	CRI - Rating	Technical Viability	Operational Viability	Infrastructure Availability	Economic Workability
Wireless Charging	Grid Tied Electric	Inductive	8	3	45%	65%	44%	33%

Assessment Table Review:

Wireless charging is a viable technology, but hurdles will still need to be overcome in the regulatory and compliance space. The infrastructure also may pose a problem for future proofing a commercial deployment because the inductive charging unit is installed in the ground, and hard-wired electrical connection will be required. This type of installation's permanence could hamper the port operations' flexibility.

Technology Deployment Examples:

Port of Los Angeles – Power ten class-8 yard trucks (UTRs) with 125kW WAVE and Top Handlers will be powered by WAVE 250kW and WAVE 380kW system.[12]

Figure 2.8: (Example of Electric Bus & WAVE Charging Pad)

Source: Chang, Daphne. "WAVE Wireless Charging Propels AVTA to Zero-Emission Milestone - WAVE."

[12] **Source:** "Ports - WAVE." *WAVE Wireless Charging*
Source: "Advanced Infrastructure Demonstration Project." *Port of Los Angeles*

Hydrogen Infrastructure Technology

Technology: Skid Mounted Hydrogen Stations (Gaseous/Liquid)

Key Findings:

The modular skid-mounted hydrogen/EV stations allow for better operational flexibility. They should be considered a priority selection to ensure that future commercial development is not hindered by fixed location infrastructure. While the Initial CAPEX is the same as a fixed station, operational flexibility to scale with port partners as they acquire new cargo handling equipment or to support the transition from one partner to another partner with a different inventory of CHE should be considered.

Table 11: Skid-Mounted Hydrogen Stations Assessment

Technology	Fuel Technology	Fuel Interface	TRL - Rating	CRI - Rating	Technical Viability	Operational Viability	Infrastructure Availability	Economic Workability
Skid-Mounted Hydrogen Stations	Gaseous/Liquid Hydrogen	Manual	9	4	35%	40%	56%	25%

Assessment Table Review:

- Modular hydrogen stations show promise to reduce costs through manufacturing and productization efficiencies. Standardized components assembled offsite may also improve quality and reliability over field-integrated conventional stations. Appropriately designed modular stations could further shrink station footprints thanks to reduced separation distances.

  "Modular fueling stations have the compressor, hydrogen cooling block, chiller, high-pressure storage, and control electronics housed in and/or on a single container. Manufacturing and installing these components in this way reduces installation labor, allows leak and operation checking at a dedicated facility, and can potentially reduce equipment costs by enabling high volume production of standardized components."[13]

- However, modular equipment still doesn't eliminate operational barriers tied to deliverable hydrogen volumes and fuel cell equipment performance constraints. Modular equipment does not intrinsically address permitting unknowns as ports introduce hydrogen fuel.

  "While hydrogen is not a new technology, and using hydrogen as backup power is commercially available, the specific port operational requirements and the supporting component integration

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[13] **Source:** Hecht, Ethan S., et al. "Comparison of Conventional vs. Modular Hydrogen Refueling Stations, and On-Site Production vs. Delivery." *Department of Energy*

have additional work to be completed and significantly impact the technical and operational viability assessment scores."[14]

- Regulations and infrastructure to support hydrogen as an energy storage vector are still developing. Workforce training strategies still need to be fully characterized. Near-term reliance on third-party maintenance is likely until mechanics develop expertise with hydrogen technologies

- In summary, the modular configuration provides a pathway to enhance hydrogen fueling stations' economics and spatial efficiency. However, it does not inherently overcome operational limitations around fueling capacities, equipment endurance, and procedural uncertainties in these early stages of port decarbonization.

Technology Deployment Examples:

Figure 2.9: (Weeze WyRefueler)

Source: "WyRefueler." *Wystrach GmbH*

Figure 2.10: (PowerTap On-Site Methane Reformer)

[14] **Source:** 2021 SPBP CAAP Feasibility Assessment for Cargo-Handling Equipment.

Source: "PowerTap Technology." *PowerTap*

Comparison of conventional vs. modular hydrogen refueling stations, and on-site production vs. delivery -- Ethan S. Hecht, Joseph Pratt, Sandia National Laboratories[15]

Technology: Fixed Infrastructure Hydrogen Stations (Gaseous/Liquid)

Key Findings:

The fixed infrastructure hydrogen/EV stations are a mature technology already deployed in transit agencies and for local light-duty vehicles. The Initial CAPEX is in line with a modular station, but scalability will be a factor since we are utilizing already scarce real estate availability, and once built, the ability to add components and extra capacity will be greatly reduced.

Table 12: Fixed Infrastructure Hydrogen Station Assessment

Technology	Fuel Technology	Fuel Interface	TRL - Rating	CRI - Rating	Technical Viability	Operational Viability	Infrastructure Availability	Economic Workability
Installed Hydrogen Stations	Gaseous/Liquid Hydrogen	Manual	9	4	55%	45%	50%	25%

Assessment Table Review:

Conventional stations currently benefit from greater control over custom-designing equipment to meet fueling requirements in a port environment. However, this likely comes at a higher price

[15] **Source:** Hecht, Ethan S., et al. "Comparison of Conventional vs. Modular Hydrogen Refueling Stations, and On-Site Production vs. Delivery." *Department of Energy*

than future modular alternatives once we achieve manufacturing scale. Conventional Stations also face more permitting uncertainties by tackling on-site integration work.

"Notably, even for existing major OEMs, it can be a resource-intensive, costly endeavor to establish strong pre- and post-sale customer support for new-technology products that use alternative fuel/energy sources. The ability to meet this need must be continually proven."[16]

Over time, Conventional Stations expect to close the pricing gap on modular alternatives through volume equipment supply contracts, particularly once fueling performance metrics stabilize. But there is a viable pathway to overcoming these hurdles through manufacturing scale and familiarity building. The current barriers to managing delivery logistics and sub-optimal storage capacities have also received meaningful industry attention.

"Liquid hydrogen permits the evolution from compressed gas tube trailers to the next generation of equipment..." [17]

This fuel-type discussion highlights the potential for enhanced throughput capacity and delivery logistic improvements as storage and transportation technologies evolve. Early operational uncertainties faced by conventional delivered hydrogen stations will moderate over time. The flexibility of a conventional hydrogen station offers the ability to adapt to new delivery and storage solutions, which sustains long-term market competitiveness.

> "With greater industry experience and higher volume production, we anticipate the cost of modular stations to reduce in the near future. Developing stations this way may lead to better quality control and reduced maintenance requirements for hydrogen fueling stations. It is also possible to achieve more compact station footprints by modularizing the station components by building appropriate fire-rated barrier walls. Because of these potential benefits, we anticipate increasing modularization and standardization."13

Technology Deployment Examples:

hydrogen-as-a-Service™ (HaaS™) trucking pioneer, Hydra Energy, continued accelerating the adoption of hydrogen-based transportation by breaking ground on the world's largest hydrogen refueling station in Prince George, British Columbia.[18]

Comparison of conventional vs. modular hydrogen refueling stations, and on-site production vs. delivery -- Ethan S. Hecht, Joseph Pratt Sandia National Laboratories[19]

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[16] **Source:** Hecht, Ethan S., et al. "Comparison of Conventional vs. Modular Hydrogen Refueling Stations, and On-Site Production vs. Delivery." *Department of Energy*
[17] **Source:** Hecht, Ethan S., et al. "Comparison of Conventional vs. Modular Hydrogen Refueling Stations, and On-Site Production vs. Delivery." *Department of Energy*
[18] **Source:** "Hydra Energy Breaks Ground on World's Largest Hydrogen Refuelling Station for Heavy-Duty Trucks." *Hydrogen Central*
[19] **Source:** Hecht, Ethan S., et al. "Comparison of Conventional vs. Modular Hydrogen Refueling Stations, and On-Site Production vs. Delivery." *Department of Energy*

Figure 2.11: (Thousand Oaks Hydrogen Station)

Source: “Thousand Oaks.” *H2 Station Maps*

Figure 2.12: (Cal State LA Hydrogen Research Facility)

Source: “Cal State L.A. hydrogen station becomes first in California to be certified to sell fuel to the public.” *Cal State LA*

SPARC Stakeholder Engagement

Engagement Summary

As a part of producing a blueprint, the Coalition for Clean Air (CCA) and Breathe Southern California (BSC) are subcontractors on the SPARC project with the goal of engaging stakeholders to provide input on the SPARC project. BSC and CCA sought stakeholder feedback from community members, including environmental organizations, public health organizations, government agencies, elected officials, business organizations, and labor representatives.

Stakeholder engagement was offered to interested parties in numerous ways, including participation in various roundtable meetings over Zoom, in-person meetings, opportunities to provide feedback in writing, and private meetings involving representatives from BSC and CCA and stakeholders. Translation was made available at several meetings, in both Spanish and Mixteco. The stakeholder engagement process aimed to address the following key objectives:

- Establish criteria for identifying and prioritizing stakeholder groups,
- Identify strategies for effectively engaging all stakeholder groups in the SPARC project input process,
- Provide multiple opportunities and methods for stakeholders to provide input regarding the SPARC project,
- Establish iterative cycles of stakeholder engagement by identifying opportunities for ongoing feedback, and
- Encourage transparency by ensuring stakeholders are aware of and informed about the overall process, especially stakeholder engagement.

The stakeholder engagement process was driven by the following guiding questions:

- What are the needs and concerns of each stakeholder group?
- What does a zero emissions Port of Hueneme mean to each stakeholder, and why is it important?
- How does a zero emissions Port of Hueneme benefit each stakeholder group?
- What concerns and opportunities do you see in bringing zero\ emission technologies to the Port?
- What would you like to see come out of this process?

In addition, we used survey tools to ask participants at later meetings:

- What technologies are you most interested in seeing implemented?
- What outcomes do you want to see come out of a zero emission blueprint process

Broad Themes Across Stakeholder Groups

Some broad themes emerged throughout the various stakeholder engagement meetings, including:

1. The need to transition to zero emission technologies
2. Collaborative partnerships
3. Addressing the needs of the individuals who live and work in Ventura County

These broad themes were the key pillars in the stakeholder feedback, and each of these broad themes is further discussed below.

The Need to Transition to Zero Emission Technologies

A theme of the necessity of transitioning to zero-emission technologies emerged across the meetings with various stakeholder engagement groups involved in the stakeholder engagement process. The need for a transition included environmental protection, public health factors, and addressing the Port impacts beyond the physical location itself.

Environmental Benefits: Some stakeholder groups cited environmental protection as one of the reasons why the Port must transition to zero emission technologies as soon as possible. Stakeholders want to protect greenspaces, specifically community and environmental organizations stating greenspaces are "a need," not "a want." A transition to zero emissions at the Port of Hueneme would certainly bring the environmental benefits that many stakeholders advocate.

Public Health Factors: Stakeholder groups also cited public health factors as reasons why a zero emissions transition at the Port is necessary. Stakeholders believe the diesel emissions caused by the ships and trucks have a negative impact on the health of residents and workers throughout the Ventura County region. A move to zero emissions at the Port would mitigate the negative health impacts.

Holistic Approach: Many stakeholders cited the need for the Port to take a holistic approach to the emissions that are the result of port operations. The Port's footprint goes beyond Port Hueneme, goes beyond Oxnard, and goes beyond even the entirety of Ventura County. Stakeholders want a zero emissions blueprint to address the concerns they have beyond the immediate region.

Collaborative Partnerships

Stakeholders value collaboration. Virtually all meeting attendees stressed the need for collaboration among the various sectors with a stake in port operations. To reap the benefits of a zero emissions Port of Hueneme blueprint, it will be imperative for community groups, environmental organizations, business interests, labor organizations, and government entities and agencies to work together. The collaboration includes strategic partnerships, workforce development training, and education for the broader public on the new technologies being deployed at the Port.

Strategic Partnerships: The need for cross-sectoral stakeholders to come together was expressed. While there already are existing relationships in the community, different groups should collaborate with others to maximize their collective goals and objectives. Stakeholders cited a willingness to explore potential opportunities with the Port itself and other groups.

Workforce Development: Workforce development was a common theme among various stakeholder groups. Elected officials have an interest in the creation of good-paying jobs in their region and not seeing talent flee to other parts of the state, and workforce development can play a critical role in this goal. Additionally, some stakeholder groups explicitly demonstrated a willingness to provide education to the workforce that will train them on zero emissions jobs.

Public Education: Stakeholder groups want the community to be educated on zero emission technologies. This is an opportunity for various stakeholders to educate others on how zero emission technologies can be beneficial to Ventura County, their professions, and their lives. Some stakeholder groups indicated misconceptions about zero emissions technologies, so providing stakeholders with accurate information will be necessary.

Addressing the Needs of the Individuals Who Live and Work in Ventura County

Stakeholder groups stressed the need for individuals who live and work in Ventura County to receive the benefits of a healthy environment, strong public health considerations, good-paying jobs, and access to job training resources. Stakeholders do not want current Ventura County residents and workers to go elsewhere to receive these kinds of benefits and resources. Stakeholder groups seem committed to doing their part in creating and maintaining a strong and vibrant Ventura County, which many feel might start with the Port of Hueneme adopting a strong zero emissions blueprint.

Jobs: As mentioned earlier in the "Workforce Development" sub-theme in the previous section, elected officials throughout Ventura County expressed a desire for more good-paying jobs to come to Ventura County and see an opportunity for zero emission technologies to play that role. Stakeholder groups are also cognizant of not wanting to displace those currently employed and wanting a "just transition" to jobs in zero emissions technologies. Nobody wants to be left behind in the Port of Hueneme zero emissions blueprint.

Playing a Role: Some stakeholder groups are willing to do whatever they can to ensure a zero emissions blueprint at the Port is inclusive and effective, which will be important for maximizing its benefit. Particularly, community groups (e.g., colleges with workforce curricula) and business groups are willing to help ensure workers are trained and prepared for the zero emissions jobs that can be expedited in creation as a result of the blueprint. Stakeholder groups seem to understand that the benefits of a zero emissions blueprint can only be maximized by their participation in the overall process.

Big Tent Meetings

Big Tent Meeting (in-person):

On Thursday, August 4, 2023 Coalition for Clean Air (CCA) and Breathe Southern California (BSC) hosted our first "Big Tent" meeting to present our findings from roundtable and one-on-one meetings and to continue receiving input from stakeholders.

Following a round of introductions and background on the project and our roles, we described the broad themes we discovered throughout our stakeholder engagement process. Following the presentation, we allowed participants to include additional priorities they wanted to see addressed, and then we conducted an interactive ranking activity. The activity involved asking all participants to rank their top three priorities for both "Technological Priorities" and "Plan Takeaway Priorities." The ranking system was dictated by colored stickers, red being first, yellow being second, and blue being third.

Technological Priorities included: off-road equipment, power generation, trucks, ships, light-duty vehicles, materials, and trains. Plan Takeaway Priorities included: relevant commitments to zero emission goals, green jobs, education and training, greenspace, public health, coordinating with regional agencies, and climate.

Results:

We found that for "Technological Priorities" trucks were a major focal point followed by power generation. And for "Plan Takeaway Priorities," public health was clearly top of mind for all participants.

Additional priorities and questions that participants want to see addressed in the blueprint:

- Want the Port to prioritize an equitable transition, not an equal transition?
- How are other cities, not just Port Hueneme, reacting to the plan?
- Concerned about timelines – needs to be completed quickly.
- How is rail being prioritized within the Port? Does the Port own the rail line?
- What financing mechanism, like a container fee, can be utilized for the community?
- Focusing on how this will impact environmental justice communities. Is a zero emission corridor a possibility?
- The role other companies, who are not transitioning to zero emission, have in using the port.
- Community Benefit Agreements
- Port Hueneme not being in any community choice energy programs (i.e., Clean Power Alliance).
- Is Port Hueneme facilitating any oil import or export?
- The economic externalities to a zero emission port. Will prices rise on goods in the surrounding community?
- How is zero emission defined? Does it mean full electrification or does it include natural gas or hydrogen?
- What is the role Port Hueneme has in wind energy generation and facilitation?
- Concerns surrounding zero emission technologies not being ready for deployment.
- Wanting access to raw data from the SPARC project.

Big Tent Meetings (Virtual):

On Wednesday, September 7, 2023 we hosted our final "Big Tent" meeting to go over the results of our previous meetings, including the previous "Big Tent" meeting. The virtual meeting brought together approximately fifteen individuals from numerous organizations.

Following the structure of the first "Big Tent" meeting, we did introductions, an overview of the project, findings from previous meetings, and again utilized an interactive exercise. The exercise allowed participants to rank their priorities for both technologies and plan takeaways. In this version of the exercise, we included priorities that were added from the last "Big Tent" meeting. Technological Priorities Analysis:

we are seeing that Power Generation is a clear priority for all participants, followed up by transportation-related technologies.

Plan Takeaway Priorities Analysis: we are seeing somewhat mixed results with no clear priority in the 1st choice; however, we do see that education and training have some consensus as a 2nd choice. The 3rd choice again is mixed.

Next Steps:

Some organizations have a strong desire to see the Port move to a zero emission system. These groups have expressed desires to help where possible, particularly when they see tangible steps taken and strong commitments made toward that goal.

Given this, with the caveat that funding is always needed, we recommend creating a Working Group to address specific technical needs and opportunities. When and if funding becomes available, we recommend inviting the individuals who attended and actively participated in our working group meetings.

Table 8: Stakeholder Invitees and Participants

Category	Organizations
Community Groups	· Antioch University, Santa Barbara (invited) · California State University, Channel Islands (participant) · Friday's for Future (participant) · Future Leaders of America (participant) · Interfaith Sanctuary Alliance (invited) · Mixteco Indigena Community Organizing Project (participant) · Moorpark College (invited) · National University (invited) · Naval Base Ventura County (invited) · Ocean Friendly Garden (invited) · Oxnard College (participant) · Oxnard School District (participant) · Showing Up for Racial Justice (invited) · Thomas Aquinas College (invited) · University of California, Santa Barbara (invited) · Ventura College (invited) · Ventura County Community Foundation (participant) · Wishtoyo Chumash Foundation (invited)

Environment	· Coalition for Clean Air (in addition to the facilitation role) · Breathe SoCal (in addition to the facilitation role) · Central Coast Alliance United for a Sustainable Economy (participant) · Central Coast Climate Justice Network (invited) · Citizens Planning Association and Foundation (invited) · Climate First: Replacing Oil & Gas (participant) · Community Environment Council (participant) · Community Interpreter (invited) · Environmental Working Group (invited) · Food and Water Watch – Ventura (participant) · Los Padres ForestWatch (invited) · National Resources Defense Council (participant) · PSR-LA (invited) · Sierra Club – Los Padres Chapter (participant) · Surfrider Foundation – Ventura Chapter (invited)
Government	· Camarillo City Council (participant) · Clean Power Alliance (participant) · Fillmore City Council (participant) · Moorpark City Council (participant) · Office of Congressmember Julia Brownley (participant) · Office of State Assembly Member Jacqui Irwin (invited) · Office of State Assembly Member Steve Bennett (participant) · Office of State Senator Monique Limon (participant) · Supervisor Nora Vargas (participant) · Ojai City Council (invited) · Oxnard City Council (participant) · Port Hueneme City Council (participant) · Santa Paula City Council (participant) · Simi Valley City Council (invited) · Thousand Oaks City Council (participant) · Ventura City Council (invited) · Ventura County Board of Supervisors (participant) · Ventura County Transportation Commission (invited) · Port of Hueneme Staff (participant)

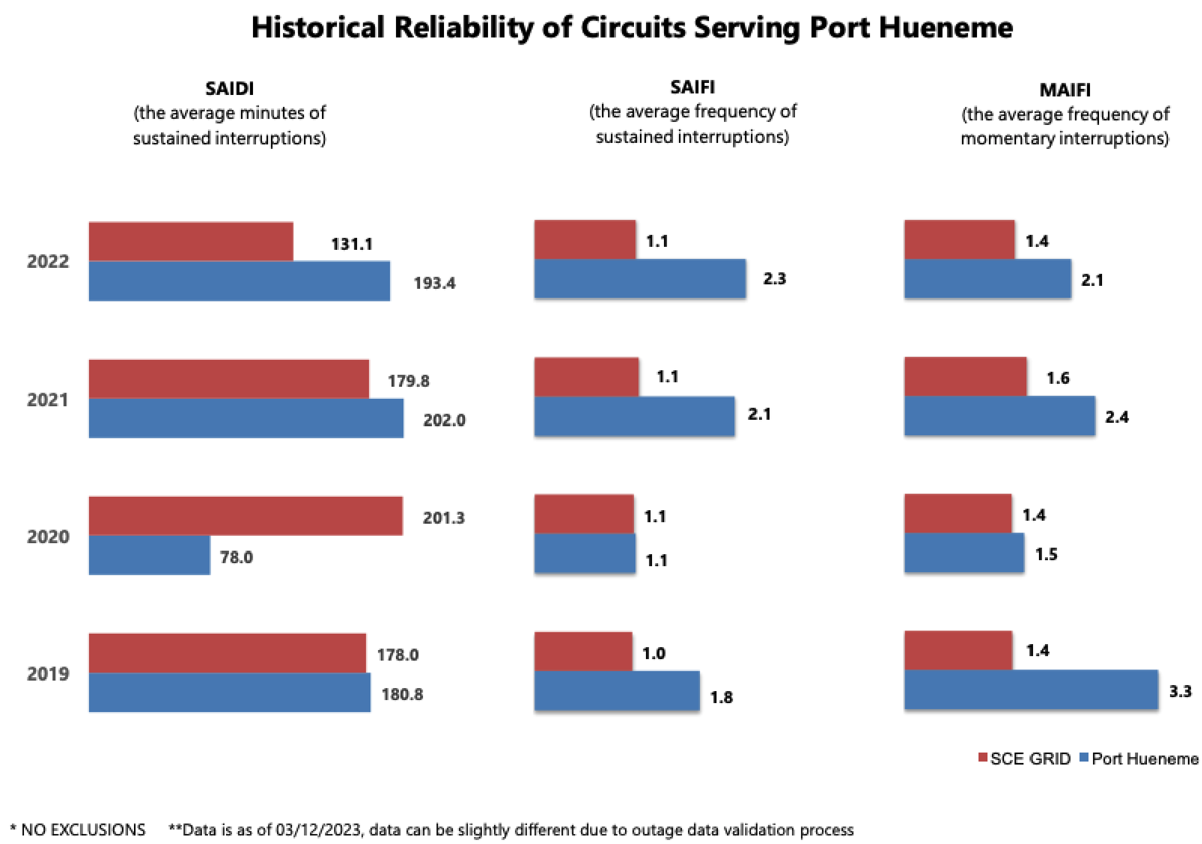
Business	· Amazon (participant) · Amgen (invited) · Economic Development Collaborative of Ventura County (participant) · Economic Development Corporation of Oxnard (participant) · Patagonia (invited) · Port Hueneme Chamber of Commerce (invited) · SEA Electric (participant) · Ventura Chamber of Commerce (invited) · West Ventura County Business Alliance (invited) · Wiggins Lift (participant)
Labor	· ILWU Local 46 (invited) · Ironworkers Local 433 (invited) · Laborers' International Union of North America Local 585 (participant) · SEIU 2015 (participant) · Southwest Regional Council of Carpenters (invited) · Teamsters Local 186 (invited) · Tri-Counties Building Trades & Construction Council (invited)
Public Health	· Selfa Saucedo, Ventura Public Health Department · Dr. George Yu, Pulmonologist, Dignity Health Ventura County
General Public	· At least twenty members of the general public not formally affiliated with any organization. · Our translators, both of whom live in Oxnard, participated actively

Basis for Transition to ZE CHE

As part of the ongoing strategic review of decarbonization initiatives, the potential for transitioning from fossil fuel cargo handling equipment to zero emission equipment at the Port of Hueneme has been extensively analyzed and considered. Findings underscore the adoption of BEV alternatives' practicality, feasibility, and strategic value for the port, its operators, and stakeholders.

The reliability of the Southern California Edison electric grid, which maintains an uptime exceeding 98%, ensures a consistent power supply for battery electric equipment operation. This high uptime level underscores the grid's reliability, reducing risks associated with power outages and enabling smooth operations. The ongoing commitment to improving the ratio of renewable energy inputs into the California grid also support the longer-term vision of tackling full life-cycle emissions.

Figure 3: ("Reliability Reports | Historical Reliability of Circuits Serving Port of Hueneme." Southern California Edison)



Our technological evaluation in Task 3 reveals that battery electric cargo handling equipment has attained a Technology Readiness Level (TRL) above eight and a Commercial Readiness Index (CRI) score of four or above. These scores indicate that the technology has been tested and proven in operational environments and is commercially viable for broad deployment. The high TRL and CRI ratings substantially mitigate the risks associated with technology adoption, assuring stakeholders of the equipment's readiness for full commercial deployment.

Table 9: CHE Technology Evaluation			
Technology	Fuel technology	TRL - Rating	CRI - Rating
Large Capacity Forklifts (Type V)	Battery Electric	9	3
Large Capacity Forklifts (Type V)	Gaseous Hydrogen	6	2
Mobile Harbor Crane	Battery Electric	9	6
Mobile Harbor Crane	Gaseous Hydrogen	5	2
Rubber-tired Gantry (RTG) Crane	Battery Electric	9	4
Rubber-tired Gantry (RTG) Crane	Gaseous Hydrogen	5	2
Ship to Shore Crane (STS)	Battery Electric	9	6
Ship to Shore Crane (STS)	Gaseous Hydrogen	5	2
Standard Forklift	Battery Electric	9	6
Standard Forklift	Gaseous Hydrogen	9	6
Top Handler (Reach Stacker)	Battery Electric	8	2
Top Handler (Reach Stacker)	Gaseous Hydrogen	5	2
Yard Tractor (UTR)	Battery Electric	8	4
Yard Tractor (UTR)	Gaseous Hydrogen	7	2

The port can ensure reliable power supply to support its ongoing needs with the support of its local utility provider SoCal Edison. This strategy offers the lowest risk-reward profile among all potential zero-emission options. By expanding the current electrical infrastructure, the Port can enhance its capacity to support battery electric equipment, further enabling the decarbonization of cargo handling operations.

Moreover, the maturity of battery electric technologies ensures the availability of robust safety and operations protocols. All Port of Hueneme partners can easily adapt these established procedures, facilitating a smooth transition and integration into current operations. The ability to leverage existing protocols not only simplifies implementation planning but safety and usage training with commercial partners.

MD/HD Infrastructure Plan

Infrastructure Design Parameters:

Remaining in line with the 2019 Port of Hueneme Electrical Master Plan, continued deployment of Battery Electric cargo handling equipment has been recommended. An extensive data collection and analysis effort to understand the specific utilization of CHE at the Port of Hueneme was conducted and resulted in the POH Utilization Model. Meeting with POH staff, partners, and electrical consultants, CHE utilization was mapped to vessel calls, and a determination of peak electrical loads, if all equipment was to be electrified, was calculated at up to 4MW for CHE, and 2MW for shore power. POH electrical consultants recommended that SCE increase circuit capacity to handle the additional load.

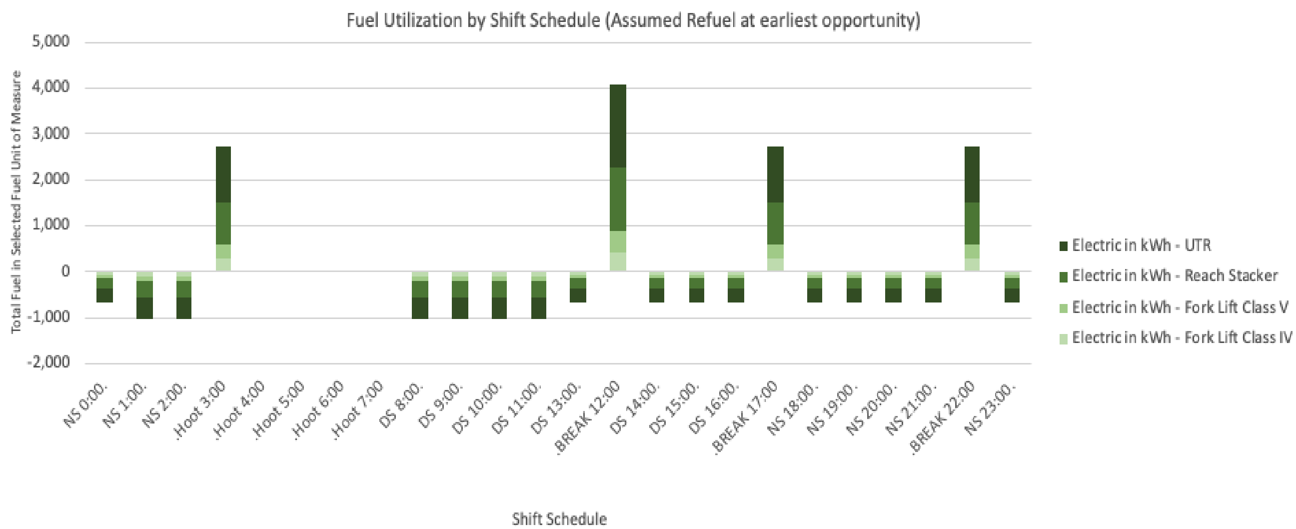


Figure 3.1: (Electric Fuel Utilization by Shift Schedule)

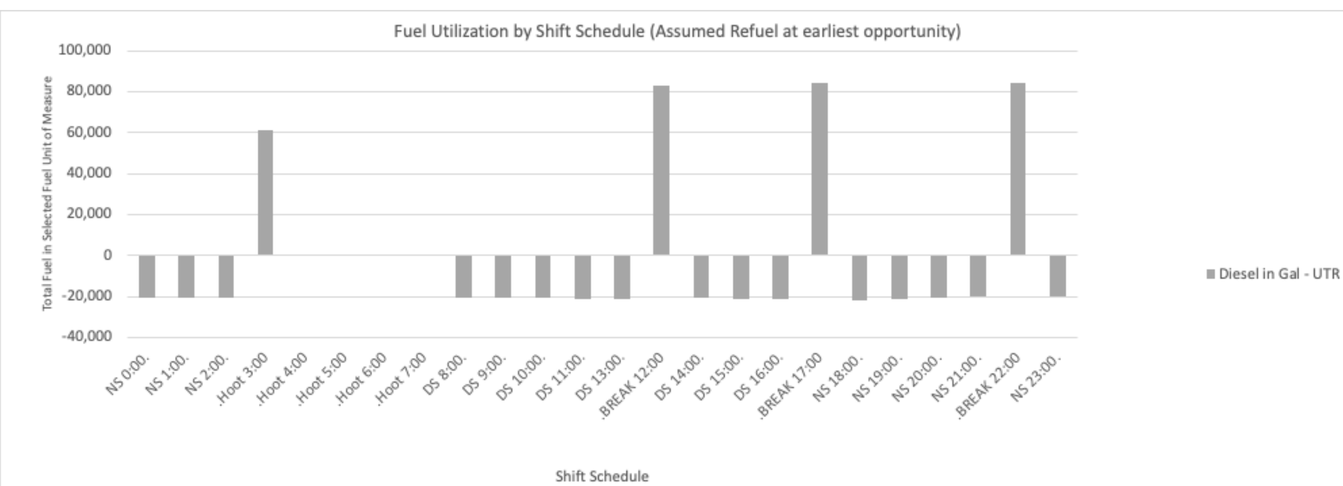


Figure 3.2: (Diesel Fuel Utilization by Shift Schedule)

Load & Energy Modeling:

The charging infrastructure used for all estimated loads was a 50kW DC charger with the capacity to charge two units at 50 kW. Based on our findings in task two there are 36 pieces of CHE that will need charging infrastructure. In a deployment configuration of two charging ports per charger, requiring eighteen (18) chargers.

The battery sizes for each type of Cargo Handling Equipment (CHE) were selected based on an analysis of OEM specifications and pilot projects. The chosen sizes—UTRs with 180 kWh, Reach Stackers with 985 kWh, Fork Lift Class IV with 40 kWh, and Fork Lift Class V with 245 kWh—correspond to the average or median values in the market. Importantly, these sizes were also aligned with the equipment's consumption rates to fit within the available charging windows, in accordance with existing safety and operational protocols.

The following figures are modeled to demonstrate the state of charge of proposed equipment over time, based on certain assumed charging windows.

Figure 3.3: (Combined Battery Discharge and Recharge During Breaks and Hoot Shift)

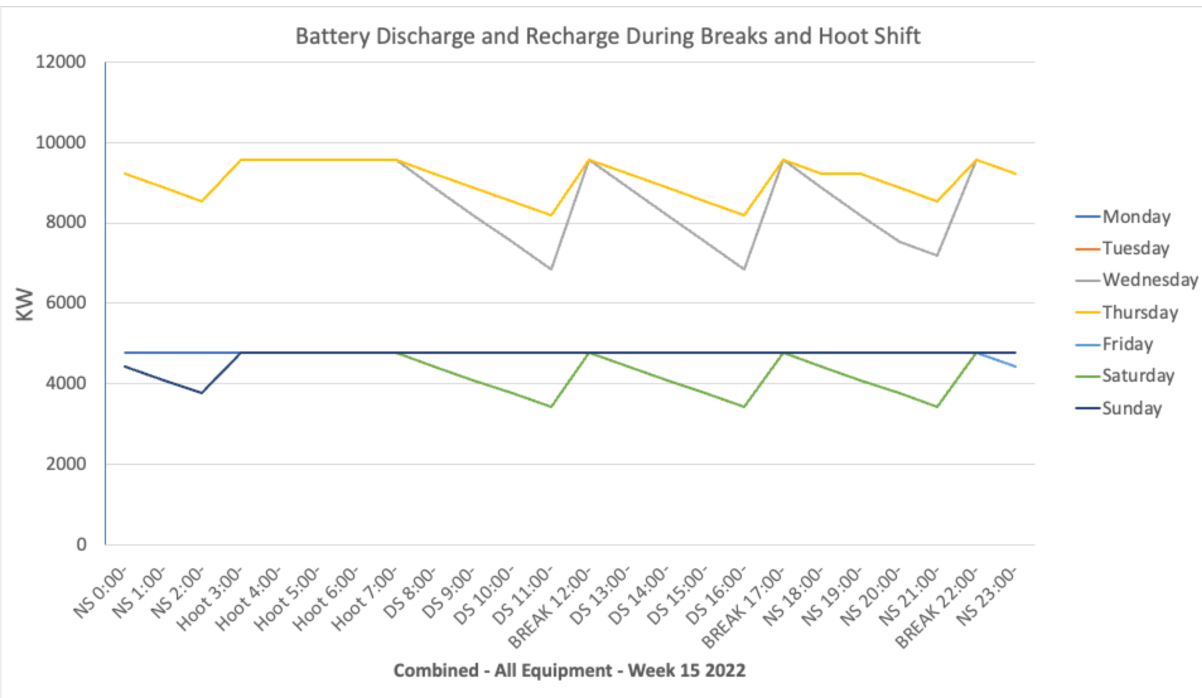


Figure 3.4: (UTR Battery Discharge and Recharge During Breaks and Hoot Shift)

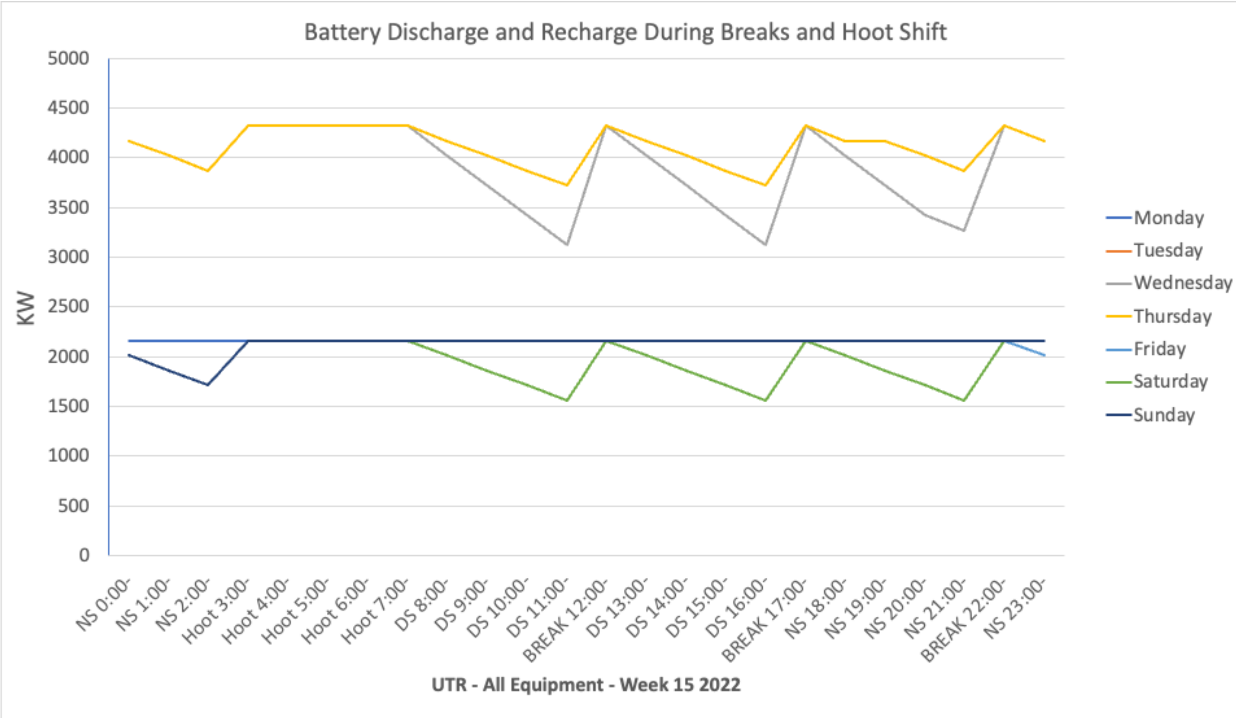


Figure 3.5: (Reach Stacker Battery Discharge and Recharge During Breaks and Hoot Shift)

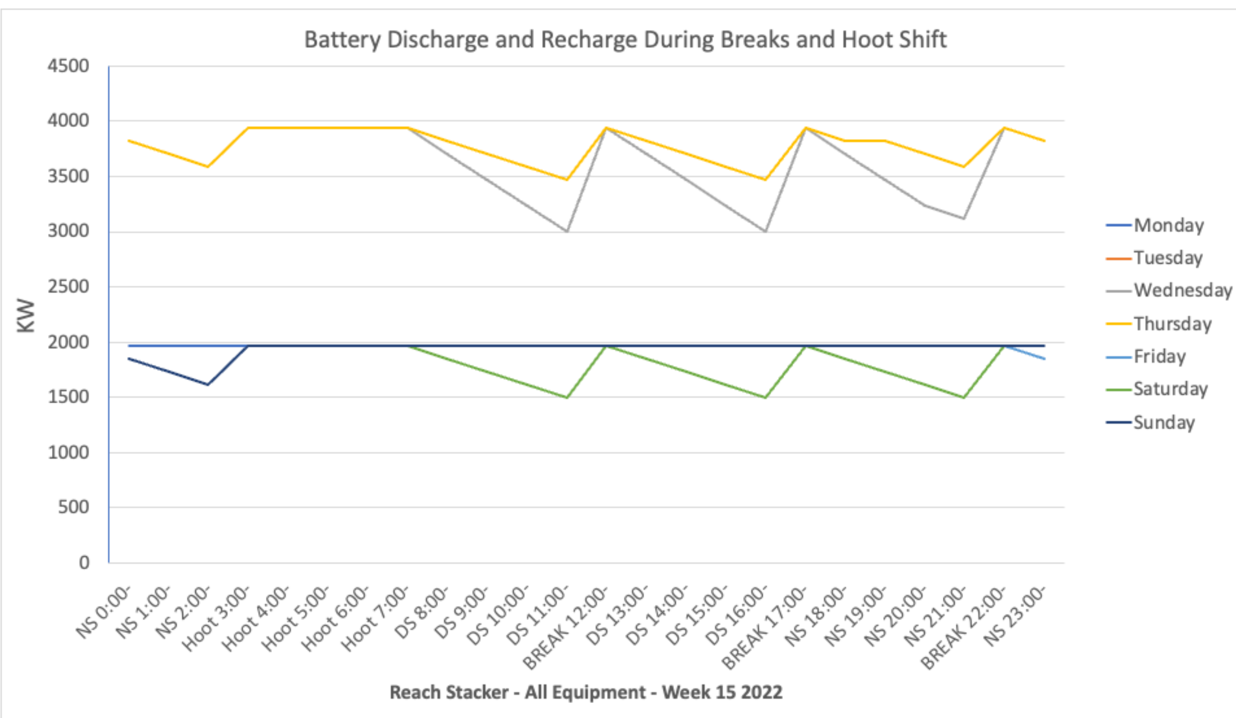
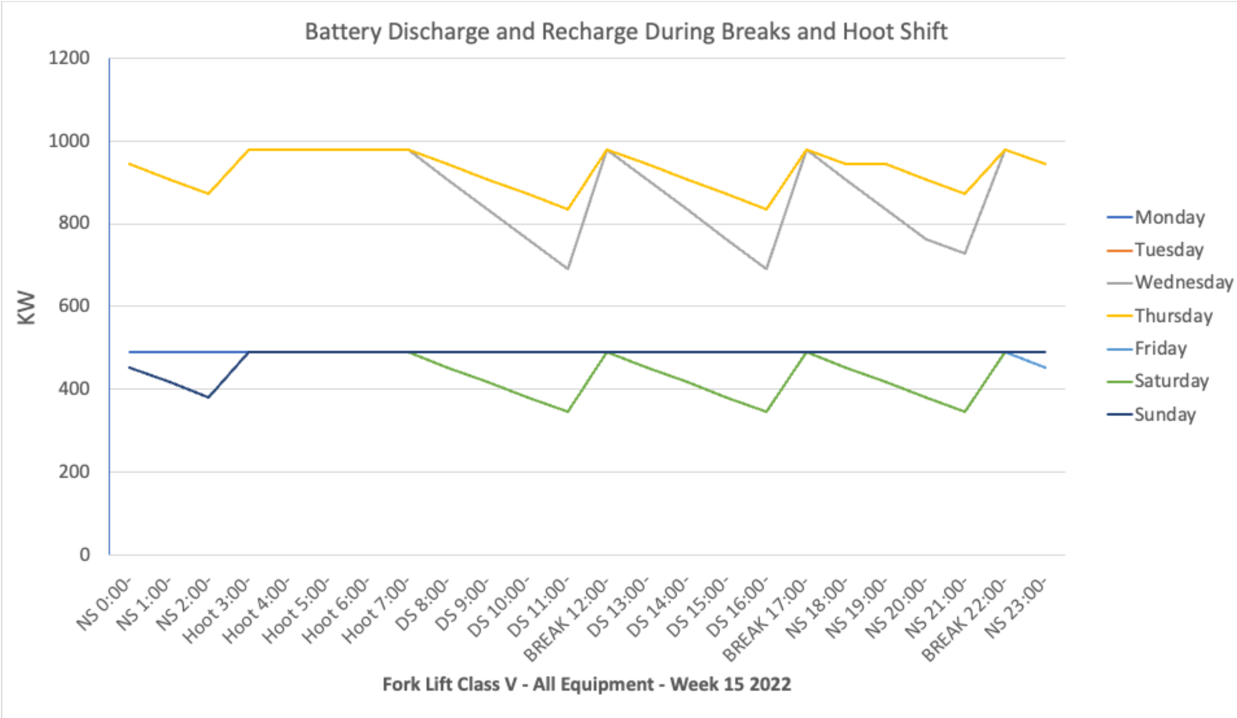


Figure 3.6: (Fork Lift Class V Battery Discharge and Recharge During Breaks and Hoot Shift)



The following table demonstrates the ramping instantaneous load demands represented by the proposed deployment schedule for ZE CHE (assuming a 50 kW charge rate across all units):

Table 10: Equipment Acquisition and Projected Instantaneous Load

Year of Acquisition	BEV UTR	BEV Forklift Class V	BEV Reach Stacker	Instantaneous Load (kW)
2023	0	0	0	0
2024	9	0	0	450
2025	0	0	0	0
2026	5	0	0	250
2027	5	0	0	250
2028	4	1	1	300
2029	2	1	1	200
2030	0	1	1	100
2031	0	0	0	0
2032	0	0	0	0
2033	0	0	0	0
2034	0	0	0	0
2035	0	0	0	0
2036	0	0	0	0

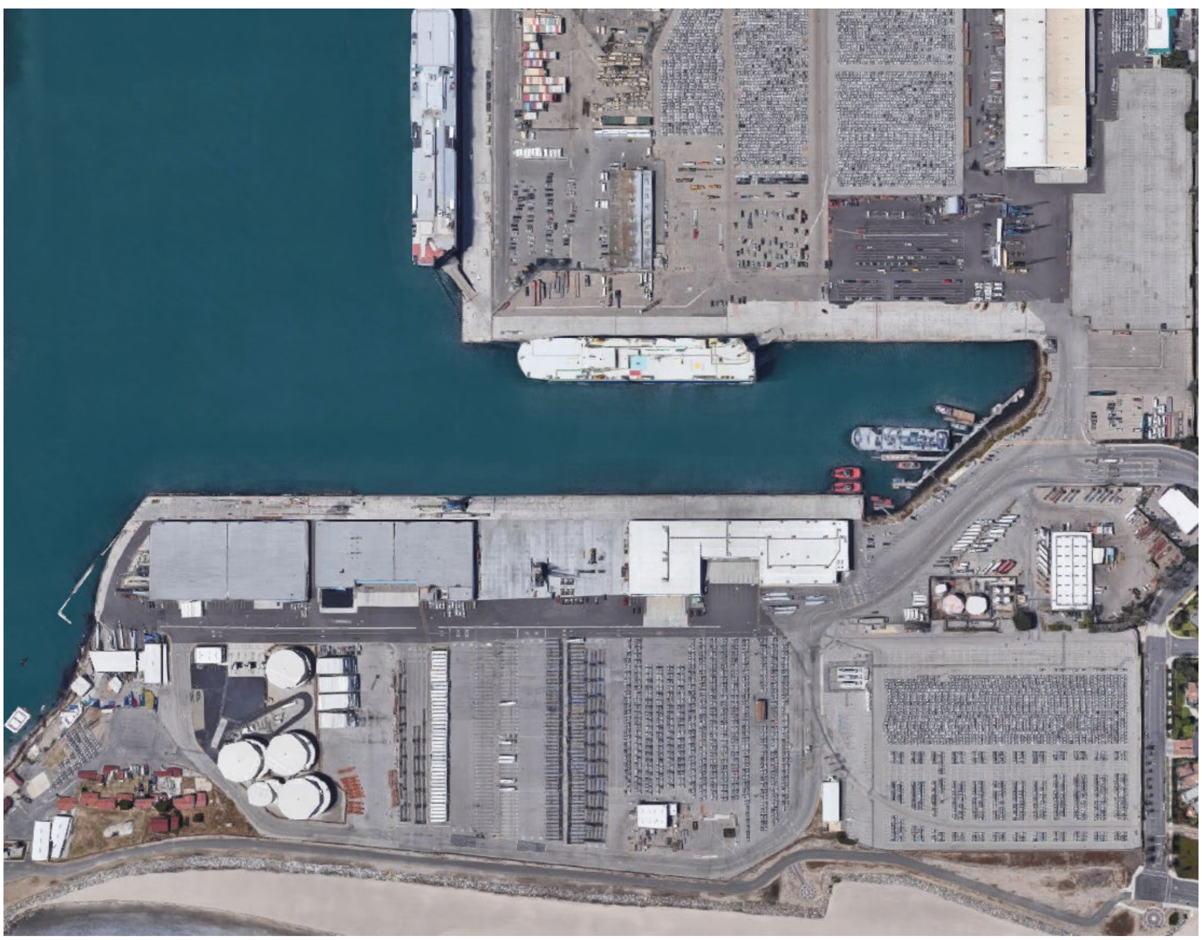
Proposed Infrastructure Sites

The following sites were assessed for viability for siting EV charging infrastructure. Sites have not been finalized for full commercial-scale deployment however, a clear pathway for doing so has been established. There are several planned infrastructure projects funded by the CalTrans Port Freight and Infrastructure Program that will result in the demolition of buildings to increase usable space for cargo operations. Site evaluation criteria are as follows (not ranked in order of importance):

- Impact on current and future operations
- Stranded asset risk
- Proximity to work locations
- Available footprint
- Access to electrical service

Satellite images of the Port of Hueneme have been provided for reference. Operations are principally split between the north and south terminals. The north terminal supports rolling stock like automotive imports as well as certain "high-and-heavy" cargo requiring special support. The south terminal supports container and bulk cargo operations. Space is highly limited despite the port's quick movement of cargo and low dwell times for containers due to the relatively small footprint of the commercial seaport relative to its cargo volumes. Waterfront property is crucial for operations and thus not viable for charging infrastructure, necessitating sites somewhat removed from the berths.

Figure 3.7: (Port of Hueneme - Satellite Image)



Site #1

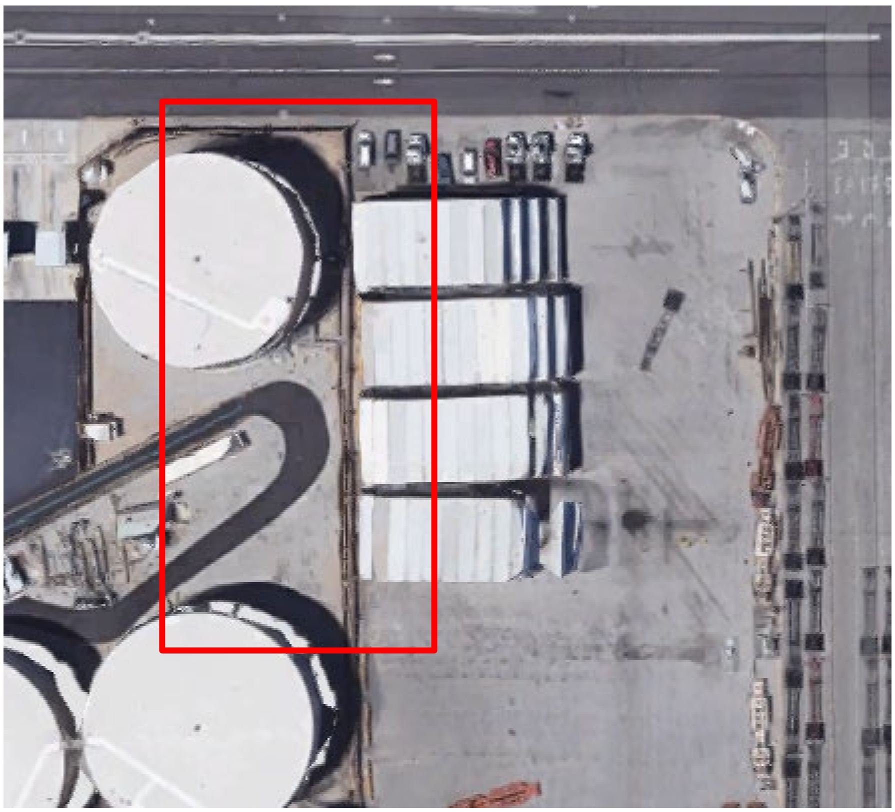
The proposed site illustrated below is on the eastern property line of the Port. This site is considered viable, though any infrastructure located here should be designed to minimize footprint as this is valuable staging space for operations. This proposed site can access multiple points of electrical service, as well as support charging for equipment utilized on both the north and south terminals, making its proximity to both work locations high. If the infrastructure is located along the property line stranded asset risk can be minimized as would any adverse impact on current operations. Presently there are no proposed alternative uses for this space, though further north there are preliminary plans for a vertical parking garage. This site is considered viable for future design and engineering efforts.

Figure 3.8: (Port of Hueneme - Site #1)

Site #2

The proposed site illustrated below is located to the west of the center of the southern terminal. This site is adjacent to ammonia tanks, as seen in the satellite image. There are presently two UTR chargers installed at this location, as well as conduit to support an additional nine. This location is in close proximity to the southern terminal and due to the proposed infrastructure layout offers minimal disruption to current operations. Recent awards through the Caltrans Port Freight and Infrastructure program (PFIP) have provided funding for the installation of the remaining nine charge points. This location can support additional charging infrastructure, though due to footprint limitations expansion opportunities are limited. This site is considered viable for future design and engineering efforts to determine the potential capacity expansion beyond the currently planned implementation of the additional nine units.

Figure 3.9: (Port of Hueneme - Site #2)



Site #3

The proposed site illustrated below is located in the southwest corner of the port. The buildings and grounds were used to support Navy NCO quarters in the past but have been slated for demolition under the Caltrans PFIP grant award. This would make the space available for the potential deployment of EV charging infrastructure. This site would require some travel for labor to access the equipment unless parking is provided in proximity. The location is fairly removed from the wharfs resulting in a moderate distance to access the operational workspace and return equipment for charging after shifts. This site offers limited disruption to current and future operations. The site is considered viable for further engineering and design efforts to consider the deployment of EV charging infrastructure in the future after it has been demolished and cleared.

Figure 3.10: (Port of Hueneme - Site #3)

Quantitative Goals and Timelines

Timeline & Key Phases

SPARC Technology Blueprint (2021-2023): identifies and outlines a strategic plan of action based on the port's operational requirements and state of technology. In the case of the Port of Hueneme, the "blueprint project" known as SPARC (Sustainable Power Advancement & Resiliency for our Community) was created to chart a pathway to zero emission CHE operations which is the Port's overall long-term plan for air quality improvement and climate change adaptation. The plan takes a comprehensive look at the operations of MD/HD equipment to address technology selection, infrastructure requirements, and plot a timeline for the complete transition of equipment to zero emission alternatives.

Formally Engage SCE Regarding Electrical Service Requirements (2023-2025): The port does not currently have sufficient capacity to support CHE electrification goals. It is imperative that the port formally engage Southern California Edison (SCE) and submit an electrical service request to prepare to meet electrification goals. The port can leverage the existing Electrical Master Plan (EMP) along with newly forecasted loads from the SPARC Blueprint to support SCE's understanding of the required electrical for future facility expansions and equipment electrification projects. The EMP lists the existing major electrical loads currently installed at the POH's South and North terminals and can be updated as appropriate to incorporate projected new electrical loads for each of the two terminals from the SPARC blueprint and further analysis on the remaining light- and medium-duty assets.

Policy Development & Implementation (2023-2025):

Central to enabling a forecastable and timely transition to zero emission operations will be implementing several port policy changes to create the right incentives and requirements for its commercial partners. It is recommended that the port set clear guidelines on how infrastructure is developed, owned, and operated to create a consistent and unified approach to infrastructure deployment. Limitations on when and how new fossil fuel equipment can be integrated into the port ecosystem will need to be set to ensure compliance with the port's zero emission targets. The port can leverage tariff agreements, board resolutions, and lease agreements to collaboratively affect these changes with its commercial partners. The port can also implement incentives for commercial partners to adopt ZE CHE in support of infrastructure deployment. The Port will be undergoing the development of a comprehensive Clean Air Action Plan, which will include climate change adaptation elements to inform future implementations. This planning effort will include scope to address the aforementioned policy gaps neccessary to support an holistic energy transition.

Fleet Transition (2025-2030): Activate commercial-scale deployment of Zero Emission infrastructure and CHE with port partners within the revised policy framework and electrification goals. Integrate any engineering and design considerations from climate change adaptation work regarding storm water intrusion and sea level rise for critical infrastructure. This will also allow time to complete necessary engineering and design work for the deployment of additional EV charging infrastructure and prepare for procurement. The port taking the lead on infrastructure development will reduce stranded asset risk and operational risk associated with user-driven one-off deployments.

Parallel Decarbonization Projects to Support ZE Port Operations (2023-2036): Additional projects will remove dilapidated obsolete buildings, install zero-emission container plug-in units, and have some limited on-site generation capacity. Said projects will bring resilience and safety improvements while paving the way for new zero emission infrastructure. Continued support of shoreside power and emission control systems that ensure compliance with CARB at berth regulations will ensure emissions reductions of ocean-going vessels while in port. Growing EV imports also raise the issue of potential charging needs for imported vehicles along with the potential for more efficient use of port space through the development of a parking garage. This could present a substantial additional load and should be analyzed soon to incorporate into materials submitted to SCE.

Foster Innovation and Regional Partnerships (Ongoing): Foster an environment of innovation, encouraging new technologies and solutions. Form partnerships with stakeholders, including local communities, businesses, research institutions, and government agencies. Leverage convening authority and potential as a project partner to enable regional projects that improve the resilience of local infrastructure and supply chains, promote economic development, and reduce air pollution.

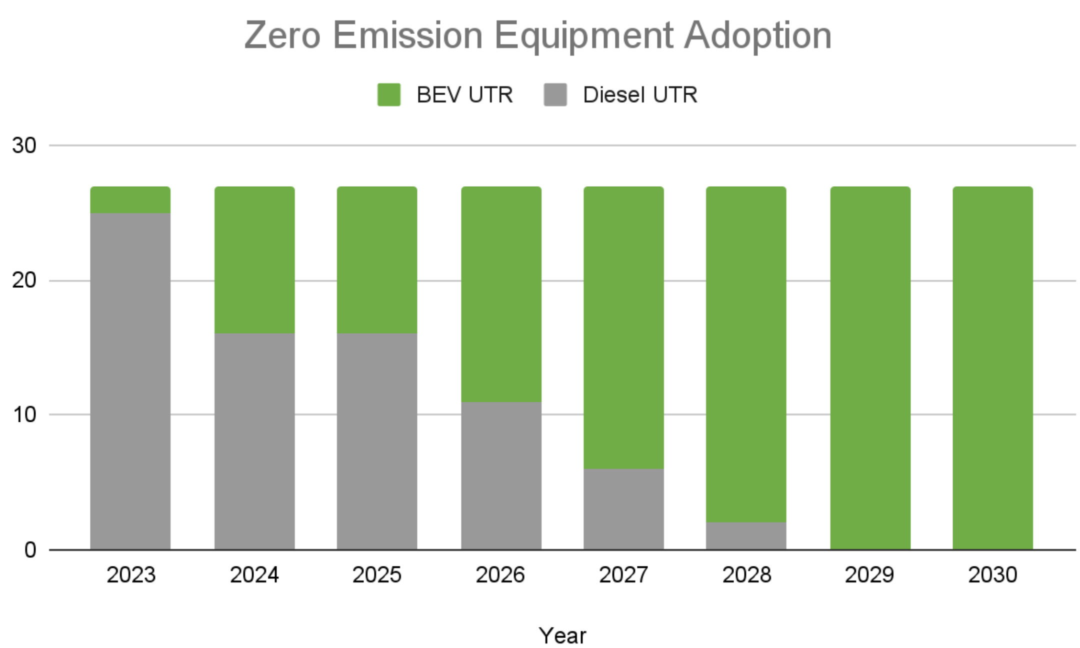
Figure 3.11: (Proposed Implementation Timeline)

Table 11: Proposed Fleet Transition Timeline

Year	Diesel UTR	BEV UTR	Diesel Forklift Class V	BEV Forklift Class V	Diesel Harbor Crane	Hybrid Harbor Crane	Diesel Reach Stacker	BEV Reach Stacker
2023	25	2	3	0	2	1	3	0
2024	16	11	3	0	1	2	3	0
2025	16	11	3	0	0	3	3	0
2026	11	16	3	0	0	3	3	0
2027	6	21	3	0	0	3	3	0
2028	2	25	2	1	0	3	2	1
2029	0	27	1	2	0	3	1	2
2030	0	27	0	3	0	3	0	3

100% of all Utility Tractors (UTRs) will be BEV by 2030 – Estimated five (5) units per year starting in 2026. 2026 was chosen to allow for 18-24 months to select, permit, and install electrical infrastructure.

Figure 3.12: (UTR Equipment Adoption)



100% of all Reach Stackers & Class V Forklifts will be BEV by 2032 – Estimated one (1) unit per year starting in 2030.

Figure 3.13: (Reach Stacker Equipment Adoption)

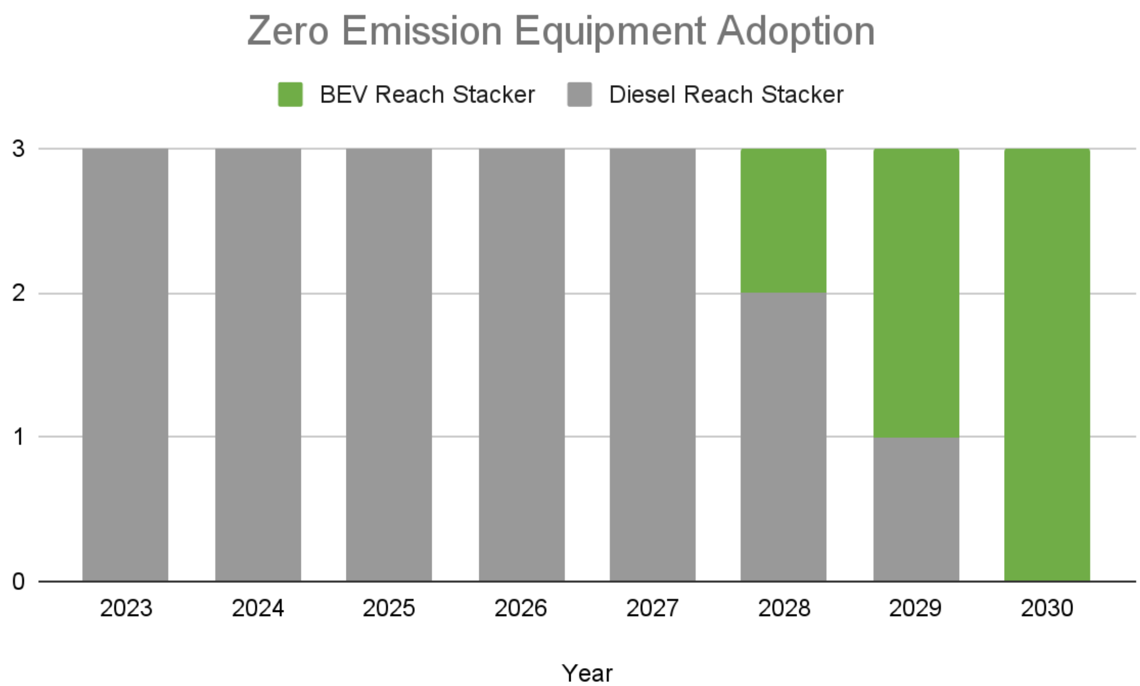


Figure 3.14: (Forklift Class V Equipment Adoption)

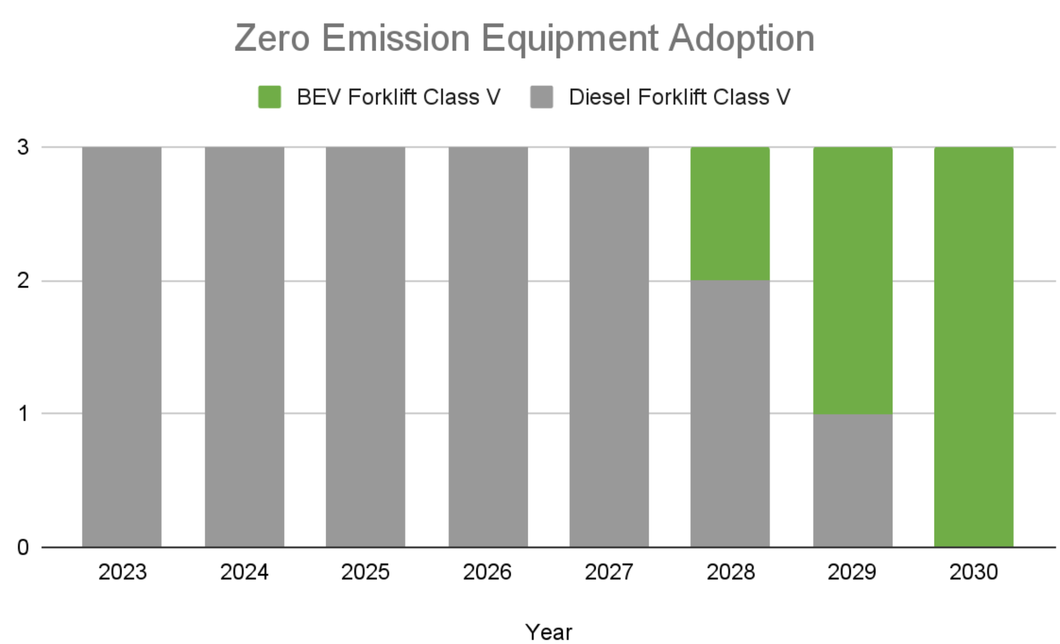
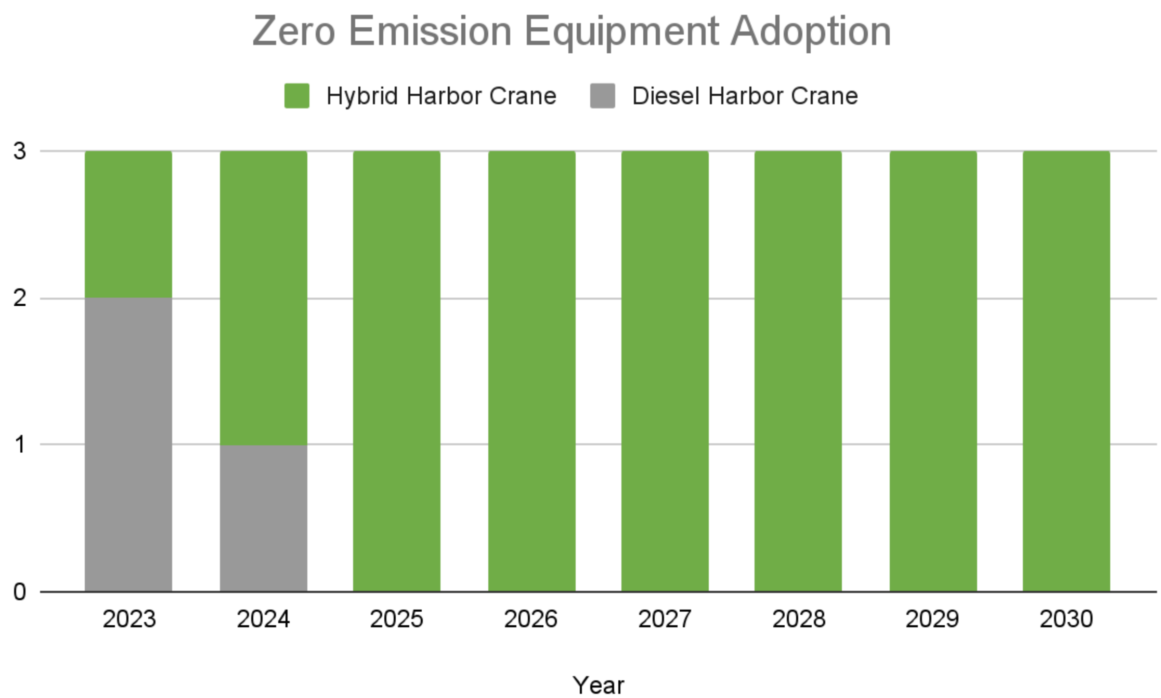


Figure 3.15: (Hybrid Harbor Crane Equipment Adoption)



*100% of all Mobile Harbor Cranes will be hybrid by 2025

Equipment CAPEX Table: Budgetary Cost Estimates (California Core Credits Included):

Table 12: Equipment Capital Expense Table

Equipment Type	Equipment Capital Cost	CORE VIP
UTR[1]	$370,000.00	$120,000.00
Class V Forklift[2]	$720,000.00	$380,000.00
Harbor Crane[3]	$3,800,000.00	
Reach Stacker[4]	$1,200,000.00	$500,000.00

[1]UTR - Zero-Emission Cargo-Handling Equipment Feasibility Assessment - AECOM 2019
[2]Class V Forklift - OEM 2023 Phone survey - Estimated pricing based on 2023 market
[3]Harbor Crane - https://container-news.com/port-of-immingham-to-receive-new-cranes/
[4]Reach Stacker - https://terminalift.com/product/tl-electric-reach-stacker/

Table 13: Equipment Capital Expenses; Timeline Projected

Year	BEV UTR	BEV Forklift Class V	Hybrid Harbor Crane	BEV Reach Stacker
2023	-	-	-	-
2024	$2,250,000.00	-	$3,800,000.00	-
2025	-	-	$3,800,000.00	-
2026	$1,250,000.00	-	-	-
2027	$1,250,000.00	-	-	-
2028	$1,000,000.00	$340,000.00	-	$700,000.00
2029	$500,000.00	$340,000.00	-	$700,000.00
2030	-	$340,000.00	-	$700,000.00
Total	**$8,650,000.00**	**$1,020,000.00**	**$7,600,000.00**	**$2,100,000.00**

Infrastructure CAPEX Table:

Estimates for charging infrastructure are inclusive of engineering and design, installation and major equipment with a 50% contingency. Estimates assume that the required electrical service is provided at the location of the installed charger. Estimated charger CapEx inclusive of installation for a 50kw charger is $100k USD. Additional input is required from SCE to determine further costs associated with utility service improvements to meet power requirements.

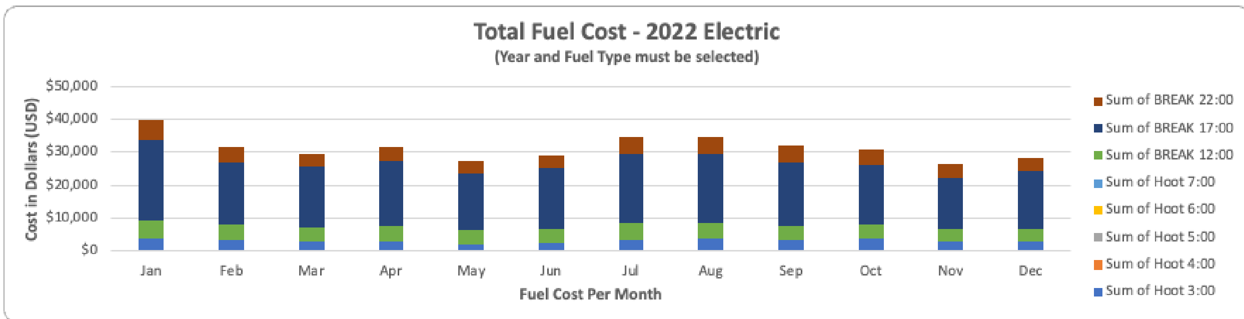
Table 14: Infrastructure Capital Expense Table

Year	BEV UTR	BEV Forklift Class V	Hybrid Harbor Crane	BEV Reach Stacker
2023	-	-	-	-
2024	$900,000.00	-	$100,000.00	-
2025	-	-	$100,000.00	-
2026	$500,000.00	-	-	-
2027	$500,000.00	-	-	-

2028	$400,000.00	$100,000.00	-	$100,000.00
2029	$200,000.00	$100,000.00	-	$100,000.00
2030	-	$100,000.00	-	$100,000.00
Total	**$2,500,000.00**	**$300,000.00**	**$200,000.00**	**$300,000.00**

Equipment Fuel Cost Table (Estimated Cost for Year 2022 with all Equipment was Electric - Potential Opex savings +40% over diesel):

Figure 3.16: (Total Electric Fuel Cost - 2022)



The charging event at BREAK 17:00 falls on a peak rate of the TOU-EV-9 Tariff and represents approximately 60% of the monthly cost. The potential of transferring this charging event to an off peak window and realizing the average monthly cost would increase the potential OPEX saving to +80%

Table 15: Total Fuel Cost - Electric (FLTIV, FLTV, RS, & UTR) - 2022 - Tariff TOU-EV-9

Month	Sum of Hoot 3:00	Sum of Hoot 4:00	Sum of Hoot 5:00	Sum of Hoot 6:00	Sum of Hoot 7:00	Sum of BREAK 12:00	Sum of BREAK 17:00	Sum of BREAK 22:00	Monthly Totals
Jan	$3,948.26	$-	$-	$-	$-	$5,527.56	$24,377.32	$5,878.52	**$39,731.66**
Feb	$3,465.69	$-	$-	$-	$-	$4,650.17	$18,919.71	$4,737.91	**$31,773.48**
Mar	$3,027.00	$-	$-	$-	$-	$4,386.95	$18,192.03	$3,904.39	**$29,510.37**
Apr	$2,983.13	$-	$-	$-	$-	$4,650.17	$19,647.39	$4,255.34	**$31,536.03**
May	$2,237.35	$-	$-	$-	$-	$4,167.61	$17,282.43	$3,465.69	**$27,153.08**
Jun	$2,588.30	$-	$-	$-	$-	$4,386.95	$18,192.03	$4,079.87	**$29,247.15**
Jul	$3,421.82	$-	$-	$-	$-	$5,088.87	$21,102.76	$4,825.65	**$34,439.10**
Aug	$3,597.30	$-	$-	$-	$-	$4,957.26	$20,920.84	$5,088.87	**$34,564.27**
Sep	$3,377.95	$-	$-	$-	$-	$4,430.82	$19,101.63	$5,088.87	**$31,999.27**

Oct	$3,685.04	$-	$-	$-	$-	$4,255.34	$18,010.11	$5,001.13	**$30,951.62**
Nov	$3,027.00	$-	$-	$-	$-	$3,641.17	$15,463.23	$4,167.61	**$26,299.01**
Dec	$2,807.65	$-	$-	$-	$-	$4,167.61	$17,282.43	$3,904.39	**$28,162.08**

Equipment Fuel Cost Table (Estimated Cost for Year 2022 with all Equipment was Diesel):

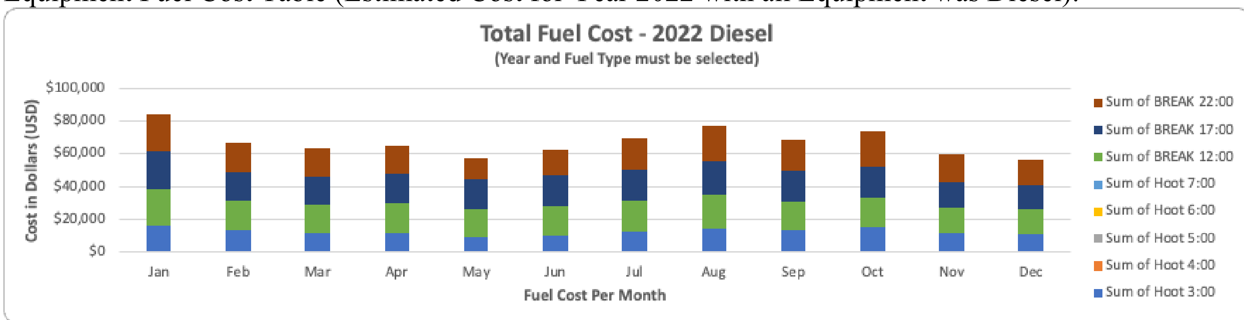


Figure 3.17: (Total Diesel Fuel Cost - 2022)

Table 16: Total Fuel Cost - Diesel (FLTIV, FLTV, RS, & UTR) - 2022

Month	Sum of Hoot 3:00	Sum of Hoot 4:00	Sum of Hoot 5:00	Sum of Hoot 6:00	Sum of Hoot 7:00	Sum of BREAK 12:00	Sum of BREAK 17:00	Sum of BREAK 22:00	Monthly Totals
Jan	$16,246.73	$-	$-	$-	$-	$22,011.70	$23,234.57	$22,710.48	**$84,203.48**
Feb	$13,800.98	$-	$-	$-	$-	$17,818.99	$17,120.21	$17,818.99	**$66,559.17**
Mar	$11,529.94	$-	$-	$-	$-	$17,469.60	$17,469.60	$17,120.21	**$63,589.35**
Apr	$11,879.33	$-	$-	$-	$-	$17,818.99	$18,168.38	$16,770.82	**$64,637.52**
May	$9,433.58	$-	$-	$-	$-	$17,294.90	$17,294.90	$13,626.29	**$57,649.67**
Jun	$10,307.06	$-	$-	$-	$-	$18,168.38	$18,168.38	$16,072.03	**$62,715.85**
Jul	$13,102.20	$-	$-	$-	$-	$18,867.17	$18,867.17	$18,517.78	**$69,354.32**
Aug	$14,325.07	$-	$-	$-	$-	$20,439.43	$20,788.82	$21,662.30	**$77,215.62**
Sep	$13,451.59	$-	$-	$-	$-	$17,644.30	$18,343.08	$19,216.56	**$68,655.53**
Oct	$15,023.86	$-	$-	$-	$-	$18,343.08	$18,692.47	$21,662.30	**$73,721.71**
Nov	$12,228.72	$-	$-	$-	$-	$15,198.55	$15,547.94	$16,596.12	**$59,571.33**
Dec	$10,831.15	$-	$-	$-	$-	$15,198.55	$15,373.25	$14,849.16	**$56,252.11**
Grand Total	**$152,160.22**	**$-**	**$-**	**$-**	**$-**	**$216,273.65**	**$219,068.78**	**$216,623.04**	**$804,125.69**

*Energy.gov Price Diesel $4.08/Gal

Consideration of Hydrogen Technology

In our comprehensive assessment of potential solutions for zero-emission cargo handling equipment at the Port of Hueneme, we considered various energy alternatives, including hydrogen. The decision to not recommend hydrogen at this stage is based on the following considerations:

- **Technology Readiness Level (TRL) Status:**
  - **Assessment:** Hydrogen technology's TRL 7 status signifies that it has been demonstrated in an operational environment but still requires further development to reach full commercialization.
  - **Comparison with Battery Electric:** In contrast, battery electric technology has reached TRL 9, indicating that it's well-established and tested in multiple operational environments. This difference in maturity levels contributes to our current preference for battery electric solutions.
  - **Future Potential:** We recognize the promise of hydrogen, especially for heavy duty applications (container handlers and harbor craft), and will continue to monitor its progression. Any significant advancements in technology readiness could prompt a reevaluation of its applicability.
- **Port of Hueneme's Operational Context:**
  - **Unique Operational Tempo:** Unlike larger container ports, the Port of Hueneme has a different operational tempo and duty cycle reducing the endurance requirements of its equipment. This is largely due to the size of the vessels that make calls at the Port based on the wharf infrastructure; this constrains the overall container volume per vessel.
  - **Battery Discharge and Charging:** The reduced duty cycle allows for less frequent battery discharging and provides shorter charging cycles. This supports optimal battery health by maintaining charge levels between 20% and 80%.
  - **POH Utilization Model:** The POH utilization model demonstrated that most Cargo Handling Equipment did not drop below 70% battery charge before a charging window was available.
- **Infrastructure and Cost Challenges:**
  - **Infrastructure Cost:** Hydrogen would necessitate substantial investment in refueling infrastructure, with estimated costs far greater than EV charging alternatives. Current hydrogen supply is limited, though rapidly expanding. Time will be needed before cost parity with diesel.
  - **Comparison with Electrical Infrastructure Expansion:** The existing electrical infrastructure can be expanded and provide a lower cost of energy for equipment operation.
  - **Alternative Considerations:** Other energy alternatives such as biofuels and synthetic fuels were also considered but did not align with the State of California’s policy goals and posed greater risk of stranded assets.

Impact Assessment

Estimated Environmental Impacts

The surrounding communities range from a 40th to 80th percentile under CalEnviroScreen 4.0. Specifically, the census tract directly east of the port, 6111004400 represents several disadvantaged communities with a population characteristics percentile of 69 and pollution burden percentile of 83. The port has invested heavily over the years to monitor local air quality and reduce air pollutants related to port operations. The SPARC Blueprint is another step in this ongoing effort and has mapped a transition of all cargo handling equipment which would provide notable air quality benefits to this population and others in the air basin. While the port is not the sole nor largest contributor to air pollutants, exhibiting strong leadership and leveraging its convening authority within the local logistics community will enable significant progress towards improving public health and air quality for the county.

By affecting the transition to ZE cargo handling equipment to significantly reduce greenhouse gas emissions and criteria air pollutants, the proposed plan will also be contributing to the State of California Air Resources Board (CARB) 2030 Zero Emission/Near Zero Emission regulation.

GHG Estimating Methodology:

The following formula supplied by CARB was used to calculate the emissions of all CHE equipment. **Emissions = Population * Activity * Horsepower * Load Factor * Emission Factor**

Emissions: CHE emissions for each calendar year

Population: Engine population

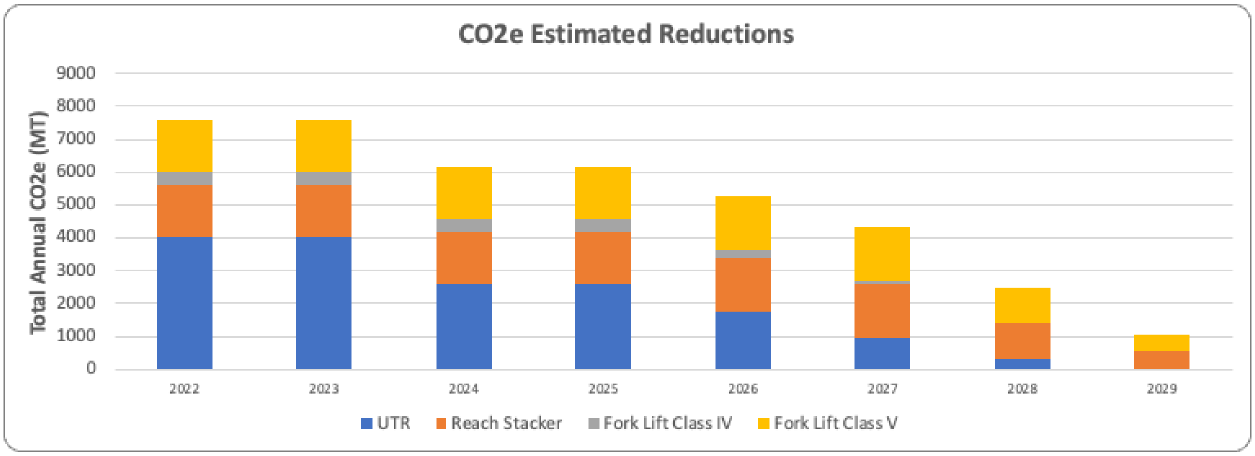
Activity: Average number of hours the engine is running per year

Horsepower: average rated brake-horsepower (bhp)

Load factor: average fraction of engine maximum brake horsepower used while running (unit-less)

Emission factor: emission of pollutant in units of grams per brake-horsepower-hour (grams/bhp-hr) including fuel correction for diesel engines, and deterioration rates

Figure 4: (Combined CO2e Estimated Reductions)

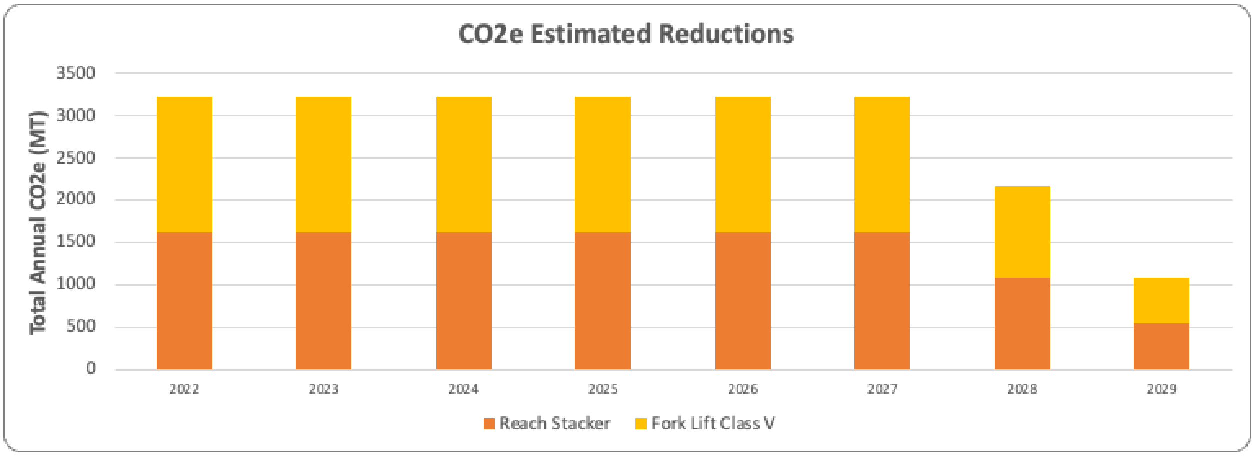


Estimated Reduction in Greenhouse Gas Emissions:

- **Class V Forklift & Reach Stacker Emissions Savings (Metric Tons)**
  - Baseline Emission: A standard Class V Forklift & Reach Stacker emits 539 MT CO2e annually[20].
  - Replacement Schedule: Replacement with battery electric Class V Forklifts & Reach Stackers will occur at a rate of 1 Class V Forklift & 1 Reach Stacker per year starting in 2030.
  - Emission Reduction Calculation:
    - 2027: 1 Forklift & 1 Reach Stacker * 539 MT CO2e = 1078 MT CO2e reduction
    - 2028: 1 Forklift & 1 Reach Stacker * 539 MT CO2e = 1078 MT CO2e reduction
    - 2029: 1 Forklift & 1 Reach Stacker * 539 MT CO2e = 1078 MT CO2e reduction
    - And so on, accumulating over the replacement period.
  - Total Estimated Reduction: Based on the replacement schedule, the total CO2e reduction over the planned timeline would be 3234 MT CO2e annually.

[20] POH - Utilization Tool - Factors derived from Starcrest Emission inventories POLA

Figure 4.1: (Reach Stacker and Fork Lift Class V - CO2e Estimated Reductions)



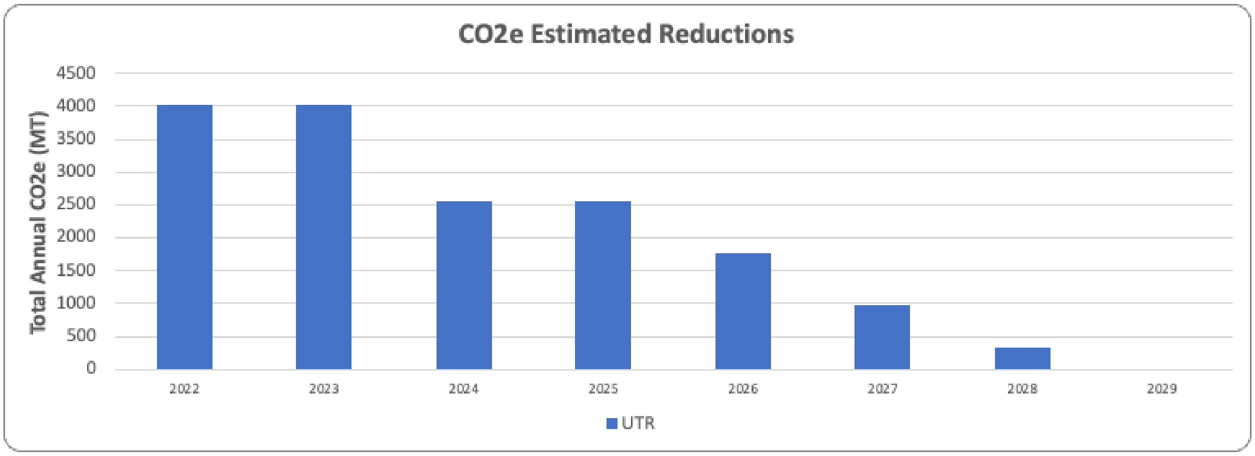
- **Harbor Crane Emissions Savings (Metric Tons)**
  - Baseline Emission: A standard Harbor Crane emits 41.72 MT CO2e annually[21].
  - Replacement Schedule: Replacement with Hybrid Harbor Crane will occur at a rate of 1 Hybrid Harbor Crane per year starting in 2023.
  - Emission Reduction Calculation:
    - 2023: 1 Harbor Crane * 41.72 MT CO2e = 41.72 MT CO2e reduction
    - 2024: 1 Harbor Crane * 41.72 MT CO2e = 41.72 MT CO2e reduction
    - 2025: 1 Harbor Crane * 41.72 MT CO2e = 41.72 MT CO2e reduction
    - And so on, accumulating over the replacement period.
  - Total Estimated Reduction: Based on the replacement schedule, the total CO2e reduction over the planned timeline would be 125.16 MT CO2e annually.
- **UTR Emissions Savings:**
  - Baseline Emission: A standard terminal tractor emits 161 MT CO2e annually[22].
  - Replacement Schedule: Replacement with battery electric terminal tractors will occur at a rate of 5 tractors per year starting in 2026.
  - Emission Reduction Calculation:
    - 2024: 5 tractors * 161 MT CO2e = 805 MT CO2e reduction
    - 2025: 5 tractors * 161 MT CO2e = 805 MT CO2e reduction

[21] POH - Utilization Tool - Factors derived from Starcrest Emission inventories POLA
[22] POH - Utilization Tool - Factors derived from Starcrest Emission inventories POLA

- And so on, accumulating over the replacement period.

- Total Estimated Reduction: Based on the replacement schedule, the total CO_2e reduction over the planned timeline would be 4020 MT CO_2e annually.

Figure 4.2: (UTR - CO_2e Estimated Reductions)



Reduction in Air Pollutants: The shift to battery electric technology also contributes to reductions in other air pollutants.

Energy Consumption: The energy-efficient nature of battery electric tractors is expected to decrease overall energy consumption.

Additional Benefits: Noise reduction and other ancillary benefits.

Workforce Development

The port is actively engaged in several workforce development efforts within the local community as detailed below.

Global Trade & Logistics Class (High School) - Established Program

The port has an MOU with the local Oxnard Union High School District to offer a HS class at the Port where our Port customers present to students about what they do locally, globally, and how they can follow a career in the industry. Top performing student gets a paid internship at the Port.

Port of Hueneme Internship Program - Established Program

The port offers post-college & college level internships to local students who are interested in the various functions of the Port (Port Ops, Finance, Gov't Affairs, Community Outreach, etc.)

Oxnard College Logistics Tract (College) – In Progress

The port collaborates with Ventura County Community College District to create a Certificate Program at Oxnard College for College Students on a "Logistics" Certificate Program. The first Course will be offered Fall 2024.

Ventura County Community College District (College) - In Progress

The port is partnering with all three local community college districts to prepare the future workforce for opportunities in the port sphere related to decarbonization infrastructure projects and greater regional transition. The port is also connecting Community Colleges with Agriculture/Environmental focuses to port related projects, as with colleges focusing on Construction/Engineering/Business

The port's collaboration with the community college district presents a powerful opportunity to leverage upcoming deployments of MD/HD equipment and infrastructure for educational and workforce development programs. The ongoing construction, service, and maintenance of ZE equipment and infrastructure offers opportunities for high quality jobs requiring skilled labor. Training existing and new members of the workforce for these jobs is essential for achieving the goals of the port, state, country, and global community.

Community Outreach

Summary of Community Outreach

The Coalition for Clean Air (CCA) and Breathe Southern California (BSC) are subcontractors on the SPARC project with the goal of providing information to the community on the results of the SPARC project. BSC and CCA distilled the complex technical information presented in the SPARC blueprint to create graphic explanatory documents that were provided in both English and Spanish to the stakeholders who had previously participated in earlier stages of the project and made available online. The audience and focus for the communication materials was informed by the extensive research conducted in the Stakeholder Engagement phase of the project, also conducted by CCA and BSC. This audience of nearly 200 included community members, including environmental organizations, public health organizations, government agencies, elected officials, business organizations, and labor representatives.

Outreach Strategy:

1. Target Audience: We identified key demographics within the potentially affected community, including age, language spoken, and socio-economic factors. An outreach list of 187 members was created during the Stakeholder Engagement phase.

2. Channel Selection: The pamphlet was distributed to stakeholders who had participated in earlier project stages, keeping them informed and engaged. Additionally, was made available online, widening its reach to the broader community.

3. Multilingual Approach: All communications and materials were made available in both English and Spanish.

4. Messaging: The messaging focused on education about the planning efforts, potential benefits and impacts, and the future of the Port's zero emission efforts. The goal was to bridge the gap between the technical information and detailed plans presented in the Blueprint, distilling its essence into a digestible and engaging format. We emphasized transparency, clear information, and a conversational tone to make the information as accessible as possible to the widest audience. Complex terms were simplified, data was presented visually, and language was kept clear and concise.

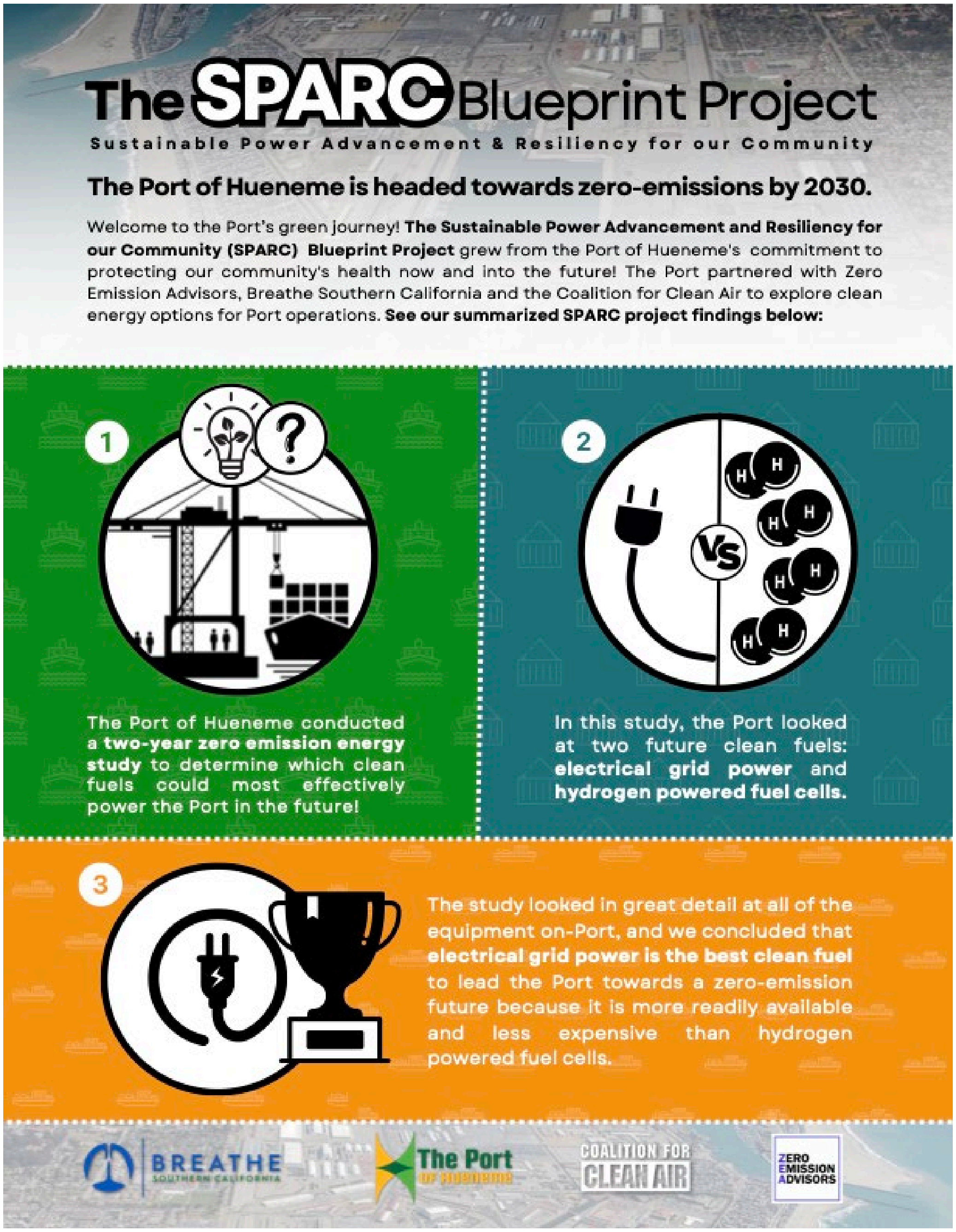
Results:

By presenting complex information in a user-friendly format, the community is empowered to participate meaningfully in the SPARC project's discussions and future implementation. This transparency fosters trust and collaboration, crucial for achieving a successful zero emissions future for the Port of Hueneme.

It will allow the Port to continue to leverage the engagement and expertise of local stakeholders in the future. Materials were created and distributed to summarize key takeaways to stakeholders, and will continue to be made available by Port Staff in ongoing outreach and engagement efforts.

Outreach Material Examples:

Blueprint Flyer



Email Outreach

Exciting News: Going Green at the Port of Hueneme!/Emocionantes noticias: ¡el Puerto de Hueneme se vuelve verde!

Nicole Roberts <nicole@ccair.org>
Tue 2024-02-20 4:17 PM
To:Nicole Roberts <nicole@ccair.org>

1 attachments (2 MB)
Port_of_Hueneme_SPARC_Eng_Esp.pdf;

(Versión en español a continuación)

Dear Community Partner,

We've got some exciting news to share about making operations greener at the Port of Hueneme! Recently, the Port partnered with the Coalition for Clean Air and Breathe Southern California for the **SPARC Zero Emissions Blueprint Project**. This California State grant-funded initiative aims to guide the transition of the Port's cargo handling equipment to zero-emission (ZE) operations by 2030. It has been a very detailed effort to make sure they are taking the right steps to make the Port cleaner and even more environmentally friendly.

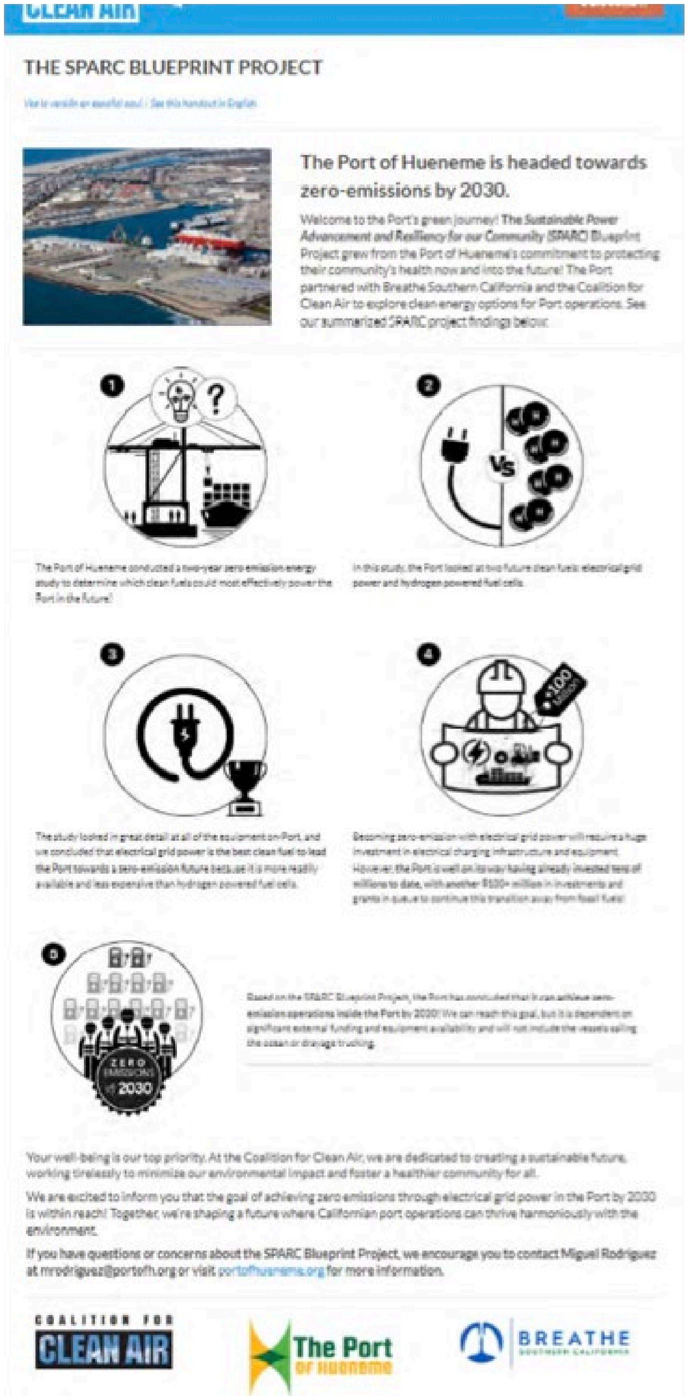
After considering different technologies, the team found that electrical powered equipment is the most practical path to zero-emissions by 2030. It's more available and cost-effective, especially considering the size of the Port. While hydrogen fuel cells show promise for certain uses like trucking, they're not quite ready for prime time.

To make this happen by 2030, the Port is focusing on 1) planning to transition out fossil fueled equipment, and 2) building charging infrastructure and making sure everyone has a fair shot at using it. They will need to upgrade electrical infrastructure, and new policies and incentives will help to make this big shift. Using a mix of battery electric and, in the future, hydrogen-based energy storage will help keep things reliable.

Even though harborcraft and drayage trucking weren't analyzed in the report, the Port of Hueneme is already working on using cleaner technologies for other equipment, like emissions capture barges and fuel cell powered big rigs, to reduce emissions.

We've included a **SPARC Blueprint Project Summary** for you to check out (**También en español**). Let's

Online Landing Page (Coalition for Clean Air Website)



https://www.ccair.org/clean/the-blueprint-sparc-project/

Replicability

Generalized Project Partner & Stakeholder List

The following table is a generalized list of project partners and stakeholders derived from specific stakeholders engaged throughout the course of the blueprint. These stakeholders and project partners represent critical touch points for any planning effort in a port to ensure success.

Stakeholder/Project Partner	**Relevance to Project**
Local Community	The local community is a key stakeholder due to their proximity to the port and substantial interest in economic development and air quality benefits.
Environmental Justice & Advocacy	The environmental justice and advocacy community is an important cohort that is quite active and engaged with the local community. These groups may offer technical, policy, outreach or other inputs to the planning process and foster alignment for future project development efforts.
Commercial Partners & Tenants	The port's commercial partners and tenants are key stakeholders as the primary operators of equipment subject to conversion. They have a vested interest in the operational and commercial viability of any proposed changes and alignment with this cohort is crucial to the port's long-term success.
Technology Providers & OEMs	Technology providers & OEMs are key stakeholders as this cohort provides important information on current and planned technologies. This is critical in a forward-looking planning effort with competing technologies undergoing rapid innovation and commercialization efforts.
Utility Provider	The local utility provider is a key stakeholder in any planning effort potentially requiring electrical service. It is important to communicate early and clearly state forecasted electrical service needs as the implementation of service upgrades can be a long lead, critical path item.
Local Government	Local government stakeholders represent a key stakeholder group to coordinate regional planning efforts with. It is important to foster alignment between surrounding municipalities to identify opportunities for collaboration on projects. This is especially important when considering off-port operations such as drayage trucking.
Sources of Funding	Public and private sourcing of funding are key stakeholder groups to engage with in order to identify potential sources of funding for future projects.

Tools, Software Applications & Data

Tools and software applications useful in MD/HD vehicle infrastructure planning include software for modeling and data analysis, platforms for data visualization, sources of 3rd party data, as well as 3D modeling and computer-aided design (CAD) tools. There are extensive use cases for leveraging Microsoft Excel or Google Sheets if a live document is preferred. These applications are essential for performing operational analysis, financial analysis, and producing a range of data visualizations based on the outputs of said analysis.

For the SPARC Blueprint it was determined that using generalized operational assumptions, as has been done for similar projects, would result in a potentially unacceptable margin of error. This is in part due to the unique nature of operations at the Port of Hueneme, but also because port operations can vary substantially from one port or even terminal to another. Using generalized assumptions could result in selecting the wrong equipment, improperly defining infrastructure requirements based on equipment utilization, and other errors that may result in negative commercial or operational outcomes. Due to the fact that most data collected to-date has been in support of air emissions inventories, the data was largely annualized totals and did not provide sufficient resolution into time of use as well as other key factors.

This spurred an in-depth data collection and modeling exercise to directly correlate vessel calls to equipment utilization on port property, which would produce a time of use output that would allow analysis of charge/fueling levels, windows for opportunity charging, and other critical factors. Third party data of port vessel calls was collected and tabulated against information collected from port operators to develop an equipment utilization model that produced outputs specific to the Port of Hueneme. This model and methodology can be replicated to produce valuable retrospective and forward-looking analysis of port operations. This modeling formed the basis for a lot of decision making and was essential to the planning effort.

The other data set that was critical to modeling efforts was utility meter data, as well as information on the respective tariffs. This enabled a grounded understanding of energy consumption on port as well as the commercial implications of leveraging utility power as a primary source of energy for MD/HD equipment. Additionally, it allowed a correlation between proposed charging windows and variable tariff rates to determine potentially advantageous or disadvantageous windows for charging.

Despite this substantial effort and positive outcome, there are still opportunities to improve the quality of data used in these planning efforts. The optimal outcome would be to leverage telematics data which could show in detail traffic patterns, load profiles, utilization windows, and other data that would be incredibly useful throughout the process.

The most difficult data to collect is cost related data. This is due to the fact the supply chain changes rapidly, and vendors are rightfully cautious about disseminating sensitive commercial information. Cost related data has a very short shelf life, must be managed carefully due to confidentiality, and is often hard to come by for all points of inquiry. For technologies still undergoing commercialization, as are many of the technologies being evaluated in such planning efforts, there are even greater challenges to accurately forecasting costs as the OEM's are still achieving economies of scale, adjusting go-to-market strategies, and rapidly iterating in a research and development capacity. Despite this, it is important to collect the most accurate cost related information possible to provide useful budgetary estimates to key stakeholders.

Ongoing Planning, Monitoring & Analysis

As part of our commitment to a comprehensive and adaptable transition plan, our approach extends to an ongoing monitoring and analysis of various critical factors that could impact the Port's path to zero. Additional planning and project related activities will take into account blueprint outcomes to ensure continuity of planning and policy objectives. Below are the key areas with a brief explanation of our ongoing approach:

1. Technology Advancements & Strategic Partnerships:
- **Objective:** Continuously monitor the technological landscape for relevant advancements in technology to Port operations. Determine strategic partners that can offer beneficial technologies or expertise to support the Port's transition to zero emission operations.
- **Methodology:** Monitor the industry for demonstration projects, attend relevant industry conferences, collaborate, and interface with technology providers, and engage in select pilot projects to test new innovations. Leverage partner subject matter experts for support.
- **Metrics:** Performance improvements, cost reduction, efficiency gains, operational resilience.

2. Regulatory Changes:
- **Objective:** Ensure compliance and alignment with shifting regulatory environments, from emissions standards to incentive programs.
- **Methodology:** Regularly liaise with regulatory bodies, subscribe to updates, and conduct periodic compliance reviews.
- **Metrics:** Changes in regulations, potential risks, and opportunities for leveraging new incentives.

3. Operational Modeling & Data Improvements:
- **Objective:** Improve data collection to ensure a more effective and real-time analysis of the impact on fleet operations, including range, refueling/recharging times, maintenance, and other factors. Support implementation planning in a manner that reduces operational disruptions associated with infrastructure and equipment deployments.
- **Methodology:** Conduct simulation modeling, and field trials with zero-emission vehicles, analyze real-world data, and engage commercial partners for feedback. Implement telematics tracking systems to collect more granular data. Implement effective data warehousing for modeling, analysis, and visualization of more detailed operational data.
- **Metrics:** Changes in operation time, efficiency, and maintenance requirements.

4. Financial Impacts:
- **Objective:** Monitor and analyze the financial impacts of transitioning to alternative energy sources on the port and its commercial partners.
- **Methodology:** Conduct cost-benefit analysis, engage financial experts to model different equipment financing options, and regularly monitor the financial impact of the port's transition with its commercial partners.
- **Metrics:** Return on investment (ROI), total cost of ownership (TCO), potential savings or cost increases.

5. Environmental & Public Health Impacts:
- **Objective:** Quantify the environmental and public health benefits throughout execution of the plan, including reductions in emissions and air quality improvements
- **Methodology:** Utilize environmental assessment tools, collaborate with environmental consultants, and monitor key performance indicators.
- **Metrics:** Reduction in greenhouse gas emissions, air pollutants, and energy consumption.

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