

Acknowledgements

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Acronyms & Abbreviations

AC	Advisory Committee or alternating current
ACTI	Advanced Cleanup Technologies Incorporated
AMECS	Advanced Maritime Emissions Control System
APL	Shipping line formerly known as American President Line
APT	Advanced Petroleum Technologies, Inc.
BET	battery electric truck
BEV	battery-electric vehicle
BMS	battery management system
CAAP	Clean Air Action Plan
CAMS	control alarm monitoring system
CARB	California Air Resources Board
CEC	California Energy Commission
CHE	cargo-handling equipment
CNG	compressed natural gas
CO ₂	carbon dioxide
COVID-19	Coronavirus Disease 2019
DOC	diesel oxidation catalyst
DOE	United States Department of Energy
DPF	diesel particulate filter
EVSE	electric vehicle supply equipment
GHG	greenhouse gases
HP	horsepower
kW	kilowatt
kWh	kilowatt-hours
LNG	liquefied natural gas
MW	megawatt
NO _x	oxides of nitrogen
OGV	ocean-going vessel
PHEV	plug-in hybrid electric vehicle
POLA	Port of Los Angeles
POLB	Port of Long Beach
PM	particulate matter
RFI	Request for Information
RTG	rubber-tired gantry crane
SPS	Smart-Plug System
South Coast AQMD	South Coast Air Quality Management District
TAP	Technology Advancement Program
USEPA	United States Environmental Protection Agency
ZE	zero emission

1 INTRODUCTION

The Ports of Long Beach and Los Angeles (Ports) comprise one of the world's premier seaport complexes and are recognized as global leaders in environmental stewardship. The 2017 Clean Air Action Plan Update (CAAP), jointly approved by both Ports, calls for aggressive strategies to reduce pollution and greenhouse gases and to ultimately transition to zero emissions. Development and deployment of new technologies are critical to the success of these strategies, and the Ports, in partnership with numerous stakeholders, have embarked on an unprecedented effort to hasten this transformation.

The Technology Advancement Program (TAP), is at the cornerstone of this clean-air effort. TAP was initiated in 2007 to facilitate the development and demonstration of clean technologies to support the original CAAP goals. The TAP is a funding program that relies heavily on partnerships with private industry and technology developers as well as strong relationships with regulatory agencies, which actively participate as members of the TAP Advisory Committee to evaluate technology projects, support the commercialization of these nascent technologies, and help leverage funds. More than a decade later, the TAP has undertaken more than 50 projects spanning test cycle development, hybrid and alternative fuel technology demonstrations, and zero-emission equipment deployment.

To achieve the scale of technology development required for a zero-emission transformation, however, the Ports have needed to expand beyond the TAP, which has traditionally funded smaller scale, generally lower cost, stand-alone technology demonstrations applicable to the entire port complex. Over the past few years, the Ports have made significant investments in larger scale clean-equipment deployments at specific terminals and logistics centers, benefiting from local, state, and federal grant funds. These projects have allowed the Ports to test near-zero and zero-emission technologies on a larger operational scale and to test multiple types of equipment – cargo-handling equipment, trucks, harbor craft, and ships – at a single location, replicating the real world. Lastly, the Ports have partnered with other agencies on technology demonstrations to maximize resources and to support regional efforts to reduce port-related emissions, even beyond port boundaries, such as truck demonstrations.

These various approaches – TAP, grant-funded demonstrations, and cost-sharing partnerships with other agencies – comprise the Ports' technology advancement portfolio, and this multi-pronged investment strategy has enabled the Ports to leverage dollars, engage more stakeholders, and diversify their technology projects. Since 2007, through these combined efforts, the Ports and their partners have invested well over \$402 million in technology advancement. These efforts are summarized in Section 5 of this Technology Advancement Annual Report in order to showcase the breadth and scope of the increasing emphasis on clean technology development and implementation in port operations.

Importantly, this Technology Advancement Report focuses only on pre-commercial technology advancement, which is one aspect of the CAAP. The Ports also invest heavily in the deployment of commercialized equipment and technologies, for example, by providing financial incentives for cleaner trucks and ships and by securing grants to help operators upgrade to cleaner commercially available equipment. These efforts are documented in the CAAP Progress Reports found at www.cleanairactionplan.org.

Significant Events in 2022

In 2022, the Ports, along with the rest of the world, began to recover from the COVID-19 pandemic. Technology demonstration projects that had been delayed during the pandemic resumed in 2022. The global supply-chain disruptions and record cargo volumes that had stretched marine terminals to the brink in 2021 began to ease last year, returning the Ports to a steady state of higher, but manageable, activity. Rising cargo volumes have pushed terminal equipment and trucks to their performance limits, highlighting the need to rethink the performance expectations of zero-emission equipment; equipment that was adequate pre-disruption now needs to run for longer hours at a higher use intensity, which changes the technology performance expectations. These new expectations are shaping future TAP demonstrations to ensure that clean equipment and vehicles can perform at the highest levels, under all conditions.

Meanwhile, in 2022, the California Air Resources Board (CARB) approved regulations mandating cleaner harbor craft and drayage-truck fleets. These regulations provide a clear roadmap for the path forward for port operators. The Ports can focus on technologies likely to be acceptable under these new regulations and forgo projects unlikely to align with CARB’s vision. For harbor craft, CARB is requiring Tier 4 engines with diesel particulate filters as a near-term requirement with bonus credit for zero-emission vessels; anything less than these technology platforms is not a good investment of TAP funds. Likewise, CARB has clearly signaled its intent to require zero-emission drayage trucks, obviating the need for demonstrations of combustion platforms. Further, the need to comply with the At-Berth Regulation, which went into effect in 2021, still requires substantial new technology development over the next five years; the Ports and their partners may play an important role in helping these technologies come to fruition.

In 2022, the State and federal government continued to invest billions of dollars in port infrastructure, clean technologies, specifically for heavy-duty, often port-related, equipment and vehicles. This funding will support the deployment of commercialized zero-emission trucks and cargo-handling equipment as well as new technology demonstrations. With zero-emission equipment poised to enter the market as a result of State incentives, there is opportunity to identify performance gaps in early-commercial cargo-handling equipment and to target TAP resources toward solutions. Meanwhile, the TAP may be able to leverage State funds for new demonstrations of cleaner off-road equipment, including locomotives and ships.

Looking Ahead

The Ports are committed to the goals set forth in the 2017 CAAP Update, particularly the push to transform terminal equipment to zero-emission technologies by 2030 and the truck fleet to zero-emission technologies by 2035. Commercialized zero-emission trucks are expected to arrive by 2024, but there are still gaps in charging and fueling infrastructure as well as a need for better understanding of large-scale zero-emission operations and performance requirements for vehicles and equipment that have been tested to their limits this past year. There is more work to be done on ocean-going vessel technologies and harbor craft in support of newly implemented and upcoming regulations. On the bright side, the technology pathways for trucks and cargo-handling equipment are becoming clearer. Given the significant levels of State and Federal funding available in the near term, and the collaborative framework already in place, the TAP can focus its resources on projects for which the Ports’ involvement is critical and on projects aligning with the CAAP’s vision of a cleaner future. In time, as more clean technologies become commercialized, the role of the TAP may increasingly narrow, and at some point, may become irrelevant. At that point, the Ports can shift resources away from technology advancement and toward implementation.

Agency Partnerships

Project selection is supported by the TAP Advisory Committee (AC), comprised of the South Coast AQMD, California Air Resources Board (CARB), California Energy Commission (CEC), and United States Environmental Protection Agency (USEPA), Region 9. A list of current AC members is included in Appendix A. The AC serves in an advisory capacity to Port staff for screening, evaluating, and recommending projects that merit further development or demonstration. In addition, the AC members provide information as it pertains to co-funding from their agencies that could be used to move projects toward implementation.

Technology Advancement Program
Advisory Committee



2 TECHNOLOGY ADVANCEMENT ACCOMPLISHMENTS IN 2022

In 2022, the Ports continued to implement technology advancement projects, the updates for which are documented herein. Major accomplishments in 2022 include:

- Completed the South Coast AQMD Daimler Demonstration of Heavy-Duty Electric Trucks
- Completed the South Coast AQMD Water-in-Fuel Retrofit Technology Demonstration
- Completed studies that assessed the feasibility of public charging and fueling in and near the port complex, including potential sites and business models.
- Initiated the POLB Electric Vehicle Blueprint Phase II Project (Section 5.3)
- Initiated the Toyota Tsusho America, Inc. (TAI) Hydrogen Top Handler and Mobile Hydrogen Refueler Project (Section 5.5)
- Continued to demonstrate pre-commercial zero- and near-zero emission equipment and vehicles throughout each port by leveraging port and tenant resources with state and federal funding. These ongoing demonstrations are providing valuable project data and “lessons learned” to inform deployment once these technologies have been commercialized.
- Completed the 2021 Update to the CAAP Feasibility Assessment for Cargo-Handling Equipment¹.
- Issued for public comment the Draft 2021 Update to the CAAP Feasibility Assessment for Drayage Trucks².
- Initiated an update to the TAP Guidelines to reflect new and upcoming regulations that drive the Ports and their tenants toward zero-emission operation.
- Maintained an updated TAP website³ to assure transparency and enhance communication of our technology results, as well as to provide resources for technology developers.

Table 1 provides an overview of active 2022 technology advancement projects, including those funded through the TAP, cost-sharing with other agencies, and large-scale grant-funded demonstrations. Section 5 provides a detailed status update for each of these projects, including specific accomplishments in 2022 and projected milestones for 2023.

Table 1: 2022 Technology Advancement Project Snapshot

Project Title	Project Description	Details	Technology
Advanced Infrastructure Demonstration Project (Port of Los Angeles)	Design and demonstrate inductive charging infrastructure to support opportunity charging for 10 battery-electric yard tractors.	Section 5.1, Page 10	Zero Emission
Effenco Electric Active Stop-Start™ Technology Demonstration	Evaluate effectiveness of Effenco’s Electric Active Stop-Start™ technology, a hybrid upgrade that automatically turns off the engine when a vehicle is stopped, providing electric power to vehicle systems such as transmission or HVAC without engine.	Section 5.2, Page 12	Idle Reduction

¹ <https://cleanairactionplan.org/strategies/cargo-handling-equipment/>

² <https://cleanairactionplan.org/strategies/trucks/>

³ <http://www.cleanairactionplan.org/technology-advancement-program/>

San Pedro Bay Ports Technology Advancement Report
2022 Annual Report and 2023 Priorities

Project Title	Project Description	Details	Technology
Electric Vehicle Blueprint Phase II Project (Port of Long Beach)	The objective of this project is to implement procedures outlined in Phase I of the Port of Long Beach Community Electric Vehicle Blueprint, which is a plan to work towards a zero-emission future through the deployment of electrified transportation	Section 5.3, Page 13	Zero Emission
Everport Advanced Cargo Handling Equipment Demonstration Project (Port of Los Angeles)	Develop and demonstrate three battery-electric yard tractors powered by a smart charging system and two battery-electric top handlers.	Section 5.4, Page 15	Zero Emission
Toyota Tsusho Hydrogen Top Handler and Mobile Hydrogen Refueler Project	Demonstrate the repower of a diesel top handler and develop and deploy a “mobile” hydrogen refueler to support the demonstration.	Section 5.5 Page 17	Zero Emission
Nett Technologies Inc. BlueMAX™ NOVA 320e Harbor Craft Demonstration	Design, manufacture, and verify the BlueMAX™ NOVA 320e. This emissions control system consists of a combined active diesel particulate filter with upstream diesel oxidation catalyst (DOC) in front of a selective catalytic reduction system with ammonia slip catalyst.	Section 5.6, Page 19	Tier 4, Cleanest Available
Pasha Green Omni Terminal Demonstration Project (Port of Los Angeles)	Develop and demonstrate two battery-electric yard tractors and two battery-electric on-road trucks; three 21-ton electric repowered forklifts; a microgrid with battery storage capability tied to a rooftop solar array; and a land-based ship emissions capture and treatment system.	Section 5.7, Page 20	Zero Emission and Other Platforms
Pasha Hawaii Ohana Class LNG-Powered Container Ships Project (Two New Builds)	Design and build two Ohana class vessels powered with internal combustion dual-fuel (LNG & diesel) propulsion technology to facilitate the primary use of cleaner burning LNG. AMP capability included. These propulsion engines will meet Tier III standards.	Section 5.8, Page 22	LNG
Pasha Horizon C9 Vessel LNG Engine Repower Demonstration Project	Repower one C9 class vessel from steam turbine power to internal combustion dual-fuel (LNG & diesel) technology to facilitate the primary use of cleaner burning LNG and provide a significant engine efficiency increase. AMP capability will also be included in this repower. These propulsion engines will meet Tier III standards.	Section 5.9, Page 23	LNG
South Coast AQMD Daimler Heavy-Duty Electric Trucks Demonstration	Develop and demonstrate 20 heavy-duty battery-electric trucks, ten of which will be deployed to serve the Ports.	Section 5.10, Page 24	Zero Emission

San Pedro Bay Ports Technology Advancement Report
2022 Annual Report and 2023 Priorities

Project Title	Project Description	Details	Technology
South Coast AQMD Retrofit Technology Development - Water-in-Fuel Technology	Design, manufacture, and demonstrate ocean-going vessel Water in Fuel (WiF) retrofit technology on the MSC Anzu vessel. The technology is designed to achieve a 40% NOx reduction from Tier 2 engines at lower than 50% SMCR (Specified Maximum Continuous Rating) of the main engine.	Section 5.11, Page 27	OGV Retrofit
South Coast AQMD Zero-Emission Cargo Transport (ZECT) II Demonstration	ZECT II encompasses the development of seven drayage trucks by five different contractors and includes PHEV, BEV and fuel cell technology.	Section 5.12, Page 30	Zero Emission
Shore-to-Store Project (Port of Los Angeles)	Develop and demonstrate 10 hydrogen-fuel-cell Class 8 trucks, build two heavy-duty hydrogen fueling stations, and demonstrate two electric yard tractors at the Port of Hueneme and electric forklifts at Toyota warehouses.	Section 5.13, Page 31	Zero Emission
Sustainable Terminals Accelerating Regional Transformation (START) Project (Port of Long Beach)	Demonstrate more than 100 pieces of zero-emission terminal equipment and trucks at three California seaports, develop a battery-hybrid electric tugboat, deploy two ships with some of the cleanest available engines, and advance workforce development programs to support sustainable goods movement.	Section 5.14, Page 33	Zero and Near-Zero Emission
Zero-Emission Terminal Equipment Transition Project (Port of Long Beach)	Repower nine RTG cranes for full-electric power, demonstrate 12 zero-emission yard tractors and two smart charging systems, and convert four LNG trucks to plug-in hybrid electric trucks with LNG range extender.	Section 5.15, Page 35	Zero and Near-Zero Emission

Please access additional information for completed TAP projects at the program website: <http://www.cleanairactionplan.org/technology-advancement-program/>

3 PROGRESS TOWARD ZERO EMISSIONS

As summarized in Table 1 and detailed in Section 5, the Ports continue their strong commitment to zero-emission technology development and demonstration. In 2022, the Ports led or supported 13 major zero- and near-zero emission demonstration projects valued at over \$320 million in funding from the various project team members (including public and private match funding). Our efforts have made San Pedro Bay the hub of technology advancement for heavy-duty equipment with the world's highest concentration of zero-emission trucks and terminal equipment in a single port complex. This report covers major zero-emission technology projects undertaken by the Ports, including:

- 114 new electric charging outlets
- 81 zero-emission terminal equipment, including yard tractors, top handlers, rubber-tired gantry cranes (RTGs), and forklifts
- 37 zero-emission drayage trucks (battery-electric and fuel cell)
- 2 new hydrogen fueling stations
- 1 portable hydrogen fueler

In addition to directly supporting zero-emission technologies by funding demonstration projects and supportive efforts, such as the development of test protocols and charging standards, the TAP provides a forum for multiple agencies to work together and leverage resources toward our common goal. TAP supports zero-emission technology projects led by other agencies by providing technical expertise, facilitating partnerships with port operators, offering a test bed for port-related technologies, and writing support letters to help other agencies secure funding for these demonstration projects. This direct and indirect support is critically important to making “zero emissions” a reality. An example of this support outside the traditional TAP structure is the Joint Electric Truck Scaling Initiative (JETSI) Project, which is being led by South Coast AQMD. The JETSI Project supports the development and demonstration of zero-emission, battery-electric truck technologies and infrastructure, as well as solar and energy storage technologies to enable development and demonstration of microgrids. The JETSI project directly supports the Ports’ Clean Air Action Plan 2017 Update, which established a goal for zero-emissions drayage trucks entering and exiting the Ports by 2035. Further, the mayors of Long Beach and Los Angeles committed the San Pedro Bay Ports to participating in a large-scale zero-emission truck project such as this in their 2017 joint declaration. As stated in the declaration, the intent of a 50-100 truck deployment would be to test zero emissions drayage trucks at scale in order to encourage the production of vehicles, demonstrate feasibility, and provide meaningful data in real world port operations. The Ports’ respective Boards of Harbor Commissioners approved the combined funding request of \$3 million in 2022.

The Ports also provided indirect support for South Coast AQMD’s partnership with Volvo Group North America (Volvo) under a CARB grant, the Volvo Low Impact Green Heavy Transport Solutions (LIGHTS) Project. Under this project, Volvo and its project partners demonstrated over 50 on- and off-road zero-emission trucks with associated infrastructure and solar power. The Ports contributed expertise and in-kind labor.

For more detailed information regarding in-use zero-emission technology deployed throughout the San Pedro Bay Ports, please refer to each Port’s respective Emissions Inventory⁴.

⁴ POLA Emissions Inventory: <https://www.portoflosangeles.org/environment/air-quality/air-emissions-inventory> and POLB Emissions Inventory: <https://polb.com/environment/air/#emissions-inventory>

4 2023 TECHNOLOGY ADVANCEMENT PRIORITIES

In 2023, the Ports must continue to support implementation of the 2017 CAAP Update, including a stronger focus on larger scale pilot demonstration projects that will assess the operational, maintenance, and environmental costs and benefits of zero- and near-zero emission vehicles and equipment in port applications. At the same time, the Ports must shift TAP resources to the areas in greatest need of technology development. As zero-emission vehicles and equipment become commercialized and widely available for purchase, they will no longer qualify as TAP projects, and the Ports can redirect TAP funds to more pressing needs.

Additionally, the Ports must continue to support the numerous demonstration projects already underway. These demonstration projects are in high gear, bringing early deployments of zero-emission equipment and trucks and active charging infrastructure construction. The Ports have learned from these projects and continue to identify gaps in understanding, which will shape future funding priorities. The Ports will continue to prioritize the successful completion of these projects not only to meet grant deadlines and compliance requirements but also to expedite the path to zero emissions. In 2023, the Ports look forward to bringing more projects online to show in-use operation for a variety of zero-emission technologies and to identify areas of future investment.

Thus, in 2023, the Ports commit to the following technology advancement priorities:

- Launch demonstrations to support promising technologies for ships, harbor craft and locomotives;
- Explore concepts for terminal equipment charging and fueling infrastructure that provide for fast, safe electric charging and/or hydrogen refueling; and
- Consider new projects submitted under the TAP's ongoing Request for Information (RFI) review process⁵.
- Update the TAP Guidelines in order to prioritize projects aligned with presumed regulatory compliance pathways and those that enhance performance in early commercial vehicles and equipment.
- Continue to execute the many grant-funded and TAP-funded demonstrations underway; complete the projects within grant deadlines; and pave the way for additional technology advancement based on lessons learned;
- The Ports will continue to monitor Federal grant programs under the Bipartisan Infrastructure Law and the Inflation Reduction Act to fund major emission reduction grant programs and projects to support port tenants. The Ports will support tenants in their efforts to implement zero-emission technology by providing guidance and application leadership, as applicable, to a number of state and federal funding programs including the Diesel Emission Reduction Act, Port Infrastructure Development Program, etc.

As zero-emission truck technology nears full commercialization, this source category is being phased out of TAP. For trucks, the Ports are working to develop and implement the Clean Truck Fund⁶ (CTF) Rate. The Clean Truck Fund (CTF) Rate is a key component of the Ports' efforts to transition to a zero-emission truck fleet by 2035, as established in the Clean Air Action Plan. The CTF Rate is expected to generate approximately \$90 million in the first year, or \$45 million per Port, by charging a \$10 fee per twenty-foot equivalent unit for trucks entering the Ports. Zero-emission

⁵ The TAP RFI is available at: <https://cleanairactionplan.org/request-for-information-san-pedro-bay-ports-technology-advancement-program/>

⁶ <https://www.portoflosangeles.org/environment/air-quality/clean-truck-program>

trucks are exempt from this fee. On March 24, 2022, POLA's Board of Harbor Commissioners approved a three-year CTF Rate Spending Plan, allocating 100% of the fund for zero-emission trucks in the first year. POLB⁷ is exploring various options to make the incentive funds available as quickly as possible, including working to identify a third party administrator in the next few months to assist with allocation of some of the funding. POLB has already provided \$4 million to various early action zero-emission and low NOx truck programs in recent years.

⁷ <https://polb.com/environment/clean-trucks/#clean-truck-fund-rate-faqs>

5 2022 PROJECTS

This section provides additional detail for technology advancement projects that were new or active in 2022. These projects represent the full portfolio of technology investments, including projects funded and managed by both Ports through the TAP, projects funded by grants and managed by one Port (the lead port is indicated in parentheses), and projects led by other agencies for which the Ports have contributed cost-share funds.

For information on completed TAP projects, please access the Final Reports archived on the program website: <https://cleanairactionplan.org/technology-advancement-program/reports/>.

5.1 Advanced Infrastructure Demonstration Project (Port of Los Angeles)

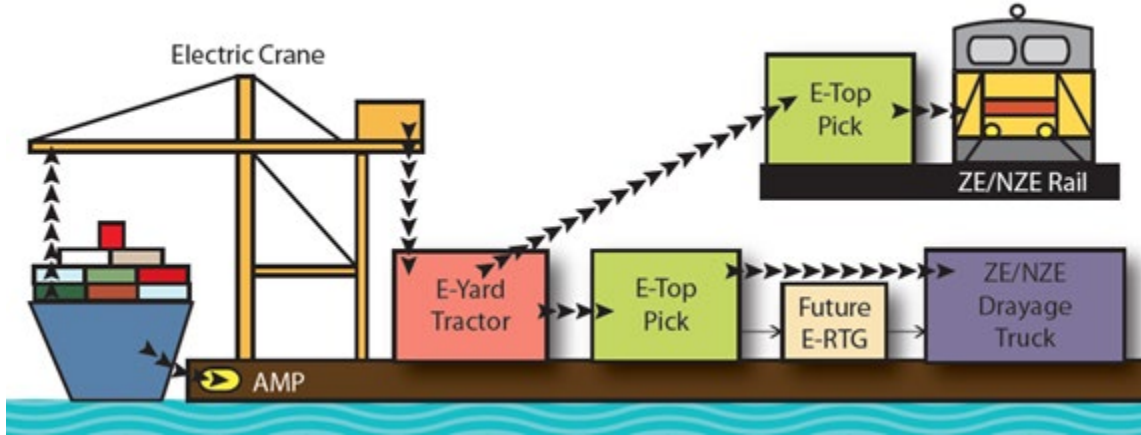
Project Description

The Port of Los Angeles Zero-Emission Freight Vehicle Advanced Infrastructure Demonstration (AID) will model elements of a system that could ultimately electrify a major container terminal at the United States' busiest container port. The demonstration will take place at West Basin Container Terminal (WBCT), which received grant funding to demonstrate 10 battery-electric yard tractors. The AID project, funded largely by a CEC grant, will enable POLA to support the design and development of advanced charging technology for the 10 yard tractors providing even better capability to complete two full 8-hour shifts each day, a proof of concept to install additional chargers and deploy more vehicles.

For this project, POLA is partnering with Wireless Advanced Vehicle Electrification, LLC (WAVE) to design and demonstrate inductive charging technology to support each of the 10 yard tractors at WBCT's equipment corral, as well as two opportunity charging stations at the central break location where the yard tractors can obtain a quick top-off mid-shift. WAVE's wireless charging pads allow completely hands-free connection for equipment to charge without a physical connection to the power source (i.e., charging with no plug). Each 250-kilowatt (kW) system can charge two trucks at up to 125 kW each. WAVE will install five systems at WBCT's equipment corral to charge 10 next-generation BYD battery-electric yard tractors while off-duty. Additionally, to increase runtime for the electric yard tractors, an opportunity charging station will be installed at a centrally located break facility on WBCT's terminal to charge two yard tractors whenever there is a break opportunity for a top-off mid-shift, such as 30-minute lunch breaks or even 10-15 minute breaks. Finally, a battery energy storage system (BESS) will be installed at the base charging stations to minimize peak-demand charges that could result from a sudden influx of 10 high-power yard tractors all charging off the electrical grid simultaneously.

Ultimately, this project will not only demonstrate a series of prototype electrified equipment and charging mechanisms but will showcase a model of how to fully realize the vision of a zero-emission container terminal, also referred to as the zero-emission pathway, shown in Figure 1.

Figure 1: Port of Los Angeles Zero-Emission Pathway Concept



Project Partners & Budget

This project is funded by a \$7.8 million CEC grant. The yard tractors will be purchased with supporting funds from South Coast AQMD in the form of a USEPA Targeted Air Shed Grant and with additional funds from OEMs, demonstration partners, and POLA. The total project cost is projected to be \$11.3 million. Table 2 summarizes the funding contributions.

Table 2: Advanced Infrastructure Demonstration Project Funding Partners

Project Partners	Contributions
Port of Los Angeles	\$392,500
California Energy Commission	\$7,842,270
US Environmental Protection Agency	\$1,344,750
South Coast Air Quality Management District	\$442,750
OEMs and Demonstration Partners	\$1,326,885

Accomplishments in 2022

Construction was completed at the Area #1 opportunity chargers near the break area and the chargers were commissioned. The first four WAVE units were constructed, validation tested, and successfully integrated with BYD yard tractors. Equipment safety and operational training was conducted. Two of the integrated yard tractors began performing operational duties at WBCT, charging at the Area #1 chargers. Yard tractor modifications and retrofits continue to be implemented, in order to align the equipment with operational needs of the terminal. Construction was nearly completed in 2022 for the Area #2 chargers at the main corral, with UL inspection of the WAVE gear expected Q1 2023. Energizing Area #2 likely will be delayed until early 2024, due to extended lead-times for the transformer, switchgear, and BESS.

2023 Milestones

The following activities are expected in 2023:

- Q1 final on-site field certification from UL for Area #2 WAVE chargers.
- Q1 delivery of WAVE integrated and modified BYD yard tractors three and four.

- Delivery of Area #2 transformer, switchgear, and BESS.
- Installation and integration of transformer, switchgear, and BESS.
- Energizing and commissioning Area #2 charging corral (likely Q1 2024).
- Integration, modification, and delivery of the remaining six yard tractors (likely Q1 2024).
- Commissioning and demonstration of all ten yard tractors and 12 charging units (likely Q1 2024).

5.2 Effenco Electric Active Stop-Start™ Technology Demonstration (Port of Los Angeles)

Project Description

The objective of this project was to demonstrate Effenco's Active Stop-Start electric hybrid technology to reduce yard tractor emissions and evaluate viability for large-scale implementation. For this project, six yard tractors at APM Terminals were retrofitted with Effenco's technology; however, due to required repairs on one of the six yard tractors, unrelated to the Effenco system, only five yard tractors were demonstrated during the project period. The demonstration was cut short after five months (November 2021 through March 2022) and the project was closed out ahead of schedule in 2022, due to Effenco filing for bankruptcy on April 6, 2022.

The Effenco technology is a hybrid upgrade that automatically turns off the combustion engine when the vehicle is immobile and provides electric power to vehicle systems such as transmission or HVAC when the engine is off, thus reducing the amount of vehicle engine run time. Along with the installation of the Start-Stop technology, Effenco's bi-directional telemetry systems was installed to monitor the performance of the retrofit with the precision of capturing over 100 operating parameters every tenth of a second.

In previous studies of Effenco's technology with New York City Department of Sanitation, engine run time was reduced by 39-52%, resulting in a 12-31% reduction in fuel consumption and related emissions. For this project, Effenco projected emission reductions ranging from 30-60% percent, depending on pollutant type. Demonstration data showed engine run time reduction between 1% and 89% and fuel savings ranging between 1% and 60% per yard tractor per day, depending on equipment usage levels. Over the course of the demonstration, Effenco's system ran for 1,592 hours and resulted in an average fuel reduction of 13% and average active engine reduction of 24%.

A significant challenge of this project was to identify a CARB approval pathway that would allow the installation of parts or modifications. CARB has several pathways relating to the sale, use, or modification of emissions control systems, including verification, certification, and aftermarket parts. Throughout the project period, Effenco engaged CARB on receiving such authorization via any pathway that CARB might deem applicable. Originally, Effenco intended to seek CARB verification of their system as a retrofit device approved for emissions reductions. However, in project meetings, CARB informed the project team that they do not issue verification for hybrid or anti-idle technology due to varied emission reductions owing to vehicle operations and duty cycle. As for certification, it is required for new vehicles and engines in order to display emissions compliance. Given that Effenco is not the OEM for the yard tractor, they were unable to move forward with the certification process. In 2021, Effenco applied for an aftermarket parts exemption and engaged CARB on the experimental permit process.

Ultimately, Effenco did not achieve an aftermarket parts exemption. In September 2021, CARB granted Effenco a one-year experimental permit to test their Active Start-Stop electric hybrid

technology on six yard tractors at APM Terminals. In September 2022, APM Terminals decommissioned the six yard tractors that had the Active Start-Stop electric hybrid technology installed to comply with CARB's experimental permit.

Project Partners & Budget

The Ports originally planned to contribute \$180,000 in co-funding to this project with a total project budget of \$625,163. With the project terminated ahead of schedule due to Effenco's bankruptcy, not all tasks were completed. As a result, each Port contributed \$71,775 for a total of \$143,550.

Accomplishments in 2022

Effenco successfully demonstrated their technology on five yard tractors at APM Terminals through March 2022. Despite the challenges, the demonstration provided valuable insight on how operator behavior can affect the performance. The effectiveness of this start-stop technology led to system reconfiguration to consider operator driving style and improved functionality. The project was closed out in 2022, prior to demonstration completion, due to Effenco filing for bankruptcy.

5.3 Electric Vehicle Blueprint Phase II Project (Port of Long Beach)

Project Description

In 2019, the Port of Long Beach finalized the first-ever [Port Community Electric Vehicle Blueprint \(EV Blueprint\)](#) to identify the path toward zero emissions and to provide a cost-effective, field-tested approach to electric vehicle planning that other California seaports can replicate. To assist reaching the Port's zero-emission goals, the EV Blueprint Phase II is a major step toward ensuring the Port's partners have the necessary equipment, vehicles, infrastructure, financing, workforce and community benefits to be successful.

In 2021, the Port was awarded \$2.5 million from the California Energy Commission for the Port's EV Blueprint Phase II. One component of the EV Blueprint Phase II is development of Zero-Emission Infrastructure Master Plans (ZEIMPs). The ZEIMPs will define the optimal operational layout and infrastructure necessary for future zero-emission operations of more than 200 pieces of cargo-handling equipment at Pacific Container Terminal at Pier J, one of the largest container terminals at the Port. A separate ZEIMP will also evaluate the infrastructure required to support electrifying the Port's fleet of vehicles and vessels. To support this fleet, the Port will install ten Level 2 charging stations, which will be immediately available for use with the remaining six stub-outs ready for future electric chargers at the Port's Maintenance Facility. The Port will also install electrical infrastructure with 10 stub-outs to support future electric chargers at the Joint Command and Control Center (JCCC).

As part of the EV Blueprint Phase II effort, the Port committed to developing the Electric Drayage Truck Charging Station Siting Toolkit. The toolkit will provide information about requirements, design guidelines, and permitting for heavy-duty charging infrastructure. The goal of the toolkit is to equip interested private facility owners with the resources necessary to install heavy-duty charging stations at their sites (Figure 2).

Figure 2: Port of Long Beach Guidance Document



To further support a zero-emission future, the Port will analyze workforce skills and competencies needed for drayage truck and infrastructure maintenance, and recommended training. The final component of the project includes the 2021 and 2024 updates to the San Pedro Bay Ports Feasibility Assessments for Cargo Handling Equipment and Heavy-Duty Trucks.

Project Partners & Budget

This project is partially funded by the \$2,500,000 that the California Energy Commission is contributing. Additional funds come from the Port of Long Beach’s match commitment in the amount of \$847,072. The total project cost is projected to be \$3,347,072. Table 3 summarizes the funding contributions.

Table 3: Electric Vehicle Blueprint Phase II Project Funding Partners

Project Partners	Contributions
California Energy Commission	\$2,500,000
Port of Long Beach	\$847,072

Accomplishments in 2022

In 2022, the Port of Long Beach released an open solicitation to select consultants to develop the Port’s two ZEIMPs. The Port selected P2S Engineering to create the ZEIMP for SSA Marine at Pier J and Jacobs Engineering (Jacobs) for the Harbor Department, a draft of which was completed by Jacobs in December 2022.

To prepare the draft, weekly meetings and in-depth data gathering and analysis occurred. Jacobs also developed a preliminary report on the energy demands of the Harbor’s vehicles and vessels.

The Port plans to develop the Pier J ZEIMP following the Board of Harbor Commissioner's approval of the selected consultant in first quarter 2023.

Construction and electrical permits were acquired for the planned infrastructure development at JCCC and the Port Maintenance Facility. In October 2022, the Maintenance Facility's preliminary 30% design for infrastructure deployment was completed. Conduits and 10 stub-outs were installed at the JCCC in December 2022.

The Electric Drayage Truck Charging Station Siting Toolkit is posted on the Port of Long Beach's website along with its companion document⁸, "Toolkit Essentials". The final 2021 Feasibility Assessment for Cargo-Handling Equipment⁹ was completed and may be found on the Clean Air Action Plan (CAAP) website. The final 2021 Feasibility Assessment for Drayage Trucks was under final report review in the fourth quarter of 2022. The development of the workforce assessment report began in 2022.

2023 Milestones

The following activities are expected in 2023:

- Final Board of Harbor Commissioners' approval of the ZEIMP contract with P2S Engineering.
- Initiating work on the Pier J ZEIMP.
- Finalization of the Harbor Department ZEIMP
- Finalization of the design plan needed for electrical infrastructure deployment at the Maintenance Facility.
- Substantial completion of construction work at the JCCC.
- Finalization of 2021 Feasibility Assessment for Drayage Trucks.
- Finalization of the LBCC workforce assessment report.

5.4 Everport Advanced Cargo Handling Equipment Demonstration Project (Port of Los Angeles)

Project Description

POLA's Everport Advanced Cargo-Handling Equipment Demonstration Project successfully completed demonstration of two Taylor battery-electric top handlers and is currently demonstrating three BYD Motors battery-electric yard tractors integrated with the Cavotec Smart Plug-In System (SPS). To support this project, POLA invested in terminal reconstruction including new switchgear and the associated electrical infrastructure. Prior to the infrastructure redevelopment, the terminal did not have enough energy capacity to support the EV equipment. The upgrade was designed to allow for the potential addition of several more battery-electric yard tractors to Everport's fleet.

Project Partners & Budget

The project is being funded by a CEC Clean Transportation Program grant, formerly known as the Alternative and Renewable Fuel and Vehicle Technology Program, in the amount of \$4,524,000, with project cost share commitment in the amount of \$2,238,331, for a total projected

⁸ <https://polb.com/environment/our-zero-emissions-future/#program-details>

⁹ <https://cleanairactionplan.org/strategies/cargo-handling-equipment/>

project cost of \$6,762,331. (With rising costs, POLA's current expenditure for the supporting infrastructure is \$2,615,997.) Table 4 summarizes the funding contributions.

Table 4: Everport Advanced CHE Demonstration Funding Partners

Project Partners	Contributions
Port of Los Angeles	\$1,071,428
California Energy Commission	\$4,524,000
OEMs and Demonstration Partners	\$1,166,903

Accomplishments in 2022

The zero-emission Taylor top handlers successfully completed 12-months of in-service demonstration in 2021 and provided valuable lessons learned for future models. The top handlers continued to be utilized in daily operations during 2022.

Three BYD battery-electric yard tractors integrated with SPS charging began demonstration in May 2022, following commissioning and training activities. Challenges regarding adaptability of the charging interface between the Cavotec arm and funnel and the BYD charging platform resulted in several design modifications prior to demonstration. Additional factory modifications to the headache rack and beavertail were performed on the yard tractors, further delaying demonstration. In April 2022, brackets supporting the SPS funnel box housing on two of the yard tractors needed to be replaced, which BYD completed in August. Brackets on the third yard tractor were replaced proactively in September. On October 30, the onboard charging pin on the truck side of one of the yard tractors was broken and would not engage. Cavotec completed repairs in December. Figure 3 shows the BYD zero-emission yard tractors engaged with the Cavotec SPS.

Figure 3: BYD Battery-Electric Yard Tractors Engaged with the Cavotec Smart Plug-In System



The SPS chargers were connected to a temporary power source in September 2021 and switched to the new permanent power from the substation in March 2022. The infrastructure redevelopment construction project was completed in August 2022.

2023 Milestones

The following activities are expected in 2023:

- Complete twelve-month demonstration of the Cavotec SPS and BYD yard tractors.
- Complete data analysis and final report.

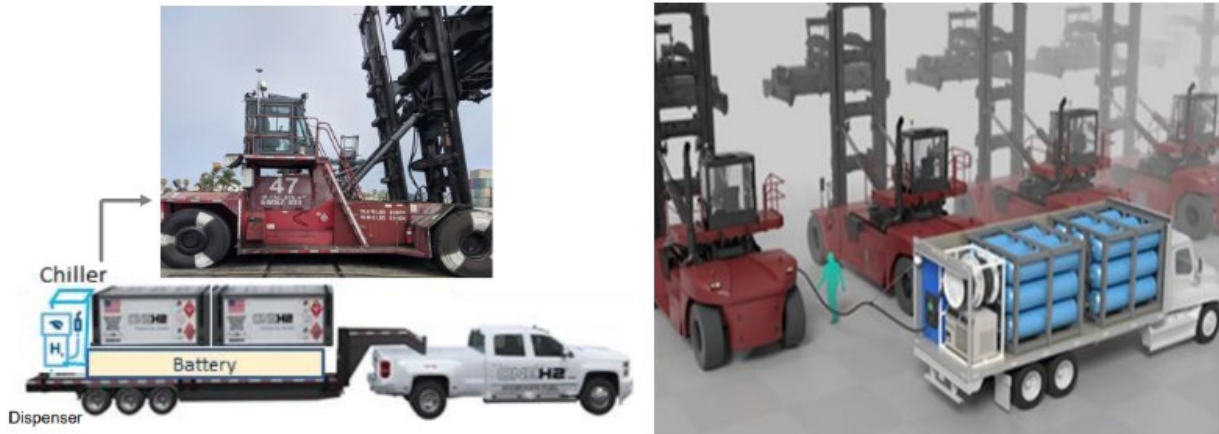
5.5 Toyota Tsusho Hydrogen Top Handler and Mobile Hydrogen Refueler Project (Port of Los Angeles)

Project Description

Toyota Tsusho America, Inc. (Toyota Tsusho) will demonstrate the repower of a diesel top handler. In other words, the engine of the diesel top handler will be replaced by a hydrogen fuel cell powered propulsion system with the help of US Hybrid. This portion of the project will be achieved through a series of steps. First, the diesel-powered top handler's performance will be assessed to provide a benchmark for future comparison. Using produced engineering drawings and simulation models, the fuel cell system will be integrated into the top handler after the diesel powertrain is removed. Once the top handler repower is complete, the demonstration will take place at Fenix Marine Services (FMS) marine terminal at the Port of Los Angeles (POLA) over twelve months. The goal with the repowered top handler is for it to function as efficiently as the original. A successful demonstration of the hydrogen top handler will prove the feasibility of fuel-cell-powered cargo handling equipment and might encourage the advancement of the heavy-duty hydrogen fuel cell market.

Along with repowering the top handler, Toyota Tsusho will develop and deploy a mobile hydrogen refueler. Six separate cylinders of hydrogen will be placed on a fixed truck chassis with a design capacity of about 163 kilogram (kg) of hydrogen. It is expected that the refueler will deliver hydrogen fuel at a rate of approximately 2 kg/minute. Once safety approvals and permits are obtained, the mobile refueler will fuel the repowered top handler, as shown below in Figure 4 (left). Longer term, the team hopes to develop experience and approvals to conduct hydrogen fueling in a manner similar to wet-hose fueling of diesel equipment that is current practice (see Figure 4 (right)).

Figure 4: Mobile Refueler Demonstration (Left) & Post-Demonstration (Right)



Project Partners & Budget

The City of Los Angeles Harbor Department and the Port of Long Beach are sharing costs associated with the project in the amount of \$430,000 each, for a total of \$860,000. This TAP funding is being match by \$2,822,568 from Toyota Tsusho. Additional support is provided by project partners US Hybrid and FMS (\$1,163,477). The total project cost is projected to be \$4,846,045. Table 5 summarizes the funding contributions from the project partners.

Table 5: Hydrogen Top Handler and Mobile Hydrogen Refueler Project Funding Partners

Project Partners	Contributions
Port of Long Beach	\$430,000
Harbor Department	\$430,000
Toyota Tsusho	\$2,822,568
US Hybrid	\$276,477
Fenix Marine Services	\$887,000

Accomplishments in 2022

Toyota Tsusho worked towards approval from the City of Los Angeles Harbor Department for their project. The contract agreements were finalized in late November 2022.

2023 Milestones

The following activities are expected in 2023:

- A project kick-off meeting.
- Benchmark testing of the test model diesel-powered top handler.
- Finalization of top handler specifications for the fuel cell top handler.
- Completion of engineering drawings and simulation models for fuel cell top handler.
- Removal of diesel powertrain from the test model top handler.

- Installation of fuel cell system into the test equipment.
- Development and building of the hydrogen top handler.
- Delivery of the complete hydrogen mobile refueler and hydrogen top handler to FMS.
- Attainment of hydrogen fueling safety approvals and permits.

5.6 Nett Technologies Inc. BlueMAX™ NOVA 320e Harbor Craft Demonstration (Port of Long Beach)

Project Description

The objective of this project is to design, manufacture, and verify the BlueMAX™ NOVA 320e retrofit emission control system, which consists of a combined active diesel particulate filter with upstream diesel oxidation catalyst (DOC) in front of a selective catalytic reduction system with ammonia slip catalyst, as a retrofit to reduce emissions of eligible harbor craft. The BlueMAX™ NOVA 320e technology is fully developed, CARB-verified and commercialized for stationary engine applications, where it achieves reductions of 85 to 99 percent in diesel particulate matter, NOx, and CO (with small increases in greenhouse gases due to the use of carbon fuel injection). The overall goal of this project is to “marinize” the retrofit system for use in a tugboat application in a manner that requires minimal operator involvement. Pacific Tugboat Service is the demonstration partner and will be using its *S.Bass* harbor craft for this project (see Figure 5).

Project Partners & Budget

The Ports contributed \$500,000 in co-funding to this project with a total project budget of \$1,200,000. Table 6 summarizes the project funding contributions.

Table 6: Nett Technologies Inc. BlueMAX™ NOVA 320e Harbor Craft Demonstration

Project Partners	Contributions
Port of Long Beach	\$250,000
Port of Los Angeles	\$250,000
Nett Technologies Inc. and Pacific Tugboat Service	\$700,000

Accomplishments in 2022

Design and fabrication of the aftertreatment system was completed in 2019, with installation and system activation completed in 2020 and 2021. In 2022 the aftertreatment system began accumulating the necessary durability demonstration hours. By the end of 2022, about half of the needed 1000 hours of durability demonstration had been accumulated and so the contract with Nett Technologies was extended to allow for additional time to complete the durability hour accumulation and conduct final emissions testing.

2023 Milestones

The following activities are expected in 2023:

- Complete accumulation of the 1,000 durability demonstration hours.
- Conduct emission testing to achieve CARB verification of the BlueMAX™ NOVA 320e as installed in the *S.Bass* harbor craft.

Figure 5: Nett Technologies Demonstration Vessel

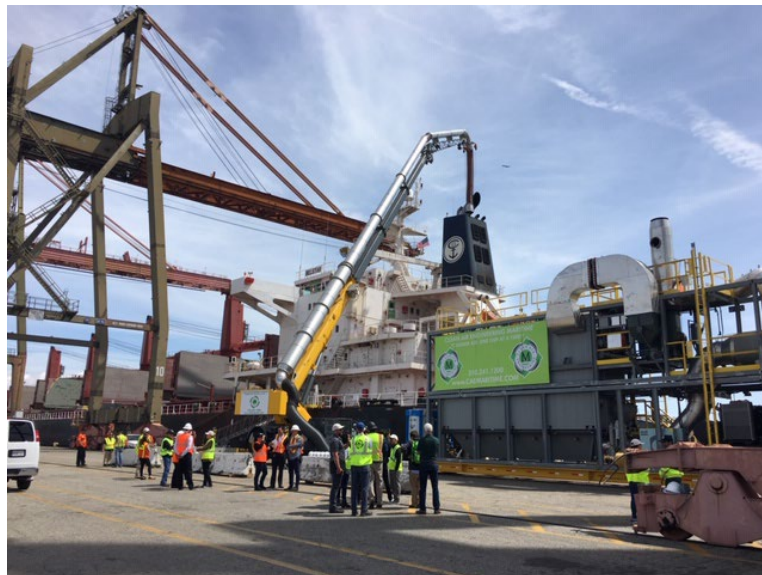


5.7 Pasha Green Omni Terminal Demonstration Project (Port of Los Angeles)

Project Description

This POLA demonstration project has several components including: two battery-electric Generation 1 yard tractors from BYD Motors, two battery-electric Kalmar yard tractors from TransPower, one commercially available battery electric Kalmar T2E+ yard tractor, two Navistar International repowered battery-electric on-road trucks from TransPower, electrification of three 21-ton forklifts from TransPower, and associated chargers. The project also includes a microgrid with battery storage capability that is tied to a one megawatt rooftop solar array, and a land-based ship emissions capture and treatment system (ShoreKat) designed for criteria emissions reduction. The system is depicted in Figure 6, below.

Figure 6: ShoreKat At-Berth Emissions Control System



Project Partners & Budget

The project is funded in part by a \$14.5 million grant from CARB’s Assembly Bill 118 Air Quality Improvement Program and Low Carbon Transportation Greenhouse Gas Reduction Fund Investments. The overall project budget is \$26,602,400. Table 7 summarizes the funding contributions.

Table 7: Pasha Green Omni Terminal Demonstration Project Funding Partners

Project Partners	Contributions
California Air Resources Board	\$14,510,400
OEMs and Demonstration Partners	\$12,092,000

Project Updates and Accomplishments in 2022

The project agreement was modified to extend the project term to December 2023 to allow additional demonstration time and more time to install rooftop solar. In Q1 2022, BYD replaced Generation 1 yard tractor with Generation 2 units, which have been found to be more reliable based on other demonstration projects and Pasha put them into use. The KalmarT2E+ yard tractor was commissioned and put into service and was used consistently and reliably in service in Q1. University of Riverside CE-CERT tested the Kalmar T2 yard tractor over cycles designed to represent typical yard tractor operations over various loads and compiled data into a performance report. TransPower contracted with a third party engineer to evaluate and determine that the vehicles, as modified by TransPower, were safe for operation. They replaced degraded batteries and the vehicles were placed in service in Q1 2022. Later that quarter, while performing a jack-knife maneuver while backing up the yard tractor with a trailer, an operator drove the trailer into one of the energy storage system (ESS) boxes, damaging the unit, and initiating a thermal event. After the thermal event, Pasha took the TransPower and Kalmar yard tractors out of service because the ESS boxes, as designed, are susceptible to being struck when a driver performs a jack-knife maneuver and risks a thermal event. Safety concerns due to this event resulted in a temporary halt of all battery electric vehicle operation at the terminal. The BYD yard tractors were eventually returned to regular service. The on-road trucks were not operated because they did not meet the needs of Pasha’s operation due to their limited range and inability to overcome electrical and mechanical issues.

In December, 2022, CARB issued Executive Order G-22-479 to Clean Air Engineering-Maritime, Inc. for the ShoreKat related to Control Efficiencies for Alternative Control Technologies used for Compliance with the “Airborne Toxic Control Measure for Auxiliary Diesel Engines Operated on Ocean-going Vessel At-Berth in a California Port.”

The Harbor Department received a permit from the Los Angeles Fire Department (LAFD) for the replacement of the fire suppression system in the battery storage system. The fire suppression system was successfully replaced.

Final Report was submitted to CARB and is under review by CARB’s project manager.

2023 Milestones

The following activities are expected in 2023:

- The solar panels are expected to be installed on the warehouse.

- Battery Storage System will be commissioned.
- Supplemental Final Report will be prepared.

5.8 Pasha Hawaii Ohana Class LNG-Powered Container Ships Project (Port of Los Angeles)

Project Description

The objective of this project is to build two new vessels that operate using diesel or liquefied natural gas (LNG). These new vessels will replace two existing vessels that currently operate on inefficient steam turbine engines; two existing vessels will be decommissioned as part of this effort to ensure they no longer operate. The new vessels will be AMP capable (to allow use of shore power) and include automatic stop start technology. The new vessel will be Tier III-certified marine diesel engines capable of burning heavy fuel oil (HFO), distillate fuel or LNG, but will be optimized for LNG.

Project Partners & Budget

Pasha budgeted over \$430M to cover the majority of project costs associated with the design and construction of the two new LNG vessels for this demonstration project. The Ports are contributing \$500,000 to this project as shown in Table 8. TAP funding will support the initial design and documentation of the demonstration and emission reduction benefits.

Table 8: Pasha Hawaii Ohana Class LNG-Powered Container Ships Project Funding Partners

Project Partners	Contributions
Port of Los Angeles	\$250,000
Port of Long Beach	\$250,000

Accomplishments in 2022

The contract agreements were finalized in late 2020 and design work was completed. Construction of the first vessel was slower than anticipated due to restrictions related to the COVID-19 pandemic. The first vessel, the George III, was delivered to Pasha and began service in August 2022. Pasha received approval for the LNG fueling process and obtained all necessary permits. The first bunkering occurred in August at the Port of Long Beach and has continued on a weekly schedule. The ship bunkers approximately 320,000 gal of LNG per fueling event and has been operating entirely on LNG.

2023 Milestones

The following activities are expected in 2023:

- The second new LNG vessel is expected to be delivered in the 2nd quarter of 2023.
- Data collection plan will be approved and emissions data collected from LNG-powered trip(s).

5.9 Pasha Horizon C9 Vessel LNG Engine Repower Demonstration Project

Project Description

Pasha Hawaii Holdings LLC (Pasha) will repower an existing OGV, M/V Horizon (see Figure 7), to operate on liquefied natural gas (LNG). Pasha’s repowered vessel will call at the Ports of Los Angeles and Long Beach as part of the demonstration.

The existing baseline engine burns heavy fuel oil (HFO) but in a high pressure, closed cylinder to generate steam and turn a turbine. The repower from steam turbine power to internal combustion LNG technology will facilitate the use of cleaner burning LNG and provide a significant engine efficiency increase. AMP capability will also be included in this repower design. At the conclusion of the repower, all engines will meet Tier III emission standards. While the engine can burn HFO when LNG is not available, the propulsion system will be optimized for LNG fueling.

Figure 7: Marine Vessel Pasha Horizon



Project Partners & Budget

Pasha budgeted \$41.5M to cover the majority of project costs associated with this repower demonstration project. The Ports are contributing \$500,000 to this project as shown in Table 9. TAP funding will support the initial repower design and documentation of the demonstration and emission reduction benefits.

Table 9: Pasha Hawaii Horizon Reliance LNG Conversion Project Funding Partners

Project Partners	Contributions
Port of Los Angeles	\$250,000
Port of Long Beach	\$250,000

Accomplishments in 2022

The design work was completed and the ship dry-docked to begin the engine repower in 4th quarter 2021. The repower process has been slow, due to shipyard closures for health concerns (COVID; Heat), and test failures for the new engine block. Modifications have been made throughout 2022.

2023 Milestones

The following activities are expected in 2023:

- Data collection plan will be approved.
- The ship will be delivered into service in Q2 2023.

5.10 South Coast AQMD Daimler Demonstration of Heavy-Duty Electric Trucks

Project Description

This project was led by South Coast AQMD, resulting in the demonstration of 20 heavy-duty (HD) battery-electric trucks (BETs) with Daimler Trucks North America (DTNA): 15 Class 8 eCascadia and five Class 6 eM2 trucks. The project include three demonstration fleets: NFI Logistics (NFI), Penske Logistics and Penske Truck Leasing. NFI is demonstrating five Class 8 trucks and is the primary drayage operator/demonstrator. Penske Logistics also has five Class 8 trucks and is pulling freight as a logistics operator itself, while Penske Truck Leasing (PTL) is engaging customers in the use of the remaining five Class 8 trucks with companies such as US Foods, UPS, Mondelez, KeHe, Core-Mark International and Black Horse Carriers. PTL is also engaging with customers, like Costco, Iron Mountain, Fastenal and Enersys on the use and demonstration of the five Class 6 eM2s. All vehicles are operating in real-world commercial fleet operations in one of the region's largest zero-emission port truck demonstrations. More information about this and other South Coast AQMD administered projects can be found at www.aqmd.gov/technology.

Regarding infrastructure, the project includes ten DC Fast Charger (DCFC) locations comprising 20 chargers, 30 charging ports and a total of 2,550 kW of electric power charging capacity. The majority of the 20 DCFC systems are 150 kW, four are 62.5 kW and one is 50 kW. Seven chargers and 1,112.5 kW of charging is located in Chino (five @150 kW and one @62.5 kW at NFI and two @150 kW at Penske). The largest Penske location is in Ontario with three 150 kW chargers. This location will also demonstrate an 800 kWh/300 kW Battery Energy Storage System (ESS). Other chargers are located in La Mirada, Anaheim, Temecula, Carson, and San Diego. Another smaller NFI charger is located closer to the Ports in Wilmington. Finally, a smaller charger is operating at Velocity Vehicle Group (a Daimler dealer in Fontana).

Project Partners & Budget

The total project budget is \$31.3 million with funding contributions primarily from South Coast AQMD and DTNA, as well as the Ports and the U. S. Environmental Protection Agency (USEPA) Region 9. Table 10 summarizes the funding contributions.

Table 10: Daimler Zero-Emission Truck Project Funding Partners

Project Partners	Contributions
Port of Long Beach	\$1,000,000
Port of Los Angeles	\$1,000,000
South Coast Air Quality Management District	\$12,670,072
Daimler Trucks North America	\$15,670,072
USEPA Region 9	\$1,000,000

Accomplishments in 2022

It has now been 18 months since the first Class 8 eCascadia BETs rolled out and one year since the first Class 6 eM2 BET rolled out. Overall, the demonstration BETs accumulated over 600,000 miles and continue to be used by demonstration fleet partners daily. The Class 8 BETs averaged 2.1 kWh/mile, with average loads around 36,000 pounds and peak loads up to 60,000 pounds. The Class 6 BETs averaged 1.4 kWh/mile.

All infrastructure was fully commissioned and continues to operate. There are 10 infrastructure sites in this project with a combined total power of 2.55 MW. Most of the charging equipment is rated at 150 kW, with some smaller chargers rated at 62.5 kW, and 50 kW. Daimler experienced issues with the Siemens electric vehicle support equipment (EVSE) at the Penske Ontario site where the system was experiencing irreconcilable issues with the charger/vehicle interface and not being able to maintain a full vehicle charging session. Siemens decided to fully replace this infrastructure. The replaced system is showing normal performance and is allowing Penske to resume full operations from their largest site under this project. The Ontario site also includes an ESS that is targeted to be commissioned in March 2021. This system consists of a 300 kW power system and 800 kWh of storage. The plan is for the ESS to demonstrate how battery storage can help address the utility costs associated with peak power and demand charges. Project trucks are depicted in Figure 8.

Figure 8: Daimler Zero-Emission Class 8 Trucks



The following activities were accomplished in 2022, reflecting completion of this demonstration project:

- Continued assessing the ESS at the Ontario site in addressing peak shaving and reducing electric operating costs through end of project in Q2 2022.

- Continue the two-year demonstration through project completion in Q2 2022.
- Collect and analyze vehicle operation data.
- Demonstration vehicles to continue operation with demonstration fleets NFI and Penske
- End of Project plans for demonstration vehicles expected to include any or all of the following actions or activities:
 - Some vehicles will remain with the Innovation fleet customers until pre-series units arrive
 - Some vehicles will transition to High Voltage training for DTNA dealer network, internal employees, and others
 - Some vehicles will be donated possibly to technical schools and Fire departments for training opportunities
 - Some vehicles will be assessed for aging and wear of all high voltage components
 - Some vehicles will have battery packs removed and repurposed into “portable” stationary storage to explore a potentially more affordable way to add site resiliency and a method to avoid peak demand charges during the day.
 - Any remaining units/pieces/components will be recycled/scrapped.
- Many of the fleet customers have also participated in the second phase South Coast AQMD administered Customer Experience (CX) project which concluded in summer of 2022.
- Series production model announced during ACT Expo 2022, which many fleets committed to deployment starting in late 2022/early 2023.

5.11 South Coast AQMD Water-in-Fuel Retrofit Technology Demonstration

Project Description

Led by South Coast AQMD, the objective of this project is to design, manufacture, and demonstrate ocean-going vessel (OGV) retrofit technology. MAN Energy Solutions USA Inc. (MAN) will demonstrate a Water in Fuel (WiF) retrofit technology on the MSC Anzu vessel (Figure 9), equipped with MAN’s 2-stroke Tier II engine. The demonstration project includes emissions testing necessary to obtain CARB approval via an Executive Order (or equivalent) for this technology application to other vessels.

The NO_x reduction effect, which is based on a significant reduction in the peak combustion cylinder temperature due to added water is highly dependent on a high-quality, stable emulsion. The mixing ratio will be subject to an optimization during commissioning of the system and will be electronically controlled using a high precision fuel-flow-meter. The technology (Figure 10) is designed to achieve a 40% NO_x reduction from Tier 2 engines at lower than 50% SMCR (Specified Maximum Continuous Rating) of the main engine. This retrofit technology targets OGV emissions as the vessel transits to and from port. Figure 11 shows the complete platform with WiF unit installed on the Anzu vessel.

Project Partners & Budget

The Ports contributed \$1 million in co-funding to this project with a total project budget of \$3.2 million. Table 11 summarizes the project funding contributions.

Table 11: MAN Energy Solutions USA Inc. Retrofit Technology Development Project

Project Partners	Contributions
Port of Long Beach	\$500,000
Port of Los Angeles	\$500,000
South Coast Air Quality Management District	\$2,000,000
MAN Energy Solutions USA Inc.	\$200,000

Accomplishments in 2022

This project scope of work was completed during 2022. The WiF unit was developed, manufactured, and installed on the MSC Anzu vessel. The final sea trial and emissions measurement was conducted in August 2022. The emission measurements were measured, including engine performance, fuel usage, NOx, PM, CO2, CO, and total Hydrocarbon emissions. The test results showed that NOx emissions were reduced by 11 to 22% when the engine was running on WiF mode, especially, higher NOx reductions at the lower load points. No significant CO2 reductions were measured, while a slight increase in PM emissions was noted. Additional tests revealed that the PM emissions increased when a higher percentage of emulsifier was added.

Since the vessel call schedule did not include any visits to the Ports of Los Angeles or Long Beach during the demonstration period, South Coast AQMD is extending its Memorandum of Understanding with MSC for this project with the hope that additional time will provide the window of opportunity for this vessel to call at the Ports.

Figure 9: Demonstration Vessel MSC Anzu



Figure 10: Water-in-Fuel Emulsifier Emulsion System installation on the Anzu Vessel



Figure 11: Main Engine of Anzu Vessel



5.12 South Coast AQMD Zero-Emission Cargo Transport (ZECT) II Demonstration

Project Description

This project is to accelerate deployment of zero-emission cargo transport (ZECT) technologies to reduce harmful diesel emissions, petroleum consumption and greenhouse gases (GHG) in surrounding communities along the goods movement corridors that are impacted by air pollution from heavy diesel traffic. ZECT II includes development and demonstration of seven drayage trucks by five different contractors, as follows:

- Transportation Power, Inc. (TransPower) developed two BETs with hydrogen fuel cell range extenders.
- US Hybrid developed two BETs, each with an on-board hydrogen fuel cell generator.
- Under project management by the Center for Transportation and the Environment (CTE), BAE Systems developed a BET with hydrogen fuel cell range extender.
- Under project management by the Gas Technology Institute (GTI), BAE Systems and Kenworth developed one battery electric hybrid truck with a CNG range extender. The truck can operate in zero-emission (all-electric) mode and in conventional hybrid electric mode using CNG.
- Hydrogenics (a Cummins Inc. Company) will develop and demonstrate a fuel cell range extended Class 8 truck.

Project Partners & Budget

The Ports are contributing \$1,291,480 in co-funding to this project with a total project budget of \$20,141,960. Table 12 summarizes the project funding contributions.

Table 12: South Coast AQMD ZECT II Demonstration Funding Partners

Project Partners	Contributions
US Department of Energy	\$9,725,000
OEMs	\$3,075,841
South Coast Air Quality Management District	\$2,400,000
California Energy Commission	\$2,400,000
L.A. Department of Water and Power	\$1,000,000
▪ Port of Long Beach	\$724,490
▪ Port of Los Angeles	\$566,990
Southern California Gas Company	\$250,000

Accomplishments in 2022

During 2022, six of the demonstration trucks continued their in-service demonstration at TTSI. Throughout the demonstration, the battery and fuel-cell-dominant fuel cell trucks have demonstrated a range of 150-200 miles, with an average fuel consumption rate of 6-8 mi/kilogram of hydrogen (fuel consumption varies by duty cycle, load, etc.). Operator feedback has been positive and TTSI is working with the truck developers to negotiate continued use upon completion of the demonstration.

For the Cummins (formerly Hydrogenics) truck, the project was delayed due to the acquisition of Hydrogenics by Cummins, Inc. and the desire to implement a new power train design. Cummins received US DOE approval for this redesign, which is underway. This truck will begin its demonstration service in Q4 2023.

2023 Milestones

The following activities are expected in 2023:

- The data collected from the six demonstration trucks will be analyzed for drive performance, efficiency, etc.
- Cummins will deploy its demonstration truck in Q4 2023, with final demonstration results expected by 2025

5.13 Shore-to-Store Project (Port of Los Angeles)

Project Description

This project features one of the region’s largest demonstrations of zero-emission hydrogen-fueled on-road trucks, including new fueling infrastructure, and zero-emission cargo-handling equipment at a smaller seaport. This project consists of three main components:

- Ten zero-emission hydrogen fuel-cell-electric Class 8 on-road trucks (Figure 12) on the Kenworth T680 platform were developed through a collaboration between Kenworth and Toyota to move cargo from the Los Angeles ports throughout the Los Angeles basin, as well as ultimately to inland locations such as Riverside County, the Port of Hueneme (POH), and eventually to Merced. The trucks were operated by Toyota Logistics Services (4), United Parcel Services (3), Total Transportation Services Inc. (2), and Southern Counties Express (1).
- Two hydrogen fueling stations (Figure 13) that fuel heavy-duty trucks were constructed by Shell in Wilmington and Ontario, California. The new stations joined two additional stations located at Toyota facilities around Los Angeles to form an integrated, four-station heavy-duty hydrogen fueling network.
- Expanded use of zero-emission technology in off-road and warehouse equipment, including the first two zero-emission yard tractors and e-cranes to be operated at POH, as well as the expanded use of two zero-emission forklifts at Toyota’s port warehouse.

Figure 12: Hydrogen Fuel-Cell Class 8 Kenworth/Toyota Trucks



Figure 13: Hydrogen Fueling Station (Wilmington, CA)



Project Partners & Budget

In late 2018, CARB awarded \$41.1 million to POLA for the Zero- and Near Zero-Emission Freight Facilities (ZANZEFF) project. Project partners, including Toyota, Shell, Kenworth, South Coast AQMD, and POH are providing \$41.4 million in match funding. Table 13 summarizes the funding contributions.

Table 13: Shore-to-Store Project Funding Partners

Project Partners	Contributions
Port of Los Angeles	\$13,999,331
California Air Resources Board	\$41,122,260
South Coast Air Quality Management District	\$1,000,000
OEMs and Demonstration Partners	\$26,427,281

Accomplishments in 2022

All ten hydrogen fuel cell electric trucks impressively completed in-service demonstration in August 2022. The trucks supported several technology awareness and media relations events during 2022.

The Ontario hydrogen fueling station completed commissioning protocols and was online for fueling in 2021. The station passed the Site Acceptance Test (SAT) in October 2022, enabling unstaffed 24/7 fueling. The Wilmington station completed commissioning activities and was online for fueling in July 2022. The station passed the SAT in November.

POH began the twelve-month demonstration of two Kalmar battery-electric yard tractors in January. The equipment is reliably performing the expected operational duty-cycle. Construction for the 4160 service e-crane infrastructure project, to operate the hybrid-electric Liebherr 420 cranes, was completed in November.

2023 Milestones

The following activities are expected in 2023:

- Commission POH’s 4160 service e-crane infrastructure project and begin operation of hybrid-electric Liebherr 420 cranes.
- Complete twelve-month demonstration of Kalmar battery-electric yard tractors at POH.
- Complete project data analysis and final report.

5.14 Sustainable Terminals Accelerating Regional Transformation (START) Project (Port of Long Beach)

Project Description

In partnership with the Port of Stockton and Port of Oakland, the Port of Long Beach received a \$50 million CARB grant for a transformative demonstration of a near-zero and zero-emission supply chain in and around its Matson Navigation Co. Pier C terminal. The Sustainable Terminals Accelerating Regional Transformation (START) Project, expected to be completed in 2024, will demonstrate more than 100 pieces of zero-emission terminal equipment and trucks at three California seaports, deploy two ships with some of the cleanest available engines, and advance workforce development programs to support sustainable goods movement.

For this project, the Port of Oakland will deploy 10 electric trucks and seven pieces of terminal equipment. The Port of Stockton will deploy more than 40 electric forklifts and an electric railcar mover with a 56 hp range-extender engine (Kohler KDI 1903TCR) that will be operated on renewable diesel. At the Port of Long Beach, the START Project will demonstrate:

- 33 zero-emission yard tractors at Pier C — one of the largest deployments of such equipment at a single marine terminal;
- Two container ships with Tier 3 engines, which will be the cleanest container ships to call in regular service on the West Coast;
- Five electric trucks at an off-dock container yard; and
- Two publicly-accessible heavy-duty truck charging outlets.

Project Partners & Budget

The START Project is funded partly by a \$50 million grant from the California Climate Investments. The project includes \$52 million in matching funds from private and public partners, for a total cost of \$102 million. Table 14 summarizes the funding contributions.

Table 14: START Project Funding Partners

Project Partners	Contributions
Port of Long Beach	\$3,531,157
California Air Resources Board	\$50,000,000
South Coast Air Quality Management District	\$500,000
Port of Oakland and Port of Stockton	\$3,250,000
OEMs and Demonstration Partners	\$43,237,585

Accomplishments in 2022

In 2022, delivery of all 38 electric yard tractors was completed and production of the five electric drayage trucks for Shippers Transport Express at the Port of Long Beach continued. Additionally,

Port of Stockton completed their demonstration of their heavy-duty forklifts and rail-car mover in port operations.

Both Tier III container ships continued operations and emissions testing of the main engines was completed on each vessel. A replacement harbor craft project, a zero-emission capable plug-in hybrid tugboat, was identified and Port of Long Beach staff worked with CARB to incorporate the replacement project into the grant award through a third amendment.

Charging infrastructure for the electric yard tractors began construction at Pier C in Long Beach, with construction expected to be completed in Q2 2023. Infrastructure for the drayage trucks and public charging stations in Long Beach were both commissioned in late 2022.

2023 Milestones

The following activities are expected in 2023:

- Delivery of the heavy-duty trucks in Long Beach.
- Complete yard tractor charging infrastructure and begin demonstration.
- Commissioning and demonstration of the electric top handlers at the Port of Oakland (Figure 14).
- Complete emission testing of the Tier III vessels (i.e., auxiliary and boiler engine testing) and full emission testing of the Tier II baseline vessel.
- Finalize data collection results and data reports for the electric forklifts and railcar mover in Stockton.

Figure 14: Zero-Emission Top Handler and Charger at Port of Oakland



Figure 15: Cable Management System at Port Long Beach



5.15 Zero-Emission Terminal Equipment Transition Project (Port of Long Beach)

Project Description

The Port of Long Beach, in partnership with terminal operators and technology manufacturers, is demonstrating zero-emission cargo-handling equipment projects at three container terminals. In addition, the Port is partnering with Total Transportation Services, Inc. (TTSI) to demonstrate near-zero emission heavy-duty trucks, which service the San Pedro Bay Ports.

The project includes:

- Repowering nine RTG cranes to full-electric power at SSA Marine Terminal (SSA), Pier J, in what would be the nation's largest deployment of fully electric RTGs (eRTGs) at a single container terminal.
- Developing and deploying 12 BYD battery-electric yard tractors – seven at International Transportation Service (ITS) and five at Long Beach Container Terminal (LBCT) of which two yard tractors, one at each terminal, be charged via a robotic arm using the Cavotec Smart Plug System (SPS).
- Converting four LNG trucks to LNG plug-in hybrid electric trucks (PHET) trucks at TTSI with zero-emission capability developed by US Hybrid.

Project Partners & Budget

The Port received \$9,755,000 in CEC funding, which is matched by over \$10 million in project partner funding, for a total project investment of nearly \$19 million. The total amount of CEC funding was reduced to \$8,610,000 upon the return of funds dedicated to the BYD demonstration at LBCT. Table 15 summarizes the funding contributions.

Table 15: Zero-Emission Terminal Transition Funding Partners

Project Partners	Contributions
Port of Long Beach	\$3,997,515
California Energy Commission	\$8,610,000
Southern California Edison	\$3,950,000
OEMs and Demonstration Partners	\$2,405,501

Accomplishments in 2022

eRTG Crane Demonstration – SSA, Pier J

The remaining three eRTG cranes were placed into service at Pier J. Collection of operational data to summarize the monthly energy usage was underway for all nine eRTGs. During the 3rd quarter, approximately 201,500 gallons of diesel fuel were estimated to be displaced by the operation of the eRTGs. The cranes operated without any issues for most of the year. However, one had to be repaired because of a complication unrelated to the conversion. The crane repair was completed in December 2022.

Figure 16: Ninth eRTG Crane at Pier J



Hybrid LNG Plug-In Hybrid Electric Trucks (PHET) Demonstration – TTSI/US Hybrid

In January 2022, TTSI used a diesel truck and an LNG truck to begin collecting data to create a baseline for benchmarking with the LNG-PHETs. A partial road test was also conducted using Truck #2 in LNG mode; however, there were issues with the onboard charger that prevented the truck from operating in PHET mode. Further road tests were not conducted due to truck issues and driver unavailability.

Additionally, during the 1st and 2nd quarters of 2022, all four PHETs operated in service infrequently due to mechanical issues. By June 2022, the trucks were completely out of service,

bringing the demonstrations to a halt. US Hybrid worked with the engine manufacturer, Cummins, to investigate the issues within TTSI's PHETs. Cummins determined that the engines were severely damaged due to excessive idling and/or metal debris found in oil filters that contained the engine, which would need to be rebuilt. The project encountered setbacks regarding charging as well. Because TTSI moved facilities, they no longer had access to the Nuvve charging station at the San Pedro facility. TTSI is currently exploring options to electrify their fleet at their property site.

BYD Battery-Electric Yard Tractors Demonstration – ITS, Pier G

The demonstrations at ITS concluded in 2021, and ITS decided to return the seven BYD electric yard tractors and charging equipment. The electric vehicle supply equipment (EVSE) systems, including the Cavotec SPS, were collected by their manufacturers in January 2022.

BYD Battery-Electric Yard Tractors Demonstration – LBCT, Pier E

In early 2022, LBCT continued testing one BYD battery-electric yard tractor at their terminal with minor setbacks due to staffing and charging issues. BYD was approved to complete the final build of the remaining four electric yard tractors; however, after failing to build and deliver the remaining tractors, BYD received a partial stop work order for those tractors. The BYD demonstration at LBCT officially concluded in the 3rd quarter of 2022, and the remaining funds were returned to the CEC.

2023 Milestones

The following activities are expected in 2023:

- Continue collecting operational data for the eRTG units and monitor any operational issues.
- Begin development of the final report, which will include summaries of the operational data collected for the eRTG, BYD and TTSI PHET projects.
- Work to address PHET engine issues with project partners and the CEC to the extent possible, and conclude the demonstration.

5 2022 TECHNOLOGY FUNDING

The Ports contribute funding to technology investments through several mechanisms as identified in the TAP Guidelines. The TAP is supported by both Ports and funding for each demonstration is subject to approval by each Port's Board of Harbor Commissioners, or is received via a competitive grant basis, by participating agencies. These include but are not limited to the South Coast AQMD, CARB, USEPA, and CEC. Project co-funding is also contributed by the Ports and project partners as either cash or in-kind contributions, or a combination of both.

Contributions from participating agencies other than the Ports are typically made on a project-by-project basis. It should be noted that TAP contractors are required to provide a minimum of 50% co-funding in the form of cash and/or in-kind contributions to each project. In order to meet the stringent agency match funding requirements, the Ports may utilize the project costs from a related or synergistic project to leverage additional grant funds to expand technology development and demonstration.

The Ports and agency stakeholder investments for all past and current technology advancement projects approved to date are shown in Table 16 below. In 2022, the TAP focused on continuing to execute its portfolio of technology advancement projects while launching two new projects.

Table 16: Ports' Technology Advancement Funding Investments as of December 31, 2022

Project Category	POLB	POLA	South Coast AQMD	CARB	CEC	USEPA / USDOE & Other Agencies	Total Port & Agency Stakeholder	OEMs & Demonstration Partners	Total Project Budget
<u>Ocean-Going Vessels</u>									
ACTI AMECS Emissions Testing	\$149,527	\$149,527	\$55,000				\$354,054	\$249,157	\$603,211
ACTI At-Berth Emissions Reductions for Ships	\$703,388						\$703,388		\$703,388
APL Singapore Slide Valve/WIFE	\$22,500	\$22,500		\$783,628			\$828,628	\$471,372	\$1,300,000
Bluefield Holdings Krystallon OGV Scrubber	\$825,000	\$825,000					\$1,650,000	\$1,740,000	\$3,390,000
Maersk OGV Energy Efficiency Measurement Demonstration	\$500,000	\$500,000					\$1,000,000	\$1,860,000	\$2,860,000
Maersk OGV Slide Valve Low-Load Emissions Evaluation	\$108,000	\$108,000					\$216,000		\$216,000
MAN Energy Solutions USA Inc. Water-in-Fuel Technology Demonstration for Ocean-Going Vessels	\$500,000	\$500,000	\$2,000,000				\$3,000,000	\$200,000	\$3,200,000
Pasha Hawaii Ohana Class LNG Powered Container Ships (Two) Project	\$250,000	\$250,000					\$500,000	*	\$500,000
Pasha Horizon C9 Vessel LNG Engine Repower Demonstration Project	\$250,000	\$250,000					\$500,000	*	\$500,000
Tri-Mer Mobile Emissions Treatment System (METS-1) At-Berth Emissions Reductions for Ships		\$1,500,000					\$1,500,000	\$9,500,000	\$11,000,000
<u>Harbor Craft</u>									
Centerline Logistics (formerly Harley Marine) Electric Drive Tugboat Design Project	\$117,500	\$117,500					\$235,000	\$364,000	\$599,000
Foss Maritime Hybrid Tugboat	\$500,000	\$889,920		\$1,000,000			\$2,389,920	\$5,610,080	\$8,000,000
Nett Technologies Inc. BlueMAX™ NOVA 320e	\$250,000	\$250,000					\$500,000	\$700,000	\$1,200,000
<u>Cargo-Handling Equipment</u>									
APT Emulsified Biodiesel	\$44,000	\$44,000.00					\$88,000.00	\$88,000	\$176,000
Balqon Electric Terminal Tractor		\$263,500.00	\$263,500				\$527,000.00		\$527,000
Balqon Lithium Battery Upgrade		\$400,000.00					\$400,000.00	\$540,000	\$940,000
Capacity Plug-In Hybrid Tractor	\$29,500	\$32,000.00					\$61,500.00		\$61,500
<i>Effenco Rapid Deployment of Electric Active Stop-Start™ Technology for Zero-Emission Idling from Port Yard Tractors Project</i>	\$71,775	\$71,775					\$143,550		\$143,550

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Project Category	POLB	POLA	South Coast AQMD	CARB	CEC	USEPA / USDOE & Other Agencies	Total Port & Agency Stakeholder	OEMs & Demonstrators on Partners	Total Project Budget
Hybrid Yard Tractor*	\$300,000	\$300,000.00				\$300,000	\$900,000.00	\$300,000	\$1,200,000
Hybrid Yard Tractor Development & Demonstration – Beta Test	\$13,000	\$13,000.00					\$26,000.00		\$26,000
Hydrogen Top Handler and Mobile Hydrogen Refueler Project	\$430,000	\$430,000					\$860,000	\$3,986,045	\$4,846,045
LBCT Eco-Crane	\$42,468	\$42,467.50				\$130,130	\$215,065.00	\$265,065	\$480,130
LNG Yard Tractor*	\$350,000					\$75,000	\$425,000.00		\$425,000
RYPOS Advanced L3+ DPF – RTG Cranes	\$36,130	\$36,130.00					\$72,260.00	\$249,880	\$322,140
<i>RYPOS Diesel Emissions Control (L2+)</i>	<i>\$64,668.42</i>	<i>\$64,668.42</i>					<i>\$129,336.84</i>		<i>\$129,337.84</i>
Vycon RTG REGEN Flywheel	\$11,500	\$11,500.00	\$8,000				\$31,000.00		\$31,000
Advanced Infrastructure Demonstration Project (AID Project; CEC Funded)		\$392,500	\$442,750		\$7,842,270	\$1,344,750	\$10,022,270	\$1,326,885	\$11,349,155
Advanced Yard Tractor Deployment and Eco-FRATIS Drayage Truck Efficiency Project (CEC Funded)					\$5,833,000		\$5,833,000	\$2,808,007	\$8,641,007
Commercialization of Off-Road Technology Demonstration (C-PORT Project; CARB Funded)	\$1,332,386		\$350,000	\$5,249,820			\$6,932,206	\$1,199,882	\$8,132,088
Everport Advanced CHE Demonstration (CEC Funded)		\$1,071,428			\$4,524,000		\$5,595,428.00	\$1,166,903	\$6,762,331
Pasha Green Omni Terminal Demonstration Project (CARB Funded)				\$14,510,400			\$14,510,400	\$12,092,000	\$26,602,400
Port of Long Beach Zero-Emission Terminal Equipment Transition Project (CEC Funded)	\$3,997,515				\$8,610,000	\$3,950,000	\$16,557,515	\$2,405,501	\$18,963,016
Sustainable Terminals Accelerating Regional Transformation (START Project; CARB Funded)	\$3,531,157		\$500,000	\$50,000,000		\$3,250,000	\$57,281,157	\$43,237,585	\$100,518,742
Container Drayage Trucks									
Daimler Truck North America/SCAQMD Battery-Electric Trucks Demonstration	\$1,000,000	\$1,000,000	\$12,670,072			\$1,000,000	\$15,670,072	\$15,670,072	\$31,340,144
Develop and Demonstrate Catenary Zero-Emission Goods Movement System	\$2,000,000	\$4,000,000	\$2,500,000		\$3,000,000	\$2,000,000	\$13,500,000		\$13,500,000
Development of a Near-Zero Emission Diesel Engine for On-Road Heavy-Duty Vehicles		\$287,500	\$287,500	\$425,000			\$1,000,000		\$1,000,000
HLT San Pedro Bay Ports Drayage Truck Demonstration of a Near-Zero Ultra-Low NOx Natural Gas Engine Operating on Renewable Natural Gas	\$37,500	\$37,500					\$75,000	\$121,555	\$196,555
<i>International Rectifier Plug-In Hybrid Electric Class 8 Truck Conversion</i>	<i>\$17,500</i>	<i>\$17,500</i>					<i>\$35,000</i>	<i>\$381,972</i>	<i>\$416,972</i>

San Pedro Bay Ports Technology Advancement Report
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Project Category	POLB	POLA	South Coast AQMD	CARB	CEC	USEPA / USDOE & Other Agencies	Total Port & Agency Stakeholder	OEMs & Demonstrators on Partners	Total Project Budget
SoCalGas CNG Drayage Truck	\$111,577.50	\$111,577.50	\$421,250				\$644,405	\$1,355,595	\$2,000,000
South Coast AQMD Zero-Emission Cargo Transport (ZECT) II	\$724,489.50	\$566,989.50	\$2,400,000		\$2,400,000	\$10,975,000	\$17,066,479	\$3,075,481	\$20,141,960
TransPower Pre-Commercial Electric Drayage Truck Demonstration	\$150,000	\$150,000			\$2,296,617	\$1,192,184	\$3,788,801	\$655,000	\$4,443,801
TransPower Electric Drayage Infrastructure and Improvement	\$300,000	\$300,000					\$600,000	\$5,700,000	\$6,300,000
US Hybrid On-Board Charger for Zero-Emission Cargo Transport Demonstration	\$37,500	\$37,500	\$75,000				\$150,000		\$150,000
<i>Vision Motor Corp. Hydrogen Fuel Cell Plug-In Hybrid Electric Truck</i>	\$95,625	\$95,625					\$191,250		\$191,250
Westport ISX LNG Engine	\$250,000	\$250,000	\$1,250,000		\$500,000		\$2,250,000	\$7,644,027	\$9,894,027
Shore-to-Store Project (CARB Funded)		\$13,999,331	\$1,000,000	\$41,122,260			\$56,121,591	\$26,427,281	\$82,548,872
Locomotives									
Johnson Matthey DPF Locomotive Demonstration	\$75,000	\$75,000		\$346,178			\$496,178	\$196,178	\$692,356
<i>VeRail Near-Zero Locomotive Demonstration – Moving Towards Zero Emissions</i>	\$25,000	\$25,000					\$50,000		\$50,000
Technology Advancement Support Efforts									
AQMD HDV In-Use Emissions Testing Program	\$153,276	\$153,276	\$1,701,156				\$2,007,708		\$2,007,708
Development of Drayage Truck Chassis Dynamometer Test Cycle	\$12,000	\$11,466					\$23,466		\$23,466
Electric Vehicle Blueprint Phase II Project	\$847,072				\$2,500,000		\$3,347,072		\$3,347,072
Heavy-Duty Drayage Truck Duty Cycle Characterization	\$12,681	\$13,000					\$25,681		\$25,681
Total Investment (Includes Funding Outside TAP)	\$20,279,234.92	\$29,666,680.92	\$25,924,228	\$113,527,286	\$37,505,887	\$24,217,064	\$251,030,380.84	\$151,587,523	\$402,617,903.84
Total Port TAP Investment	\$49,945,915.84								

*Denotes Pasha projects costs for the LNG Repower project are ~\$41.5M; project costs for the two-vessel LNG new-build project are \$430.3M.

**Denotes EPA-grant funding contribution from the USEPA West Coast Collaborative (pre-dating the TAP).

"**Bold**" denotes projects new this reporting year

"*Italics*" denote projects that were modified during implementation in a manner that changed from the original budget.

"Shaded" areas denote grant projects that were awarded State funding.

APPENDIX A: TECHNOLOGY ADVANCEMENT PROGRAM CONTACTS

Technology Advancement Program Advisory Committee Membership

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APPENDIX B: COMPLETED TAP PROJECTS

The following TAP projects are complete and additional information is available online at the Clean Air Action Plan' TAP website: <https://cleanairactionplan.org/technology-advancement-program/reports/>

1. ACTI Advanced Maritime Emissions Control System (AMECS) Project (2008)
2. Advanced Yard Tractor Deployment and Eco-FRATIS Drayage Truck Efficiency Project (2021)
3. APL Singapore Slide Valve & Water-In-Fuel Emulsion Demonstration Program (2009)
4. Alternative Petroleum Technologies' Emulsified Biodiesel (2011)
5. Balqon E-30 Electric Terminal Tractor Development & Demonstration Project (2009)
6. Balqon Lithium-Ion Battery Demonstration (2011)
7. Bluefield Holdings Krystallon Ocean-Going Vessel Scrubber (2013)
8. Capacity Plug-In Hybrid Electric Terminal Tractor (2010)
9. Characterization of Drayage Truck Duty-Cycles (2011)
10. Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT) (2021)
11. Development of a Drayage Truck Chassis Dynamometer Test Cycle (2011)
12. Development of On-Road Drayage Truck Testing Protocol (2016)
13. Foss Maritime Green Assist™ Hybrid Tugboat (2010)
14. Centerline Logistics (formerly Harley Marine) Electric Drive Tugboat Design (2020)
15. Hybrid Yard Tractor Development & Demonstration (2010)
16. Hybrid Yard Tractor Development & Demonstration – Beta Test (2011)
17. Johnson Matthey Locomotive DPF Demonstration (2014)
18. Liquefied Natural Gas Yard Tractor Demonstration (2007)
19. Long Beach Container Terminal Eco-Crane™ (2011)
20. Maersk OGV Energy Efficiency Measurement Demonstration Project (2019)
21. OGV Slide Valve Low-Load Emissions Evaluation (2013)
22. RYPOS Advanced Diesel Particulate Filter for Cargo-Handling Equipment (2012)
23. RYPOS Advanced Level 3+ Diesel Particulate Filter RTG Crane Demonstration (2014)
24. San Pedro Bay Ports Drayage Truck Demonstration of a Near-Zero Ultra-Low NOx Natural Gas Engine Operating on Renewable Natural Gas (2018)
25. South Coast AQMD Daimler Demonstration of Heavy-Duty Electric Trucks (2022)
26. South Coast AQMD Development of a Near-Zero Emission Diesel Engine for On-Road HDVs (2020)
27. South Coast AQMD HDV In-Use Emissions Testing Program (2013)
28. South Coast AQMD Water-in-Fuel Retrofit Technology Demonstration (2022)

29. SoCalGas CNG Drayage Truck Demonstration (2010)
30. TransPower Electric Drayage Infrastructure and Improvement (EDII) Project (2016)
31. TransPower Electric Drayage Pre-Commercial Truck Demonstration (2016)
32. US Hybrid On-Board Charger for Zero-Emission Cargo Transport Demonstration (2016)
33. VYCON REGEN® System for Rubber-Tired Gantry Cranes Testing & Verification (2007)
34. Westport GX LNG Engine Development (2010)