Green Ports

Possibilities on the North Coast

White Paper
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BLUE LAKE RANCHERIA
A Federally Recognized Tribe

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Cover Image Source: Robert Campbell - U.S. Army Corps of Engineers Digital Visual Library.

Background

Humboldt County is an expansive area located in Northern California along a portion of the West Coast of the United States. Specifically, its county center, Eureka, is located about 270 miles north of San Francisco and approximately 100 miles south of the Oregon border. The Humboldt area consists of over 134,000 residents and is home to 11 Tribal Nations. Humboldt is also home to over 40 percent of remaining old growth Coast Redwood forests, and comprises over 110 miles of pristine and rugged coastline, which is the largest county coastline in the United States. According to the U.S. Census Bureau, Humboldt County encompasses 4,052 square miles. For reference, the state of Rhode Island encompasses 1,214 square miles and Delaware 1,982 for a combination of 3,196 square miles.

As a result of a combination of variables including impacts associated with extractive industries, California (and the world) is facing a devastating Climate Crisis. The California Natural Resources Agency developed reports and peer reviewed science-based Climate Change Assessments that helped to inform the state's Climate Adaptation Strategy. These reports detail the existing and expected impacts of global warming in California which include:

- Sea level rise, coastal flooding and coastal erosion;
- Losses to the Sierra snowpack and water supply;
- Forestry and higher risk of fires;
- Damage to agriculture;
- Increased demand for electricity;
- Public health impacts; and,
- Habitat destruction and loss of ecosystems.

Deep Sea offshore wind generation, off the shores of the North Coast, has been identified as one Climate Change Adaptation Strategy. Subsequently, the California Energy Commission established an offshore wind goal of 5,000 MW by 2030 and 25,000 MW by 2045, which would power 3.75 million initially and 25 million homes by mid-century. In mid-2023, the U.S. Bureau of Oceanic and Energy Management (BOEM) executed five offshore wind leases in California - three off the coast of Morro Bay and two off the coast of Humboldt Bay. Developing offshore wind in these five lease areas will be critical in order to achieve California's ambitious clean energy goals.

Although offshore wind may be a viable mitigating strategy to combat climate change, it does not come without concerns. Specific concerns center on issues of port pollution, entanglement, secondary entanglement, noise and light pollution, impact to roadways as a result of increased trucking and traffic, housing, workforce readiness, sexualized violence and more. To address many of these impacts, BOEM requires the two North Coast offshore wind developers to enter into a Community Benefits Agreement with the County of Humboldt that is broadly informed. While the wind developers are required to enter into a Community Benefits Agreement which is informed by stakeholder and Tribal consultation, others, such as the Port Developer, are not legally required to do so with broader community input, as their agreement is between them and the County of Humboldt. Representatives across Humboldt need assurances that their concerns will be addressed in a legally binding agreement, thus pushing for a mechanism that will provide them with agency and industry related protections.

Additionally, in that the Humboldt offshore wind lease is scheduled to become the first deep sea offshore wind operation across the globe, what happens there will set new standards for this evolving industry and serve as a proud example of what can be accomplished in the quest for clean electrification.

About Blue Lake Rancheria

The Blue Lake Rancheria (BLR) is a federally recognized Native American Tribe in northwestern California, near the cities of Eureka and Arcata, five miles inland from the Pacific Coast, along California Highway 299.

Within the aboriginal territory of the Wiyot people, the BLR was founded in 1908 as a 'refuge for homeless Indians.' The Tribe was terminated in 1958, and then reinstated to federal recognition status in 1983. Since then, the Tribe has made a concerted effort to rebuild.

Today, the Tribe has 100 acres of land in trust and thriving economic enterprises that support hundreds of local jobs, government operations and programs, economic diversification, resilience and sustainability efforts, environmental protection, and a wide array of social services.

Since 2002, the BLR has accelerated transitions to a zero-carbon community, for its economic, environmental, health, and overall resilience benefits. The Tribe takes a "lifeline sector" approach to achieving zero-carbon sustainability and resilience. Lifeline sectors include: energy, water, food, communication/IT, and transportation.

Through local, regional, state, national, and public/private partnerships – and sound planning and policy that pairs climate mitigation and adaptation in decision-making – the Tribe is exceeding its goals.

Blue Lake Rancheria Sustainability and Resilience Goals

- Reduce and levelize operational costs (lifeline sector operations and infrastructure).
- Create economic opportunity, including new jobs in the "decarbonized marketplace."
- Achieve zero net carbon emissions by 2030.

BLR is taking a leadership role within the county of Humboldt to call for the development of a "Green Port" associated with the anticipated offshore wind industry off the North Coast.

A Green Port for Humboldt Bay Offshore Wind

The Port of Humboldt Bay is currently home to recreational and commercial fishing, mariculture, a marina, conservation programs, and more. Established mainly for the historical export of forest products and support for commercial fishing fleets, the port is now seen as one of the only sites in California which can serve all three needs of the offshore wind industry from a port infrastructure perspective; The Port of Humboldt has the good potential for staging and integration (S&I), manufacturing and fabrication (MF), as well as operations and maintenance (O&M) for an offshore wind farm. Critical to S&I, Humboldt does not have air draft restrictions (e.g. the Golden Gate Bridge in Bay Areas ports) which fully assembled turbines, expected to be over 1,000 feet above

water, will need for towing out to sea. Development of the port is thus critical for meeting California's offshore wind energy goals, however, it represents an immense project for the rural North Coast.

Members of the Humboldt county community have highlighted the necessity of a "Green Port" throughout engagement with the Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project. One such community organizing group that is working to influence a "Green Port" in Humboldt County, is the Redwood CORE Hub (CORE Hub). CORE Hub includes representation from several Tribal Nations (including Blue Lake Rancheria), environmental groups, Cal Poly Humboldt, Redwood Coast Action Agency, Surf Riders Group and more. CORE Hub has a mission to help solve the climate emergency and act with urgency to transition our built and natural systems to become both decarbonized and resilient at the same time. To do this important work, CORE Hub supports deep community engagement, expert technical assistance, and centers equity by ensuring benefits accrue to underrepresented and marginalized communities first and to the greatest extent.

The purpose of this document is to provide a list of several resources and mechanisms for a transition to a "Green Port" invoked by conversations of offshore wind and accompanied port development in California. We outline why and how seaports are transitioning to cleaner operations, including several examples of port equipment technologies that are being incentivized by state and federal emission reducing initiatives. These resources and case studies are compiled to estimate the feasibility of Green Port development in Humboldt Bay. Lastly, while we have contextualized the North Coast within the offshore wind industry thus far, we seek to provide information on Green Port initiatives generally and acknowledge additional development and economic factors must be considered for the well-being of the Humboldt county community.

Text that is written in green indicates an embedded link to the source of the information within each section. All sources of embedded links can also be found in the References section at the end of this document.

Why Green Ports?

As plans for major port developments are underway in Humboldt Bay, we must consider environmental impacts of port operations on their surrounding communities. The Humboldt Bay region is home to disadvantaged communities and Tribes (Figure 1), which share neighboring land, natural resources, and roadways with the proposed Humboldt Bay Offshore Wind Heavy Lift Marine Terminal Project. Port operations have substantial community health effects on air and water quality as well as light and noise pollution (Appendix A). Attention to the health impacts associated with this port development informs the strategies implemented to mitigate negative environmental inputs in this region.

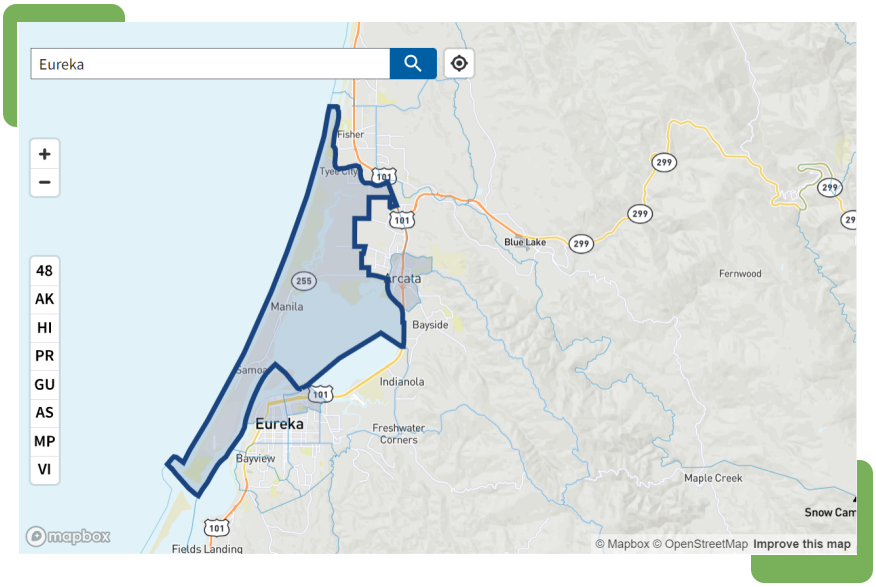

Figure 1. Map of disadvantaged communities which live in the census tract (blue highlight) within Humboldt Bay. Source: Climate and Economic Justice Screening Tool.

According to the International Maritime Organization (IMO), the shipping industry currently contributes to 3% of global carbon emissions and is projected to grow up to 15% or more of global emissions by 2050. This significant carbon footprint impacts not only the climate crisis, but also the health and energy costs of port communities worldwide. Additionally, while emission reductions from ships have been widely researched, many ports have recognized related efforts must be made towards greener port functions. At the same time, organizations like IMO and the World Ports Climate Action Program are accelerating efforts in climate action in the leading ports around the world.

Many of the world's busiest ports have begun the transition to electrify port operations that directly contribute to community scale environmental harms, as well as global climate change. To name a few, Ports of Long Beach, Los Angeles, and Rotterdam have led trends in port electrification through transitioning to electric infrastructure. The U.S. government has recognized the importance of this transition in limiting global warming to 1.5 degrees Celsius to avoid some of the worst effects of climate change (*U.S. Announcements Under the Green Shipping Challenge at COP27*). The EPA has created a National Port Strategy Assessment to address the issue of port GHG emissions, and demonstrates that the most effective strategy is to replace old diesel fueled equipment with new clean technologies. This report reveals that port electrification is not only the best strategy for mitigating climate change, but also is often the most cost-effective long term solution to on-site emissions reductions. Due to the significant contribution of GHG emissions from port activities, the federal government is funding port electrification through multiple grants, incentive programs, tax rebates, and more in support of a global shift towards greener ports (Appendix B). The following document will explore the options available for the development of a Green Port in Humboldt Bay, with a focus on port electrification due to industry trends and the significant reduction of harmful emissions related to this strategy.

Port Electrification

Electrification of port equipment is a cornerstone of Green Port policies, which have already been implemented by many ports globally. This includes transitions to zero-emissions (ZE) and near-zero emissions (NZE) equipment and the development of shore power grids. While these transitions do have higher upfront costs, they reduce social costs of port operation drastically, and are largely supported by ongoing state and federal funding programs (Appendix B). Choosing ZE battery electric over diesel engines is an investment not only in the health of the workers, community, and planet, but also the economic sustainability of the port over time.

According to Liebherr (a multinational equipment manufacturer), electric drive port equipment is in high demand. From 2019-2021 the demand for zero-emissions electric cranes doubled, and the number of electrically equipped cranes followed. This is one example of increasing demands for ZE and NZE port equipment, and the growing availability of these technologies as their sustainability, lowered maintenance costs, and performance prove to better serve ports and their communities over their diesel-only counterparts; read more in Appendix B.

Examples of NZE and ZE Equipment

"Some near-zero and zero-emission technologies that can be used in marine terminals are either commercially available or currently being utilized or demonstrated in port operations. For example, ship-to-shore gantry cranes have been electrically-powered in the [Port of Long Beach and Port of Los Angeles] for decades. Electric-powered

rail-mounted gantry cranes have also operated in various locations for several years in addition to low-emission hybrid-electric rubber-tired gantry cranes. Finally, the use of electric cargo-handling equipment was introduced with the opening of the Port of Long Beach Middle Harbor Terminal operated by Long Beach Container Terminal, and various terminals at both Ports have begun demonstrating electric yard tractors in regular operations."
- San Pedro Bay Ports Clean Air Action Plan, 2017.

Phasing in ZE Equipment

"One approach for making the transition may be to require specific types of new equipment purchases to be zero emissions beginning in a given year, for example, requiring that new yard tractor purchases be zero emissions once they have been proven to be feasible and the infrastructure is available. The useful life of the equipment, by which replacement is required, could be defined in the regulation, similar to how the state's cargo-handling equipment requirements were originally implemented. This approach would allow time for the technologies to develop, for the infrastructure to be installed, and for the terminal operators to avoid stranded assets and to recoup the value of their existing equipment, which is relatively new."
- San Pedro Bay Ports Clean Air Action Plan, 2017.

Top port operations vehicles to transition to NZE and ZE due to disproportionate emissions per unit of equipment:

1. Rubber Tired Gantry (RTG) cranes
2. Yard Tractors
3. Forklifts
4. Top Handler

ZE and NZE Equipment Feasibility

The following sections summarize zero-emissions and near-zero emissions port equipment feasibility by type. Feasibility is determined by evaluating the equipment's performance, market availability, and price. These factors are considered alongside available funding opportunities and incentive programs that support the transition to Green Port infrastructure.

1. Rubber Tired Gantry (RTG) Cranes

RTGs are large mobile gantry cranes used in ports to move, stack, and load containers, which can be one of the largest polluters in ports. The majority of RTGs in use today are powered by large diesel engines, and old cranes which do not conform to current emissions standards are still being utilized at several ports in the U.S. and around the world.

Implementation of Hybrid RTGs and eRTGS are specific to each port. Hybrid RTGs are identified as the most viable RTG for significant near-term emission reductions (for DPM and CO2), annualized operating (OpEx) and capital (CapEx) costs, as well as with minimal disruption to ongoing operations or infrastructure changes in the Ports of Oakland and San Pedro Bay compared to diesel and full electric RTG cranes.

Other U.S. West coast seaports can begin hybridizing existing RTGs and/or purchasing new hybrid RTGs now, since they can reduce costs regardless of high or low operating use (Figure 2), and do not require any infrastructure changes that may be needed for eRTGs depending on the terminal's operating style.

"Hybridizing RTGs will result in healthier workplaces for terminal staff, cleaner air for local communities, and lower climate impacts." - Hybrid RTGs: On the Path to Zero-Emissions, 2020.

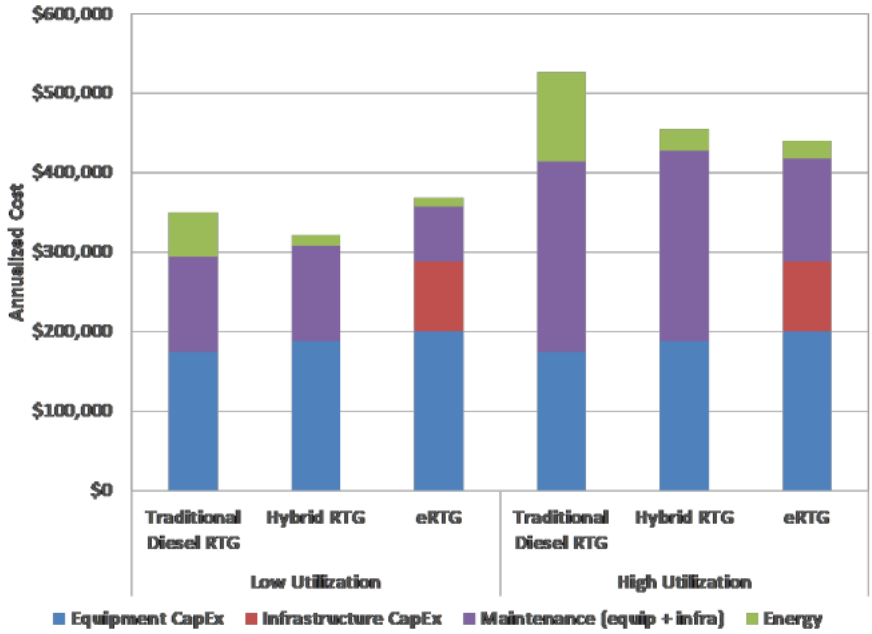

Figure 2. Annualized Cost Comparison of Traditional Diesel, Hybrid, and eRTG with low or high use. Fixed CapEx annualized at 6% interest. Source: Hybrid RTGs On the Path to Zero Emissions.

With upfront infrastructure planning, eRTGs (Figure 3) can still provide substantial cost savings and emission reductions at ports. Grid power can be supplied either by motorized cable reel or a conductor bar/rail system for eRTGs. In the Port of Savannah, bus bar eRTGs demonstrated efficiency gains and approximately $19,000 annual cost savings on average over identical diesel RTGs. Additionally, new-build ZE RTG cranes are equipped with relatively small battery packs which can store and manage regenerative electricity from the down-stroke of each RTG crane lift. Other advances in eRTG technology include concepts with an extra large, grid power battery pack and a design with a grid-free fuel cell/battery pack combination that generates electricity using a hydrogen fuel cell, both by Conductix Wampfler.

Hybrid and eRTGs are both commercially available, including NZE hybrid-electric conversion kits for existing RTG cranes.

Manufacturers of eRTGs:

- Kalmar
- Konecranes
- Shanghai Zhenhua Port Machinery (ZPMC)

Figure 3. Mi-Jack JL1400P eRTG. Source: Mi-Jack Products Website.

2. Yard Tractors

Yard tractors move containers and trailers short distances around a port or other facility. Powered by heavy duty diesel engines, yard tractors are another leading source of carcinogenic diesel particulate matter, oxides of nitrogen (NOx, the primary precursor for formation of ozone), and GHGs at ports.

Battery-electric and NZE natural gas yard tractors are being used and monitored for commercial feasibility at the Ports of Long Beach, Los Angeles, and Oakland. While still "early commercial" products, battery-electric and NZE yard tractors perform comparable hours of operation to diesel counterparts over a typical 8-hour shift. Additionally, NZE natural gas tractors have been proven to emit much lower NOx than state-of-the-art diesel, and provide similar fueling times with lower fuel costs. Battery-electric and NZE yard tractors also have a similar size and look to diesel counterparts, but may be more comfortable with reduced noise and vibration levels.

"...Battery-electric yard tractors will exhibit very low noise levels. Drivers have also routinely noted reduced vibration as being positive attributes for heavy-duty battery electric technology."
- Cargo Handling Equipment Feasibility Assessment Report, 2021.

As California ports are leading the transition to ZE and NZE yard tractors, they will navigate the initial growing pains of this new technology. Battery degradation is possible over time in battery-electric yard tractors, and therefore, characterizing the various duty and charging cycles at actual ports will help researchers understand the rate of degradation on battery packs. For San Pedro Bay Ports, high-utilization operations currently make estimates that a battery-electric yard tractor has 7-11 years of "useful life" compared to diesel's 10 - 12 years. However, future battery replacements are anticipated to be a small cost relative to the total cost of ownership of a battery-electric yard tractor. For the Port of Oakland, battery-electric yard tractor maintenance costs are also assumed to be 30 percent less than the diesel baseline maintenance costs.

In 2021, the California Air Resources Board (CARB) had three battery-electric yard tractors eligible for incentive funds, up to $200,000 per unit, under the California Clean Off-Road Equipment Project (CORE) (Table 1 and Figure 4).

Make	Model	ZE Battery-Electric	ZE Fuel Cell	NZE Hybrid Electric	NZE CNG and/or LNG ICE	CORE Status	Status: SPBP Deployment*
BYD	8Y	√	-	-	-	Eligible	~10 units with SPBP MTO(s)
Kalmar Ottawa	T2E 4X2	√	-	-	-	Eligible	~ 1 to 3 units with SPBP MTO(s)
Orange EV	T-Series	√	-	-	-	Eligible	None with SPBP MTO(s)
Capacity Trucks	TJ9000	-	-	-	√*	Not Eligible	22 units with SPBP MTO(s)
TICO	Pro-Spotter	-	-	-	√*	Not Eligible	None with SPBP MTO(s)
Autocar	ACTT XSPOTTER	-	-	-	√*	Not Eligible	None with SPBP MTO(s)

Sources: OEM websites and publicly available literature (e.g., CORE); *SPBP deployment status based on various grant awards for POLA and/or POLB demonstration / deployment projects, and interviews with MTOs (July/August 2021).
*In recent years, these OEMs may have offered a CNG and/or LNG engine option for yard tractors. Based on publicly available information, all have ongoing capability to produce and sell large numbers of NZE units. However, specific plans and timelines for these OEMs to produce NZE yard tractors are proprietary, and subject to unclear customer demand associated with an uncertain regulatory environment. At least one of these OEMs is expected to announce in early 2022 that it will make and sell NZE yard tractors for port applications.

Table 1. Late 2021 snapshot of yard tractors "commercially offered" as Zero-Emissions (ZE), Near Zero-Emission (NZE), NZE Compressed Natural Gas (CNG) and/or Liquified Natural Gas (LNG) platforms. Source: Cargo Handling Equipment Feasibility Assessment Report, 2021.

CORE has funded approximately 306 ZE or NZE cargo-handling equipment units and 46 percent of which have been yard tractors. (See Appendix B).

Manufacturers of ZE Yard Tractors:

Kalmar Ottawa
BYD
Orange EV2

Figure 4. Mid-2021 snapshot of Zero Emission battery-electric yard tractors eligible for incentives under Clean Off-Road Equipment (CORE) program. Source: Cargo Handling Equipment Feasibility Assessment Report, 2021.

Additionally, TICO manufacturing, the largest yard tractor owner and operators in North America, recently partnered with Volvo to now produce their first electric ZE yard tractors for the retail market (Table 1) (Read more on Volvo Electric Port Equipment). Called the Pro-Spotter, the electric yard tractor features reduced maintenance fees, faster charging, and unique driveline system which are now eligible for CORE incentive funding as well as an additional ten percent voucher enhancement if deployed in Disadvantaged and Low-Income Communities (DAC). The recent advancements in battery-electric yard tractors by manufacturers and encouragement for purchase of clean equipment by the state of California have thus made deployment in ports more feasible than ever before.

3. Large Capacity Forklifts

Large capacity forklifts are used to move heavy load materials around the port.

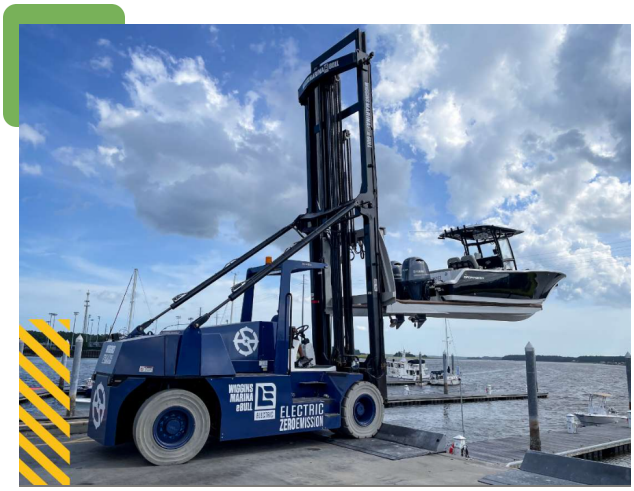

Figure 5. Wiggins Lift Co. eBull Source: Wiggins Lift Co. Inc.

As of 2021, multiple cargo-handling equipment (CHE) original equipment manufacturers (OEMs) have made significant recent progress to develop and demonstrate operation of ZE large-capacity forklifts. Kalmar's battery-electric model DCE160-12 is now listed by CARB as eligible equipment for CORE incentive funding (see California CORE). The Port of Los Angeles also employs Kalmar ZE prototypes during regular port operations.

Additionally, the "Yard eBull" (ZE forklift) from Wiggins Lift Company is available by special order for MTOs (Figure 5). 18 Yard eBulls have been successfully employed at the Port of Stockton through the support of a CA State grant, and have been claimed to run a full shift on a single charge.

While ZE large capacity forklifts are still new to market, this technology is already being implemented by multiple CA ports. Examples from Ports of Los Angeles and Stockton display the possibility of their integration into regular port operations.

4. Top Handlers

A top handler is an off-road truck-like cargo container handler that is used to lift cargo containers from the top.

In the Ports of Long Beach and Los Angeles, "large cargo-handling equipment (CHE) are operated under energy-intensive duty cycles". Because of the intensity of their use cycles and heavy load bearing, OEMs have faced more obstacles in designing a ZE top handler that feasibly compete with their diesel counterparts. These challenges explain the slower development and growth of the ZE top handler market compared to ZE yard tractors. In spite of these challenges, OEMs are still forging a path for battery electric top handlers. Taylor Machine Works, an OEM who supplies 80% of top handlers to San Pedro Bay ports, is a leader in ZE top handler development (Figure 6). *- Cargo Handling Equipment Feasibility Assessment Report, 2021.*

As progress continues to be made in ZE yard tractor development, this equipment is not yet matured or available for wide-scale application. Their certification will be a crucial step in eligibility for incentives under the CORE program.

Figure 6. Taylor Machine Works baseline diesel (left), and 2021 prototype ZE top handlers in the Port of Los Angeles (middle) and Port of Long Beach (right). Source: 2021 UPDATE Feasibility Assessment for CHE – Assessment of Commercial Availability.

Shore Power

Shore power may take the form of local microgrids, wind energy, or other renewable energy sources to reduce emissions at berth. These localized power sources may also be used to charge electric equipment and other port infrastructure, increasing port resiliency. Read more in Appendix B.

Emissions at berth are a major contributor to overall port GHG emissions. As most marine vessels still use diesel engines while at berth to power basic amenities and operations, addressing these sources of pollution is key to Green Port strategies. Shore power infrastructure may allow these vessels to reduce these emissions by offering a place to turn off their engines and plug in to a local electricity grid.

According to Macroeconomic and Environmental Impacts of Port Electrification: Four Port Case Studies port electrification transitions that include shore power increase employment benefits significantly. In each case study, it was shown that the implementation of shore power had overall positive employment changes for the region.

Related Cost Savings

"Vaishnav et al. (2016) determined that for the U.S., nationwide shore power has the potential to produce a net benefit to society of up to $33 million annually considering both costs and health benefits. Gillingham and Huang (2020) used a general equilibrium model of the U.S. energy system to estimate the net benefits of using shore power. Their analysis found that shore power fuel costs, which are generally higher than equivalent marine fuel costs, are largely offset by significant social benefits stemming from improved local air quality and reduced carbon emissions, suggesting the cost-benefit ratio is approximately neutral."- *Shore Power Technology Assessment at U.S. Ports, 2022 Update*

Volvo Electric Port Equipment

Volvo's 2022 Product Catalog includes many electric port equipment options. These E-Series port equipment models are currently available at market.

Crawler Material Handler

*Electric Options Available on all Sennebogen Models.

Crawler			
Model	Reach (ft.)	Engine (hp)	Weight (lbs)
818 R-HD E-Series	30'1" - 34'2"	132	55,115
821 R-HD E-Series	30'6" - 39'5"	141	57,800
825 R-HD E-Series	43'8" - 48'8"	197	72,300
830 R-HD E-Series	47'6" - 55'7"	225	96,780
835 R-HD E-Series	50'11" - 58'6"	305	120,151
840 R-HD E-Series	56'6" - 62'8"	305	130,072
850 R-HD E-Series	55'9" - 62'4"	355	146,300
Green Hybrid 860 R-HD E-Series	59'1" - 75'5"	364	180,000
870 R-HD E-Series	59'1" - 81'11"	355	205,690
875 R-HD E-Series	59'5" - 83'8"	525	308,644
880 EQ Crawler D-Series	114'10"	630	473,994 - 656,978
8100 EQ Crawler E-Series	68'11" - 75'6"	150	284,396 - 310,852
8130 EQ Crawler E-Series	75'6" - 88'7"	162	284,396 - 310,852
8160 EQ Crawler E-Series	88'7" - 98'5"	218	330,000
8320 EQ Crawler E-Series	131'2"	335	573,202
8400 EQ Crawler E-Series	137'10"	2x218	705,479
895 E-Hybrid	131'2"	795	925,942

Table 2. Sennebogen Electric Crawler Material Handler Models. Source: Volvo 2022 Product Catalog.

Table 3. Sennebogen Electric Rubber Tire Material Handler Models. Source: Volvo 2022 Product Catalog.

Rubber Tire Material Handler

Rubber Tire			
Model	Reach (ft.)	Engine (hp)	Weight (lbs)
818 M E-Series	30'1" - 34'2"	132	48,060
821 M E-Series	30'6" - 39'5"	141	52,800
825 M E-Series	43'8" - 48'8"	197	57,600
830 M E-Series	47'6" - 50'1"	225	84,900
830 M-HD E-Series	47'5" - 55'7"	225	88,185
830 M-HD-S E-Series	47'5" - 55'7"	225	90,389
830 M-T E-Series	41' - 50'3"	225	91,300
835 M E-Series	50'11" - 58'6"	305	100,000
840 M E-Series	56'6" - 62'8"	305	100,000
850 M E-Series	55'9" - 62'4"	355	142,600
Green Hybrid 855 M E-Series	59'1" - 68'10"	300	156,950
Green Hybrid 860 M E-Series	59'1" - 75'5"	364	206,132
870 M E-Series	59'1" - 81'11"	355	203,900
875 M E-Series	59'5" - 83'8"	525	308,644

*Specifications may vary based on machine configuration.

Stationary Material Handler

Stationary			
Model	Reach (ft.)	Engine (hp)	Weight (lbs)
818 Stationary E-Series	Consult Factory	132	66,000
821 Stationary E-Series	Consult Factory	141	66,000
825 Stationary D-Series	Consult Factory	175	72,600
830 Stationary E-Series	Consult Factory	225	118,000
835 Stationary E-Series	Consult Factory	305	162,800
850 Stationary E-Series	Consult Factory	355	193,600
Green Hybrid 860 Stationary E-Series	Consult Factory	364	227,000
870 Stationary E-Series	Consult Factory	335	246,400
880 EQ Stationary D-Series	114'10"	630	473,994 - 656,978
8100 EQ Stationary E-Series	68'11" - 75'6"	150	284,396 - 310,852
8130 EQ Stationary E-Series	75'6" - 88'7"	162	284,396 - 310,852
8160 EQ Stationary E-Series	88'7" - 98'5"	218	363,000
8320 EQ Stationary E-Series	131'2"	335	573,202
8400 EQ Stationary E-Series	137'10"	2x218	705,479

*Specifications may vary based on machine configuration.

Table 4. Sennebogen Electric Stationary Material Handler Models. Source: Volvo 2022 Product Catalog.

Crowley: Port Electrification

Crowley Wind Services Group is a wind services provider with offshore and port operations experience and logistics capabilities.

Crowley Wind Services Group (Crowley) is currently in the process of negotiating a lease option with the Humboldt Harbor District to lease and serve as the port's developer of the Humboldt Bay Offshore Wind Heavy Lift Marine Terminal.

According to Crowley's website, their "solutions include full planning and implementation of a port microgrid system to enable shore charging stations, emission barges, power barges, and e-tugs that also support the landside electrification needs for yard equipment, trucks, etc."

For Crowley, this includes:

- Building and utilizing zero-emission vessels in port.
- Identifying gaps in clean energy refueling sources to support vessels operating on electric and renewable power.
- Implementing sustainable practices in design and construction, operations, and administrative practices.
- Adopting new technologies to reduce emissions in port.

California Air Resources Board (CARB) Regulations

California ports will be required to phase in zero emissions and/or hybrid capable commercial harbor craft (CHC) equipment within the next 2 years. While these regulations are primarily focused on marine vessels, the infrastructure required to support these transitions (increased grid capacity, distribution upgrades, microgrids) are also necessary for other Green Port operations and equipment, and may help accelerate these transitions.

CHC Regulations Implementation Timeline for ZE Vehicles

➔ **January 1st, 2023 -** Operators may apply for zero emission and advanced technology (ZEAT) credit

➔ **January 1st, 2024** - All CHC required to use shore power at most facilities

➔ **December 31st, 2024** - ZEAT required for new/newly acquired excursion vessels (zero-emission capable hybrid)

➔ **December 31st, 2025** - ZEAT required for new/newly acquired and in-use short-run ferries (zero-emission vessel)

Case Studies

The following case studies are highlighted due to their successful implementation of Green Port transitions that may inform the routes for Green Port development in Humboldt Bay. Each case demonstrates the timelines by which Green Port policies were adopted, effective electrification strategies, and associated GHG emissions reductions. (Read more in Appendix C).

Port of Long Beach

Green Port Policy - Adopted 2005

Serves as a guide for decision making, and establishes an overall environmental ethic for the Port of Long Beach, placing environmental protection of air, soil, sediment, and water under a single umbrella and establishing them as a top priority.

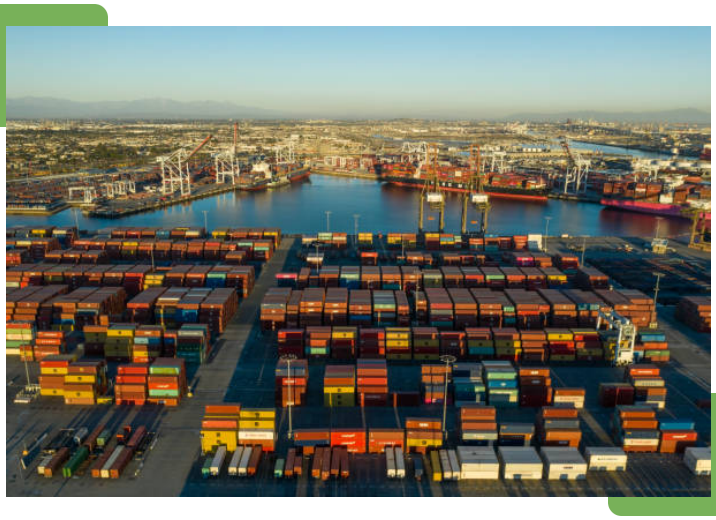

Figure 7. Port of Long Beach. Source:

Policy Elements

- **Wildlife** – Protect, maintain or restore aquatic ecosystems and marine habitats.
- **Air** – Reduce harmful air emissions from Port activities.
- **Water** – Improve the quality of Long Beach Harbor waters.
- **Soils/Sediments** – Remove, treat, or render suitable for beneficial reuse contaminated soils and sediments in the Harbor District.
- **Community Engagement** – Interact with and educate the community regarding Port operations and environmental programs.
- **Sustainability** – Implement sustainable practices in design and construction, operations, and administrative practices throughout the Port.

Key Strategies Employed

- Shore Power or "Cold Ironing"
- Electrification
- Monitoring Port Pollutants
- Clean Air Action Plan

Results

- 91% reduction in diesel particulate emissions
- 63% reduction in nitrogen oxides
- 97% reduction in sulfur oxides

The strategies employed by the Port of Long Beach have shown substantial reductions in GHG emissions. These reductions, alongside other Green Port incentive programs (Appendix C) display the successful implementation of electrified port equipment and shore power infrastructure.

Karmsund Port Authorities

Smart Port - Adopted 2016

Intelliport (Intelligent Port) is a "...concept for increased efficiency, new technology, and more sustainable solutions."

Figure 8. Port of Karmsund. Source: Intelliport.

Key Strategies Employed

- Shore Power
- Electrified harbor cranes
- Zone controlled led lighting

Read more about these strategies in Appendix C.

Results

In less than a decade, the largest port in Western Norway has implemented green port strategies that significantly reduce emissions from port operations. Karmsund Port Authorities have also entered contracts with Zinus (offers Shore Power Cruisers) to develop the next generation of shore power connection. The port plans to sell up to 9 million kWh of electricity to shore powered cruisers per season, reducing CO2 emissions by 2,500 tonnes per season.

Port of San Diego

Climate Action Plan - Adopted 2013

"With a 2020 goal to reduce GHG emissions 10% relative to a 2006 baseline, we are well on our way to meeting our near-term target. Based on activities which occurred in 2016, GHG emissions have decreased 13% since 2006. Beyond 2020, the Port will need to align long term goals with State GHG reduction targets of a 40% reduction by 2030 and a 80% reduction by 2050" (Figure 9).

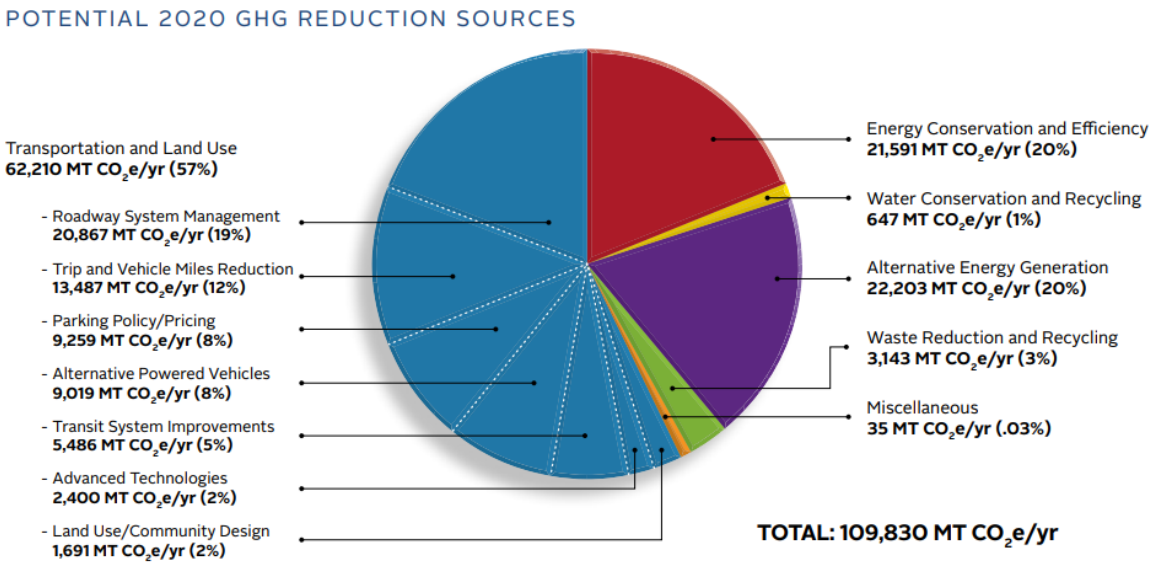

Figure 9. Potential 2020 Reduction Sources. Source: Climate Action Plan.

eWolf

The port of SanDiego is deploying the nation's first all-electric tugboat. “Capable of speeds of up to 12 knots, the eWolf will be powered by a 6.2 megawatt-hour main propulsion battery and two electric motors. The tug has bollard pull (that is, thrust) of about 70 short-tons, which is comparable to its diesel counterpart at the Port of San Diego, and two small generators for emergency use. The generators also allow the eWolf to travel longer distances at a reduced speed.”

Key Strategies Employed

- Tenth Ave. Marine Terminal Microgrid
- Shore Power
- Electrification - eWolf
- Vessel Speed Reduction Program (VSRP)

Results

The port's electrification efforts will lead to emissions reductions of 3,100 metric tons of CO2 in the first 10 years of use of the eWolf, and 47 metric tons of GHG emissions annually from the employment of 2 fully electric cranes.

Conclusion

The convergence of extensive research, robust resources, and compelling case studies collectively underscores the viability of implementing a Green Port in Humboldt County. The technological landscape, strategic frameworks, and financial support essential for such a transformation are readily available. Notably, the feasibility of Zero Emission (ZE) equipment is demonstrated by various OEMs offering market-ready options. These technologies have undergone rigorous testing and have been successfully integrated into some of the world's busiest ports, as discussed in the above case studies.

While further investigation is warranted for broader application of ZE port equipment as these technologies and markets continue to mature, this document serves as a comprehensive compilation of multiple state and federal funding opportunities and incentives that currently support their integration. These initiatives play a pivotal role in facilitating the adoption of environmentally sustainable technologies, and reflect a greater trend towards electrification in all sectors.

The Port of Long Beach serves as a compelling case study, illustrating the potential for a zero-emissions future. With ongoing Green Port initiatives and a commitment to achieving 100% ZE port equipment by 2030, it provides a roadmap for sustainable port development. Similarly, the Ports of Karmsund and San Diego are noteworthy examples, actively advancing electrification and embracing innovative Green Port initiatives.

The global shipping industry's shift towards upgrading existing ports and constructing new ones for sustainable operations is a tangible response to combating climate change through a transition to clean energy. In this context, the establishment of a Green Port in Humboldt Bay aligns not only with the successful trajectories of other California ports electrification but is also of vital importance to the community's well-being. As the port industry takes shape, the pressure for sustainable practices becomes increasingly evident, making the development of a Green Port in Humboldt Bay not just feasible but a crucial stride towards an equitable, sustainable, and successful offshore wind energy future.

Appendix

The text below each embedded link within the Appendices is an overview of the contents within the resource.

Appendix A: Community Health Effects from Port Operations

1. Air Quality

"The emissions from goods movement through trucks, marine vessels, trains, cargo handling equipment as well as from stationary sources such as refineries, oil and gas storage facilities, power generation and storage of open coal piles found near port facilities can introduce many air pollutants with the potential to severely impact the health of near-port communities. Exposure to air pollution associated with emissions from diesel engines can contribute to significant health problems—including premature mortality, increased hospital admissions for heart and lung disease, increased cancer risk, and increased respiratory symptoms—especially for children, the elderly, outdoor workers and other sensitive populations."

2. Water Quality

"Port operations can have a significant impact on neighborhood water quality. Runoff from impervious surfaces can carry pollutants that may prevent people from enjoying local creeks, lakes or bays, and from eating fish and shellfish from these waters. In some cases, community members may rely on fishing as a subsistence source of food."

3. Light and Noise Pollution

"Health impacts of light and noise pollution from port operations can include hearing impairment, high blood pressure and sleep deprivation."

Appendix B: Electrification Resources and Funding

Clean Off-Road Equipment (CORE) Vouchers

"The most readily accessible incentive funding beginning in 2020 will be CARB's Clean Off-Road Equipment Voucher Incentive Project (CORE) administered by CALSTART on a first-come-first-serve basis. The program will likely provide incentives up to 80% of the capital cost differential between diesel and NZE/ZE equipment. Yard tractors can be purchased via CORE with a voucher up to $180,000, plus an additional 10% ($18,000) for operations within a Disadvantaged Community (DAC)."

Clean Heavy Duty Vehicle Program

"EPA will be distributing this $1 billion in funding for clean heavy-duty vehicles between now and 2031. $400 Million will be going to communities in nonattainment areas. We will be offering grants and/or rebates to eligible recipients to replace existing heavy-duty vehicles with clean, zero-emission vehicles. Further, we will supply funds for:

- *zero-emission vehicle infrastructure*
- *workforce development and training*
- *planning and technical activities*

All in support of zero-emission vehicle adoption and deployment. EPA anticipates this new funding opportunity will become available for application through a notice of funding opportunity (NOFO) released in early spring 2024."

Clean Ports Program

"The Inflation Reduction Act of 2022 provides EPA with $3 billion to fund zero-emission port equipment and technology and to help ports develop climate action plans to reduce air pollutants at U.S. ports. This new funding program will build on EPA's Ports Initiative that helps our nation's ports, a critical part of our infrastructure and supply chain, address public health and environmental impacts on surrounding communities. EPA anticipates this new funding opportunity will become available for application through a notice of funding opportunity (NOFO) released in late winter 2024."

Electrification of California Ports

"This technical memorandum is provided to offer information related to select California ports' current and future impact on the State's energy grid. The study is limited to container and roll on/roll off (RoRo) marine terminals at the following California public ports: San Diego, Long Beach, Los Angeles, Hueneme, San Francisco, Oakland, and Richmond. The study does not address cruise, liquid and dry bulk, and break-bulk terminal electrification. The information provided within this technical memorandum is based on data collected from regional port partners, publicly available research, and Moffatt & Nichol (M&N) experience in the maritime sector."

Liebherr Press Release: Mobile harbour cranes with electric drive in high demand

"In the 2021 sales year, demand for Liebherr mobile harbour cranes with an e-drive has risen sharply. Compared to 2019, the number of units equipped with an electric motor has even doubled. Liebherr has been successfully using a hybrid drive concept consisting of a diesel engine and an electric drive for the mobile harbour cranes product segment for over 20 years. In addition to emission-free handling, the benefits of e-drive include cost savings and less maintenance."

Low Carbon Fuel Standards (LCFS) Credit Calculator

The state allows owners of electric vehicle infrastructure to generate revenue through the Low Carbon Fuel Standards Program. This calculator can help you estimate your potential revenue.

Port Community Electric Vehicle Blueprint

Developed by the Port of Long Beach, a national leader in Green Ports. This blueprint serves as a toolbox for seaport communities looking to transition to zero-emissions equipment.

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

"*To address this challenge, the Port of Long Beach has developed the Blueprint to establish a comprehensive strategy to assist in the identification of the most cost-effective technologies, financial incentives, and infrastructure upgrades for creating the model sustainable, zero-emissions port ecosystem of the 21st century. The Blueprint is designed to accelerate the deployment of electrified transportation at local and regional levels with a holistic and forward-thinking view of regional transportation planning.*"

NATIONAL PORT STRATEGY ASSESSMENT: Reducing Air Pollution and Greenhouse Gases at U.S. Ports

"*EPA developed this national scale assessment to:*

- *Examine current and future emissions from a variety of diesel sources operating in port areas;*
- *Explore a range of available strategies to reduce emissions from port-related trucks, locomotives, cargo handling equipment, harbor craft, and ocean-going vessels; and*
- *Provide an assessment tool for state and local governments, ports and port operators, Tribes, communities, and other stakeholders to:*
- *Inform their priorities and decisions for port areas; and*
- Achieve more emission reductions across the United States."

Port Emissions Toolkit Guide No.1: Assessment of port emissions

"This guide is intended to serve as a resource guide for ports intending to develop or improve their air pollutant and/or GHG emissions assessments."

Port Emissions Toolkit Guide No.2: Development of port emissions reduction strategies

"This guide is intended to serve as a resource guide for ports intending to develop an emissions reduction strategy (ERS) for port-related emissions sources. This guide builds on the principles discussed in Guide No.1 and describes the approaches and methods that can be used by ports to develop, evaluate, implement and track voluntary emissions control measures that go beyond regulatory requirements."

"This guide focuses on measures to be considered as part of an ERS plan for those port-related mobile emissions sources that are associated with cargo movement. This guide highlights key elements that ports should consider when developing an ERS, which includes evaluating, planning and implementing mobile source emissions control measures as part of an overall ERS. This guide also contains links to resources that provide further details into specific areas."

Shore Power Technology Assessment at U.S. Ports - 2022 Update

"...characterizes the technical and operational aspects of shore power systems in the U.S. and shows an approach for comparing shore power and vessel emissions while at berth."

Shore Power Emissions Calculator (SPEC)

"The shore power emissions calculator can calculate emissions of criteria and greenhouse gas (GHG) pollutants based on vessel and fuel inputs, and the regional electricity grid mix. The SPEC Version 2023 is substantially similar to Version 2022.a, with the noted exception that it relies on recently updated eGRID 2020 electricity power plant air pollutant emission factors." Source: *Shore Power Technology Assessment at U.S. Ports | US EPA, 2023*

U.S. Announcements Under the Green Shipping Challenge at COP27

"The United States is leading the transition to zero-emission shipping as part of our commitment to tackle the climate crisis at home and internationally. For example:

The Inflation Reduction Act includes a new $3 billion rebate and grant program at the Environmental Protection Agency to provide funding for zero-emission port equipment or technology, along with technical assistance for electrification and emissions reductions planning and port climate action plan development. Because ports can be a significant source of pollution, this program will promote the public health of near-port communities.

The U.S. Department of Transportation announced more than $703 million to fund 41 projects in 22 states and one territory that will improve port facilities through the Maritime Administration's Port Infrastructure Development Program. The funding, made possible by the Bipartisan Infrastructure Law and additional Congressional appropriations, will benefit coastal seaports, Great Lakes ports, and inland river ports, helping improve supply chain reliability through increased port capacity and resilience, more efficient operations, reduced port emissions, and new workforce opportunities.

The United States is working with countries in the International Maritime Organization (IMO) to include in the revision of the Initial IMO Strategy on the Reduction of GHG Emissions from Ships a goal of phasing out greenhouse gas emissions from international shipping to zero no later than 2050, goals for 2030 and 2040 that align with the midcentury target, and dedication to a just transition that leaves no one behind."

Volvo 2022 Product Catalog

"Sennebogen has been a leading name in the global material handling industry for over 65 years. Sennebogen offers a complete range of purpose- built machines to suit virtually any material handling application. Sennebogen proudly serves as a leading provider of specialized equipment solutions for recycling and scrap metal yards, demolition, barge and port operations, log- handling, transfer stations and waste facilities from coast to coast."

Zero-Emission Cargo-Handling Equipment Feasibility Assessment - Port of Oakland

"Identify near-term (2019-2023) commercially available equipment for a high-level (planning level) analysis of costs needed to transform current container handling equipment (CHE) using petroleum-based fuels at the Seaport to near-zero-emissions and zero-emissions (NZE and ZE) goods movement. Estimate timing of initial efforts for each land-side equipment type based on cost, incentive funding, charging patterns, and other relevant factors."

Appendix C: Case Studies Resources

Port of Long Beach Key Strategies

Shore Power or "Cold Ironing"

"The Port has completed more than $185 million worth of dockside power hookups and other infrastructure to facilitate shore power. Beginning in 2017, California mandated that at least half of all container ships run on shore-side electricity at berth. Carriers are subject to an additional requirement: Each fleet must reduce its total emissions by 70 percent."

"The rule affects fleets calling at the ports of Long Beach, Los Angeles, San Diego, Oakland, San Francisco and Hueneme and applies to all operators."

Electrification

"The Port has recently received nearly $70 million in total grant funding from the California Energy Commission and the California Air Resources Board to move ahead with six projects to demonstrate zero emissions equipment and advanced energy systems in Port operations.
The 2017 Clean Air Action Plan Update set the Port of Long Beach on the path to zero-emission goods movement, with a goal of transitioning terminal equipment to zero emissions by 2030 and on-road trucks by 2035."

Monitoring Port Pollutants

"Port of Long Beach uses environmental control booths that analyze air and noise quality in real-time and provide port actors of where hotspots of emissions can occur. This helps manage and measure green port programs and identify areas of improvement."

Clean Air Action Plan

"Identifies strategies to reduce pollution from every source – ships, trucks, trains, cargo-handling equipment and harbor craft."

Karmsund Port Authorities Key Strategies

Shore Power

"KH has invested in three shore power units, at a total cost of around 13 million NOK."

Electrified harbor cranes

"In the spring of 2019, KH's new mobile harbour crane arrived at Husøy. KH has taken on additional cost of between NOK 3 and 4 million for the crane to be run on electricity, and for measures for energy efficiency. Per hour run on electricity instead of diesel, there is a 52kg
reduction in Co2 emissions"

Zone controlled led lighting

"KH has replaced the lighting system at Killingøy and Husøy, for zone-controlled lighting. This is far more energy efficient, and less disturbing to the surroundings."

Intelliport Document

"Many exciting developments are taking place at the interface between environmental concern and new technology. With that in mind, the Karmsund Port Authority has adopted "lean, clean and green" as a guideline for its work. This conveys such goals as being efficient, low-cost and simple, being well organised and unfussy, and using as much renewable energy as possible. Attention will not be devoted to the environment at the expense of efficient and economic operation. The Karmsund Port Authority is considering a number of technological solutions which will yield a highly efficient and cost-effective port. Its technology, efficiency and environmental project has been named Intelliport – the intelligent port system."

Zinus to develop next-gen shore power solution for cruise ships

"Norwegian provider of shore power solutions Zinus AS has received a contract from compatriot company Havnekraft AS to develop and deliver a flexible shore power solution for cruise ships calling at Haugesund Cruise Port."

Port of San Diego Key Strategies

Tenth Ave. Marine Terminal Microgrid

"The Port was awarded a $4.9 million grant from the California Energy Commission for the installation of a renewable, solar-powered microgrid at the Tenth Avenue Marine Terminal, one of the Port's two marine cargo terminals. Solar photovoltaic panels will power the microgrid, which includes battery energy storage, energy efficiency lighting retrofits, electrical infrastructure improvements, and a centralized microgrid controller. The microgrid will provide a resilient source of power while reducing greenhouse gas emissions at the Tenth Avenue Marine Terminal, saving the Port approximately 60 percent per year on electrical utilities at the terminal and enabling the operation of critical terminal infrastructure for approximately 4 hours in the case of an electrical outage."

"The microgrid, which is anticipated to be installed starting early 2021, will provide back-up power to Port-operated facilities, including security infrastructure, site lighting, offices, and the existing jet fuel storage system, in support of the Port's role as a Strategic Port. As one of 17 designated U.S. Strategic Ports, the Port stands ready to support military deployment activities."

Shore Power

"Many cruise ships at B St. Cruise Ship Terminal and Tenth Avenue Marine Terminal plug into shorepower to reduce emissions. Shore power saves consumption of fuel that would otherwise be used to power vessels while berthed, and eliminates the air pollution associated with consumption of that fuel. Currently, 70% of passenger vessel and refrigerated cargo fleets which visit the Port of San Diego are using much cleaner electricity instead of running their diesel engines while at berth."

Electrification

"The advancement of electric vehicles and alternative fuels are beginning to reshape how we transport freight in and out of our maritime terminals. The Port of San Diego along with its tenants and operators are pioneering the latest technologies, which will drastically reduce emissions from the maritime sector. Through public/private partnerships and innovative pilot projects, the Port will continue to support the next generation of freight vehicles and equipment to improve the environmental condition of our operations."

Fully electric U.S. tugboat eWolf propelled by SCHOTTEL

"Crowley's new 25-metre-vessel eWolf, the first all-electric tug to be built and operated in the United States, will be equipped with SCHOTTEL systems. As part of the fully integrated electrical package, SCHOTTEL supplies two RudderPropellers type SRP 430 featuring the LE-Drive ("Embedded L-Drive"). MariHub, the data IoT Gateway and monitoring solution, completes SCHOTTEL's scope of delivery."

San Diego is getting nation's first all-electric tugboat

"Operated by Crowley Maritime Corporation, the 82-foot tugboat called the eWolf will slash greenhouse gas emissions for the port and its neighbors in Barrio Logan and National City by running on electricity instead of diesel fuel."

Vessel Speed Reduction Program (VSR)

"The Vessel Speed Reduction Program is a voluntary strategy to reduce air pollutants and greenhouse gas emissions from cargo and cruise ships by reducing speeds in the vicinity of San Diego Bay. Studies show that reducing vessel speeds decreases air emissions which ultimately lead to better air quality. Reduced speeds can also reduce propeller noise, which benefits provides an added benefit to the marine ecosystem."

"The Port asks cargo vessel operators entering or leaving San Diego Bay to observe a 12-knot speed limit. For cruise ships, a 15-knot limit is requested. The Vessel Speed Reduction zone extends 40 nautical miles seaward from Point Loma."

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