



SAN PEDRO BAY PORTS **CLEAN AIR ACTION PLAN**

2020 ANNUAL REPORT AND 2021 PRIORITIES Technology Advancement Program

14 Years of Progress Moving Towards Zero Emissions

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Table of Contents

1 INTRODUCTION..... 1

2 TECHNOLOGY ADVANCEMENT ACCOMPLISHMENTS IN 2020 4

3 PROGRESS TOWARD ZERO EMISSIONS 7

4 2021 TECHNOLOGY ADVANCEMENT PRIORITIES 8

5 KEY PROJECTS IN 2020..... 9

5.1 Advanced Infrastructure Demonstration Project (Port of Los Angeles)..... 9

5.2 Advanced Yard Tractor Deployment and Eco-FRATIS Drayage Truck Efficiency Project (Port of Los Angeles) 11

5.3 Centerline Logistics (formerly Harley Marine) Electric Drive Tugboat Design..... 13

5.4 Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT) (Port of Long Beach) 14

5.5 Effenco Electric Active Stop-Start™ Technology Demonstration..... 15

5.6 Everport Advanced Cargo Handling Equipment Demonstration Project (Port of Los Angeles)..... 16

5.7 Nett Technologies Inc. BlueMAX™ NOVA 320e Harbor Craft Demonstration..... 18

5.8 Pasha Green Omni Terminal Demonstration Project (Port of Los Angeles)..... 19

5.9 Pasha Hawaii Ohana Class LNG-Powered Container Ships Project..... 20

5.10 Pasha Horizon C9 Vessel LNG Engine Repower Demonstration Project..... 21

5.11 Port Advanced Vehicle Electrification (PAVE) Project (Port of Long Beach) 23

5.12 South Coast AQMD Daimler Demonstration of Heavy-Duty Electric Trucks..... 23

5.13 South Coast AQMD Development of a Near-Zero Emissions Diesel Engine for On-Road HDVs 25

5.14 South Coast AQMD Retrofit Technology Development – Water-in-Fuel Technology 26

5.15 South Coast AQMD Zero Emission Cargo Transport (ZECT) II Demonstration..... 29

5.16 Shore-to-Store Project (Port of Los Angeles)..... 30

5.17 Sustainable Terminals Accelerating Regional Transformation (START) Project (Port of Long Beach) 32

5.18 Zero-Emissions Terminal Equipment Transition Project (Port of Long Beach) 34

6 2020 TECHNOLOGY FUNDING 36

APPENDIX A: TECHNOLOGY ADVANCEMENT PROGRAM CONTACTS A-1

APPENDIX B: COMPLETED TAP PROJECTS..... B-1

List of Figures

Figure 1: Repowering RTGs to Zero Emissions8
 Figure 2: Port of Los Angeles Zero-Emissions Pathway Concept.....10
 Figure 3: Taylor Battery-Electric Top Handler at LBCT (left) and SSA (right)14
 Figure 4: Taylor Battery-Electric Top Handler17
 Figure 5: Nett Technologies Demonstration Vessel and BlueMAX NOVA System19
 Figure 6: ShoreKat At-Berth Emissions Control System19
 Figure 7: Marine Vessel Pasha Horizon.....22
 Figure 8: Daimler Zero-Emission Class 8 Trucks25
 Figure 9: Demonstration Vessel MSC Anzu.....28
 Figure 10: Water-in-Fuel Emulsifier.....28
 Figure 11: Engine Room Layout for WiF Installation28
 Figure 12: Hydrogen Fuel-Cell Class 8 Kenworth/Toyota Trucks30
 Figure 13: Electric Yard Tractor35

List of Tables

Table 1: 2020 Technology Advancement Project Snapshot.....5
 Table 2: Advanced Infrastructure Demonstration Project Funding Partners10
 Table 3: Advanced Yard Tractor Deployment and Eco-FRATIS Drayage Truck Efficiency Funding Partners12
 Table 4: Centerline Logistics Electric Drive Tugboat Design Project Funding Partners13
 Table 5: C-PORT Funding Partners.....14
 Table 6: Effenco Electric Active Stop-Start™ Technology Demonstration Project Funding Partners.....15
 Table 7: Everport Advanced Cargo Handling Equipment Demonstration Funding Partners17
 Table 8: Nett Technologies Inc. BlueMAX™ NOVA 320e Harbor Craft Demonstration18
 Table 9: Pasha Green Omni Terminal Demonstration Project Funding Partners.....20
 Table 10: Pasha Hawaii Ohana Class LNG-Powered Container Ships Project Funding Partners21
 Table 11: Pasha Hawaii Horizon Reliance LNG Conversion Project Funding Partners22
 Table 12: Daimler Zero-Emissions Truck Project Funding Partners.....24
 Table 13: Ultra-Low Emissions Diesel Engine Development Project Funding Partners25
 Table 14: MAN Energy Solutions USA Inc. Retrofit Technology Development Project.....27
 Table 15: South Coast AQMD ZECT II Demonstration Funding Partners.....29
 Table 16: Shore-to-Store Project Funding Partners31
 Table 17: START Project Funding Partners33
 Table 18: Zero-Emissions Terminal Transition Funding Partners34
 Table 19: Ports’ Technology Advancement Funding Investments as of December 31, 202037

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.
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
DPM	diesel particulate matter
FRATIS	Freight Advanced Traveler Information Systems
EGR	exhaust gas recirculation
EVSE	electric vehicle support equipment
GHG	greenhouse gases
HP	horsepower
kW	kilowatt
kWh	kilowatt-hours
LNG	liquefied natural gas
MW	megawatt
NO _x	oxides of nitrogen
NZE	near zero-emission
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
SCR	selective catalytic reduction
South Coast AQMD	South Coast Air Quality Management District
TAP	Technology Advancement Program
TEU	twenty-foot equivalent unit
USEPA	United States Environmental Protection Agency
ZE	zero emission
ZEV	zero emission vehicle

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. Over the past 15 years, the Ports have made dramatic strides in reducing air emissions. Clean Air Action Plan (CAAP) programs have slashed pollution from heavy-duty trucks. Green leases and state regulations have curbed emissions from cargo-handling equipment and harbor craft. Accelerated shore power deployment through port lease requirements, the California At Berth Regulation, and low-sulfur fuel regulations have led to significant drops in ship-related air pollution. In addition, local, state and federal grant funding has supported efforts to implement cleaner technologies at ports. Overall, between 2005 and 2019 port-related diesel particulate matter (DPM) emissions were reduced by 87%, nitrogen oxide (NO_x) emissions were reduced by 58% and sulfur oxide (SO_x) emissions were reduced by 97% at the Ports.

Still, there is much work to do. The most recent iteration of the CAAP, which was released in late 2017, calls for even more aggressive strategies to reduce pollution and greenhouse gases and to ultimately transition to zero emissions over the next 20 years. Development and deployment of near-zero and zero-emission technologies are critical to the success of these strategies, and the Ports, in partnership with numerous stakeholders, have embarked on an unprecedented effort to do just that.

At the cornerstone of this effort is the Technology Advancement Program (TAP), which was initiated in 2007 to facilitate the development and demonstration of clean technologies to support the original CAAP goals. The TAP is a competitive 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 40 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. To that end, 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 \$403 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 Quarterly Reports found at www.cleanairactionplan.org.

Significant Events in 2020

In 2020, there were several significant events that impacted the Ports' technology efforts in positive and negative ways. For one, the State adopted new regulations advancing zero-emission trucks and at-berth emission-reduction requirements, which are expected to dramatically accelerate technology advancement in those areas but also raise new challenges. Second, the Coronavirus Disease 2019 (COVID-19 or COVID) pandemic delayed many technology projects and devastated the economy, resulting in significant reductions to – if not outright elimination of – many funding programs used to support technology advancement, particularly the Low Carbon Transportation Investments program, which historically has been a significant funding source for advanced technology demonstrations at the Ports. These events may impact the TAP for years to come and are described in more detail below.

Regulatory Activities

The California Air Resources Board (CARB) adopted two major regulations in 2020 that affirm the Ports' past and current technology advancement efforts and open up new areas of technology focus in the coming years. First, the Advanced Clean Trucks (ACT) Regulation requires manufacturers to produce Class 8 zero-emission trucks at increasing percentages beginning in 2024 through 2035. In many ways, this regulation caps more than a decade of zero-emission technology development by the Ports and others. With commercialized zero-emission trucks on the horizon, the Ports can shift away from demonstrating the basic zero-emission platform and toward demonstrations that explore the operational and infrastructure challenges ahead.

CARB also amended its Control Measure for Ocean-Going Vessels At Berth (At Berth Regulation). In addition to expanding requirements for currently regulated fleets, this regulation requires at-berth emission reductions from new vessel classes, such as tankers and auto carriers, through shorepower or capture-and-control systems and introduces an “innovative concept” opportunity for fleets to use other technology options, at least temporarily. With so few approved at-berth technologies available, this regulation will require 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.

Both of these regulations may shape TAP investments over the next few years.

COVID-Related Project Delays

The COVID pandemic, which began in March 2020, impacted several technology projects that were well underway. Because many of the Ports' technology partners are headquartered overseas, COVID-related shutdowns and travel restrictions disrupted equipment manufacturing, emissions testing, and operator training on advanced technologies. Technology partners within the US also experienced several months of factory shutdowns. Several demonstrations were either impacted or delayed for various reasons including:

- temporarily shutting down businesses and facilities that design and manufacture advanced technologies;
- implementation of new equipment cleaning and safe distancing procedures at port terminals;
- restrictions on non-essential personnel boarding vessels or entering terminals, which is necessary to conduct emissions testing and to monitor the progress of demonstrations;
- sudden drops and increases in freight volumes – lower freight volumes at the start of the pandemic resulted in financial uncertainty that caused some operators to re-evaluate and in some cases rescind their demonstration commitments; higher volumes toward the end of 2020 resulted in the need to keep baseline equipment running at full capacity rather than upgrading to demonstration equipment at that time;
- difficulty acquiring necessary equipment parts from overseas; and
- prohibitions on overseas personnel traveling to California to conduct in-person testing and trainings on new equipment.

COVID-related impacts for individual projects are described in more detail in Section 5.

COVID-Related Funding Cuts

COVID-related shutdowns had a significant impact on the economy, leading to a drop in State revenue and financial hardship for many port operators. As yet, demonstration projects that were already underway with secured funding have not been affected by the downturn, but the future funding landscape is bleak. CARB has slashed its Clean Transportation Incentives Program, which was a major source of clean-technology funding, from \$449 million in 2020 to \$28.6 million in 2021 due to the Legislature's delay in approving cap-and-trade expenditures amid COVID-induced budget uncertainty. The current Clean Transportation Incentives Program budget preserves incentives for zero-emission commercialized equipment, but could impact future years of technology advancement.

Looking Ahead

Even with the challenges of COVID, 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 with interim targets for cleanest available technologies if no feasible zero-emission technologies exist. CARB's adoption of the ACT Regulation ensures that commercialized zero-emission trucks will arrive by 2024, but there are still gaps in charging and fueling infrastructure as well as understanding of large-scale zero-emission operations. Additionally, to help operators make informed decisions about zero-emission equipment, a variety of technology platforms (electric and fuel cell) and charging/fueling approaches must be vetted. The Ports must work closely with numerous stakeholders to address these gaps over the next three to five years, shifting from technology development to early implementation.

At the same time, the Ports must continue to nurture nascent ship and harbor craft emission-reduction technologies. In 2020, the TAP approved three ocean-going vessel projects. Alternatives to shorepower will be needed to support the amended At-Berth Regulation, and in 2021 the TAP is partnering with the South Coast Air Quality Management District (South Coast AQMD) on an alternative to shore power for at-berth tanker emissions. Additionally, CARB is planning to amend its harbor craft regulation, which will require new harbor craft technologies, including zero-emission platforms. Developing and achieving verification or state approval of these technologies will be key. Programs such as TAP, with heavy involvement from the regulatory agencies, can help facilitate and expedite verification and commercialization, ensuring our operators have compliance options for these new regulations.

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.

2 TECHNOLOGY ADVANCEMENT ACCOMPLISHMENTS IN 2020

In 2020, the Ports continued to support technology advancement with a particular focus on zero-emissions vehicle demonstrations and development of supporting infrastructure (i.e., charging equipment). Major accomplishments in 2020 include:

- Funded two new TAP projects that were selected from the TAP’s 2018 Call for Projects. These projects are detailed in Section 5 and listed below:
 - Pasha Hawaii Ohana Class LNG-Powered Container Ships Project (Section 5.9)
 - Pasha Horizon C9 Vessel LNG Engine Repower Demonstration Project (Section 5.10)
- Funded a new OGV retrofit demonstration project led by South Coast AQMD, with MAN Energy Solutions USA, Inc. (Section 5.14)
- Completed the Centerline (formerly Harley Marine) Logistics Electric Drive Tugboat Design project (Section 5.3)
- Completed the South Coast AQMD’s Development of a Near-Zero Emissions Diesel Engine for On-Road Heavy-Duty Vehicles (Section 5.13)
- Pursued funding for a Large-Scale Zero-Emissions Pilot Truck Deployment, which aims to demonstrate 50-100 zero-emissions drayage trucks in a single deployment. In 2020, the Ports worked with stakeholders and funding agencies to identify initial concepts and potential costs. In 2021, the Ports plan to partner with other agencies to seek State funding for this demonstration.
- Launched studies to assess the feasibility of public charging and fueling in and near the port complex, including potential sites and business models. Each Port is conducting its own assessment.
- Continued to demonstrate pre-commercial zero- and near-zero emissions 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.

- Maintained an updated TAP website¹ 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 2020 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 2020 and projected milestones for 2021.

Table 1: 2020 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 9	Zero Emission
Advanced Yard Tractor Deployment and Eco-FRATIS Drayage Truck Efficiency Project (Port of Los Angeles)	Demonstrate 20 yard tractors equipped with certified near-zero 0.02 gram/bhp-hr NOx engine and five zero-emission yard tractors. Also, demonstrate integration of intelligent transportation system technologies for on-road trucks.	Section 5.2, page 11	Zero- and Near-Zero Emission
Centerline Logistics (formerly Harley Marine Services) Electric Drive Tugboat Design	Completed in 2020. Design and cost out an electric drive tugboat with multi-mission capabilities (ship assist, escort and rescue towing) with a 6,800 horse-power electric drive and a range of 2,400 nautical miles. The tugboat will have six Tier IV C32 diesel engines and two electric propulsion motors.	Section 5.3, page 13	Hybrid Electric
Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT, Port of Long Beach)	Demonstrate three battery-electric top handlers and a battery-electric yard tractor.	Section 5.4, page 14	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 5.5, page 15	Idle Reduction
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 5.6, page 16	Zero Emission

¹ <http://www.cleanairactionplan.org/technology-advancement-program/>

San Pedro Bay Ports Technology Advancement Report
2020 Annual Report and 2021 Priorities

Project Title	Project Description	Details	Technology
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 (ADPF) with upstream diesel oxidation catalyst (DOC) in front of a selective catalytic reduction (SCR) system with ammonia slip catalyst.	Section 5.7, page 18	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 5.8 page 19	Zero Emission and Other Platforms
Pasha Hawaii Ohana Class LNG-Powered Container Ships Project (Two New Builds)	Initiated in 2020. 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 5.9, page 20	LNG
Pasha Horizon C9 Vessel LNG Engine Repower Demonstration Project	Initiated in 2020. 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 5.10, page 21	LNG
Port Advanced Vehicle Electrification, PAVE Project (Port of Long Beach)	Design, install, and deploy electrical fast-charging infrastructure to support battery-electric cargo handling equipment and battery storage.	Section 5.11, page 21	Zero Emission
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 5.12, page 23	Zero Emission
South Coast AQMD Development of a Near-Zero Emissions Diesel Engine for On-Road Heavy-Duty Vehicles	Completed in 2020. Develop an ultra-low NOx (0.02 g/bhp-hr) emissions <i>diesel</i> engine for on-road heavy-duty vehicles.	Section 5.13, page 25	Near-Zero Emission
South Coast AQMD Retrofit Technology Development - Water-in-Fuel Technology	Initiated in 2020. 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 5.14, page 26	OGV Retrofit

Project Title	Project Description	Details	Technology
South Coast AQMD Zero Emissions 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 5.15, page 29	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 5.16, page 30	Zero Emission
Sustainable Terminals Accelerating Regional Transformation (START) Project (Port of Long Beach)	Demonstrate more than 100 pieces of zero-emissions terminal equipment and trucks at three California seaports, develop a near-zero emissions tugboat, deploy two ships with some of the cleanest available engines, and advance workforce development programs to support sustainable goods movement.	Section 5.17, page 32	Zero and Near-Zero Emission
Zero-Emissions Terminal Equipment Transition Project (Port of Long Beach)	Repower nine RTG cranes for full-electric power, demonstrate 12 zero-emissions yard tractors and two smart charging systems, and convert four LNG trucks to plug-in hybrid electric trucks with LNG range extender.	Section 5.18, page 33	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-emissions technology development and demonstration. In 2020, the Ports continued to lead 12 major zero- and near-zero emissions demonstration projects valued at over \$312 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-emissions trucks and terminal equipment in a single port complex.

These Ports and agency technology advancement projects include the following²:

- 37 zero-emissions drayage trucks (battery-electric and fuel cell)
- 80 zero-emissions terminal equipment, including yard tractors, top handlers, rubber-tired gantry cranes, and forklifts
- 5 near-zero emissions drayage trucks
- 20 near-zero emissions yard tractors
- 114 new electric charging outlets
- 2 new hydrogen fueling stations
- 1 near-zero emissions tugboat with Tier IV engines and an electric-drive system

²

In addition to directly supporting zero-emissions 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-emissions 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.

Figure 1: Repowering RTGs to Zero Emissions



Nine diesel RTGs are being repowered at SSA, Pier J from diesel to full electric under the Zero Emissions Terminal Transition Project. See Section 5.18.

Specifically, the Ports are providing indirect support for SCAQMD'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 are demonstrating over 50 on- and off-road zero-emission trucks/equipment with associated infrastructure and solar power. The Ports are contributing expertise and in-kind labor.

The Ports are also facilitating demonstration fleet participation in SCAQMD's Zero-Emission Drayage Truck Demonstration Project under CARB's Greenhouse Gas Reduction Fund program. This project includes 42 demonstration trucks (zero-emission and plug-in hybrid technology) as well as supporting infrastructure.

In terms of direct support, the Ports have provided cost-share funds for SCAQMD's ZECT II project (Section 5.15) and allocated \$1 million each (total of \$2 million) to support SCAQMD's demonstration of Daimler heavy-duty electric trucks (Section 5.12).

4 2021 TECHNOLOGY ADVANCEMENT PRIORITIES

In 2021, 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.

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-emissions equipment and trucks and active charging infrastructure construction. The Ports already have learned so much from these projects and have begun to identify the gaps in understanding,

which will shape future funding priorities. These projects are complicated and resource-intensive and have never before been attempted at this scale. The Ports must 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 2021, 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 2021, the Ports commit to the following technology advancement priorities:

- 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;
- Pursue funding for a pilot deployment of 50 to 100 zero-emission trucks;
- Launch demonstrations to support promising technologies for ships;
- Explore concepts for terminal equipment charging and fueling infrastructure that provides for fast, safe electric charging and/or hydrogen refueling; and
- Consider new projects submitted under the TAP's ongoing Request for Information (RFI) review process³.

5 KEY PROJECTS IN 2020

This section provides additional detail for technology advancement projects that were active in 2020. 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: <http://www.cleanairactionplan.org/technology-advancement-program/>. All completed TAP projects are listed in Appendix B. More information about SCAQMD-led projects can be found at www.aqmd.gov/technology.

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.

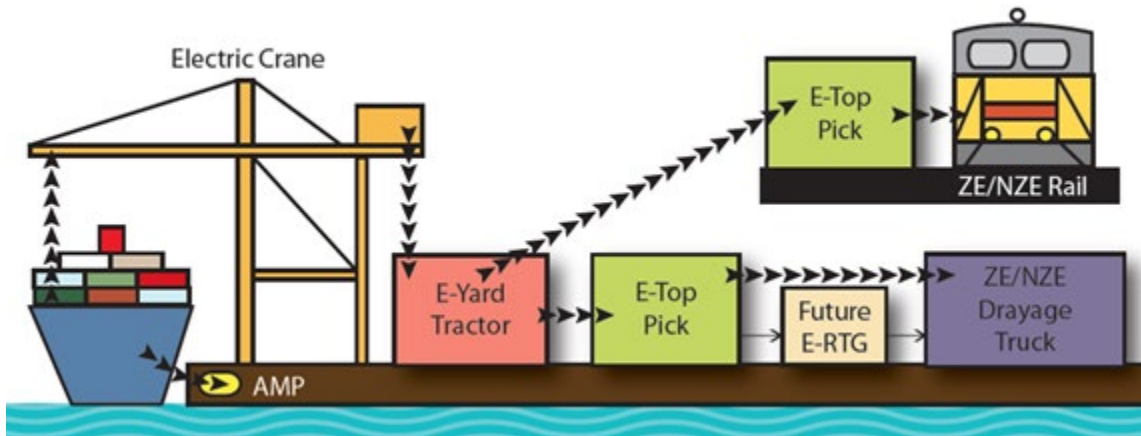
For this project, POLA is partnering with Wireless Advanced Vehicle Electrification, Inc. (WAVE) to design and demonstrate inductive charging technology to support each of the 10 yard tractors at WBCT's equipment corral as well as two opportunity charging stations at the central break

³ The TAP RFI is available at: <https://cleanairactionplan.org/request-for-information-san-pedro-bay-ports-technology-advancement-program/>

location where the yard tractors can obtain a quick (10-15 minute) 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 125kW each. For this project, WAVE will install five systems at WBCT’s equipment corral to charge 10 second-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, such as 30-minute lunch breaks, or between-shift changes. Finally, a battery-storage system will be installed at the base charging stations so as to minimize peak-demand charges that could result from a sudden influx of 10 high-power yard tractors all charging off the electrical grid at once.

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-emissions pathway, shown in Figure 2.

Figure 2: Port of Los Angeles Zero-Emissions Pathway Concept



Project Partners & Budget

This project is funded partly with a \$7.8 million CEC grant. Additionally, SCAQMD is contributing nearly \$1.8 million in the form of a USEPA Targeted Air Shed Grant to WBCT, and OEMs, demonstration partners, and POLA are contributing the balance. The total project cost is roughly \$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 2020

The project team moved forward with engineering designs for infrastructure development to support the WAVE system. Design concepts and engineering configurations were completed for the battery storage system that would meet the needs of terminal operations and interface with equipment specifications. Parts procurement neared completion.

2021 Milestones

The following activities are expected in 2021:

- 100% design plan approval.
- Third-party contractor RFP bid and award process.
- Construction work will begin at WBCT to install the background infrastructure to support the WAVE systems.
- The prototype WAVE unit will be constructed, validation tested, and pre-certified.
- The WAVE units will be integrated with the BYD yard tractor.
- Two integrated yard tractors and two WAVE systems will be delivered, commissioned, and begin demonstration.
- Manufacturing and integration will continue for the additional ten WAVE charging systems and eight BYD yard tractors.

5.2 Advanced Yard Tractor Deployment and Eco-FRATIS Drayage Truck Efficiency Project (Port of Los Angeles)

Project Description

For this project, POLA is demonstrating near-zero- and zero-emission cargo-handling equipment, as well as an intelligent transportation system (ITS) technology designed to improve on-road truck efficiency. The project includes three major components:

- Demonstrate 20 yard tractors that are equipped with the Cummins Westport near-zero 0.02 gram/bhp-hr NOx engine. To further enhance project benefits, a temporary renewable natural gas (RNG) system is used to fuel these demonstration units.
- Demonstrate five yard tractors equipped with BYD's first-generation zero-emission propulsion technology.
- Demonstrate integration of intelligent transportation system technologies, called Eco-FRATIS. The base ITS system is already being demonstrated on trucks, but with this project, a suite of additional technologies including traffic signal control were added to further enhance efficiency benefits.

This project is related to the Everport Advanced Cargo-Handling Equipment Demonstration Project described in Section 5.6, which will demonstrate BYD's second-generation battery-electric yard tractors.

Project Partners & Budget

The project is funded in part by a \$5.83 million grant from CEC's Low Carbon Transportation Greenhouse Gas Reduction Fund Investments. The overall project budget is \$8.64 million. Table 3 summarizes the funding contributions.

Table 3: Advanced Yard Tractor Deployment and Eco-FRATIS Drayage Truck Efficiency Funding Partners

Project Partners	Contributions
California Energy Commission	\$5,833,000
OEMs and Demonstration Partners	\$2,808,007

Accomplishments During 2020

The 20-unit LNG low-NOx yard tractor demonstration wrapped up November 1, 2020. Driver feedback was positive regarding the units’ capabilities, and other than minor warranty repairs, the fleet has been reliable. The units were operated one shift per day, due to the additional time it took to fuel each unit. At best during the demonstration, fueling took between 10 and 15 minutes per unit, which did not efficiently integrate with Everport’s operation to allow for these units to operate double shifts. Clean Energy and Everport are reviewing options to overcome the fueling challenge, since Everport intends to utilize the low-NOx yard tractors in daily operations beyond the demonstration period.

The five BYD yard tractors and associated EVSE continued to face technical challenges in 2020. The one-year demonstration of the BYD zero-emission units was officially kicked off in March 2020. Subsequently, the units experienced a number of different issues that required return to BYD’s manufacturing facility in Lancaster, CA for trouble shooting, redesign and/or repair. Major issues included the door hydraulics design and ongoing issues with the fifth wheel design, which even after redesign to address an earlier fifth wheel weight distribution issue, continued to rub at the bombcart or chassis during tight maneuvers. Additionally, Everport requested a breakaway design for the glad hands, coupling devices that connect emergency air lines and electrical services from the yard tractor to the trailer, to address a safety concern. Further, the units experienced intermittent charging issues that are believed to be resolved as of late 2020. Parts to address the above issues were received at the end of 2020 and repairs are underway.

The Eco-FRATIS demonstration was completed in 2020.

2021 Milestones

The following activities are expected in 2021:

- Data analysis for the near-zero emission LNG demonstration will be completed and the project final report will be developed.
- The zero-emissions yard tractors should be able to operate for the balance of their demonstration period with relevant data collection through March 2021.
- Data analysis for the zero emission BYD demonstration will be completed and the project final report will be developed.
- The Eco-FRATIS demonstration results will be analyzed and final report will be developed.

5.3 Centerline Logistics (formerly Harley Marine) Electric Drive Tugboat Design

Project Description

For this project, Centerline Logistics (formerly known as Harley Marine Services), developed a design and cost estimate of an electric-drive tugboat that has multi-mission capabilities (ship assist, escort and rescue towing) with a 6,800 horse-power electric drive and a range of 2,400 nautical miles. The tugboat design has six C32 diesel engines (Tier 4) and two electric propulsion motors. Compared to a tugboat constructed in 2018 that meets today’s USEPA marine engine standards (Tier IV propulsion engines and Tier III auxiliary engines), NOx, PM and ROG emissions from this electric drive tugboat design are projected to be reduced by 68%, 68%, and 70%, respectively. Reductions are projected to approach 90% for all pollutants when compared to a tug that meets 2013 emission standards. This project is a component of the larger START Project described in Section 5.17.

The goal of this project is to bring diesel electric technology into tugboat utility. Currently, there are no electric drive tugboats in North America. Key deliverables include the tugboat specifications, a complete design drawing package, projected emission and fuel consumption reductions, a minimum of two shipyard construction quotes, and a final project report.

It should be emphasized that TAP funding is limited to the design of the electric drive tug. Construction costs are expected to be covered by grants and Centerline Logistics funding. The construction phase would also include comprehensive emissions testing to document emission reduction benefits. The overall cost to design and construct the electric drive tugboat is estimated to be \$18 to \$20 million.

Project Partners & Budget

The Ports are contributing \$235,000 in co-funding to this project with a total project budget of \$599,000. Table 4 summarizes the project funding contributions:

Table 4: Centerline Logistics Electric Drive Tugboat Design Project Funding Partners

Project Partners	Contributions
Port of Los Angeles	\$117,500
Port of Long Beach	\$117,500
Centerline Logistics and Other Partners	\$364,000

Accomplishments During 2020

In 2020, Centerline Logistics completed contract design, which is the step required in order to obtain bids for the new tugboat and put the specifications out for bid with shipyards. Having secured cost estimates for building the tugboat, the TAP portion of the project has been completed; however, construction and demonstration will continue as part of the START Project (Section 5.17).

5.4 Commercialization of POLB Off-Road Technology Demonstration Project (C-PORT) (Port of Long Beach)

Project Description

The Port of Long Beach C-PORT project, in partnership with SSA Marine and Long Beach Container Terminal (LBCT), will demonstrate four zero-emission cargo-handling equipment. The demonstration included three never-before-tested battery-electric top handlers manufactured by Taylor Machine Works and BYD Motors, Inc. and a battery-electric yard tractor manufactured by Kalmar with TransPower. This project also includes an educational component by which Long Beach Unified School District students learned about the Port of Long Beach's zero-emission technology efforts through a capstone research project.

Project Partners & Budget

The project is funded in part by a \$5.2 million grant from CARB's California Climate Investments. The overall project budget is \$8.3 million. Table 5 summarizes the funding contributions.

Table 5: C-PORT Funding Partners

Project Partners	Contributions
Port of Long Beach	\$1,373,485
California Air Resources Board	\$5,249,820
South Coast Air Quality Management District	\$350,000
OEMs and Demonstration Partners	\$1,388,066

Accomplishments in 2020

The three Taylor top handlers were commissioned in the first quarter. The Kalmar yard tractor was previously commissioned in 2019. All four units of the project were in commercial service operation. All necessary infrastructure, EVSE and energy meters were deployed. The demonstration at SSA, two of the Taylor units, was completed December 2020. Data collected are being analyzed and will be detailed in a full report, which will be shared in the 2021 TAP Annual Report. Figure 3 includes photos of battery-electric top handlers operating at two port terminals.

Figure 3: Taylor Battery-Electric Top Handler at LBCT (left) and SSA (right)



2021 Milestones

The following activities are expected in 2021:

- The LBCT demonstration of the yard tractor and one top handler is expected to be completed in the first half of 2021.
- Development of the final report is expected to begin in mid-2021.

5.5 Effenco Electric Active Stop-Start™ Technology Demonstration

Project Description

The objective of this project is to demonstrate Effenco’s Active Stop-Start electric hybrid technology to reduce yard tractor emissions and evaluate viability for large-scale implementation. This project will retrofit six yard tractors at APM Terminals. 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 projects emission reductions ranging from 30-60% percent, depending on pollutant type. Effenco plans to seek an aftermarket parts exemption from CARB in order to be able to sell and install their system in California.

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 will be installed to monitor the performance of the retrofit with the precision of capturing over 100 operating parameters every tenth of a second.

Project Partners & Budget

The Ports are contributing \$180,000 in co-funding to this project with a total project budget of \$625,163.

Table 6 summarizes the project funding contributions.

Table 6: Effenco Electric Active Stop-Start™ Technology Demonstration Project Funding Partners

Project Partners	Contributions
Port of Los Angeles	\$90,000
Port of Long Beach	\$90,000
Effenco	\$445,163

Accomplishments During 2020

In Q3 2020, the system units were delivered to APM Terminals. Installation of the system on the demonstration units was delayed due to set backs associated with receiving CARB authorization that allows the installation of parts or modifications proven by their manufacturers and certified by CARB not to increase vehicle emissions. CARB has several pathways relating to the sale, use, or modification of emissions control systems, including verification, certification, and aftermarket parts. During 2020, Effenco focused on active coordination with CARB to identify the approval pathway that best served their technology and to initiate the application process.

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.

Effenco ultimately applied for aftermarket parts exemption and is concurrently engaging CARB on the experimental permit process. It is important to note that the only mode of operation of the Active Stop-Start technology, which is combined with certified engines, is to shut off the engine at stop and thus should not increase emissions. Overall, the project team has encountered challenges due to the technology's anti-idle design and Effenco not being the OEM of the yard tractors. These challenges are now being addressed since CARB's exemption process is designed to address concerns about modifying OEM technology and ensuring original specifications and emissions are not adversely affected by the retrofit technology. To facilitate installation under COVID-related travel limitations, Effenco has developed an installation manual and is prepared to remotely guide Pacific Crane Maintenance Company and APM Terminals staff on system installation once CARB authorization is received.

2021 Milestones

The following activities are expected in 2021:

- Finalize CARB approval to proceed with installation of the Effenco technology on the demonstration units.
- Complete installation of the Effenco Active Stop-Start technology in the yard tractors.
- Commence the six-month demonstration.

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

Project Description

POLA's Everport Advanced Cargo-Handling Equipment Demonstration Project will demonstrate three BYD electric yard tractors and two Taylor battery-electric top handlers. This project also will demonstrate the Cavotec SmartCharging System (SCS) for yard tractors. For this project, POLA is investing in new switchgear and the associated infrastructure to support this project, since the terminal does not currently have enough capacity for this new equipment. This upgrade is being designed to allow for the eventual addition of up to 25 battery-electric yard tractors.

Project Partners & Budget

The project is being funded by a 2017 CEC grant in the amount of \$4,524,000, with project cost share in the amount of \$2,238,331, for a total project cost of \$6,762,331.

Table 7 summarizes the funding contributions.

Table 7: Everport Advanced Cargo Handling Equipment 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 2020

Final permit approval was issued for the two BYD EVSE, associated with the Taylor top handlers, on February 27, 2020. Both zero-emission top handlers were commissioned in April 2020 and began their 12-month in service demonstration. The top handlers function well, with positive feedback from the terminal and equipment operators. Cumulatively, both top handlers operated a total of 1,770 hours during 2020. Although the hours are less than anticipated, due to ongoing challenges with the EVSE and the onboard charger, utilization remains consistent and the terminal plans to continue using the equipment beyond the demonstration period. Figure 4 shows the Taylor zero-emission top handler in operation at Everport.

Figure 4: Taylor Battery-Electric Top Handler



Further, both Cavotec and BYD experienced factory shutdowns, due to the COVID-19 pandemic. In Q3, engineers and technicians at Cavotec and BYD resumed collaborative efforts to finalize designs for the SCS integration, which will electrify the next-generation BYD battery-electric yard tractors. Challenges regarding the adaptability of the charging interface between the Cavotec arm and funnel and the BYD charging platform resulted in design modifications.

2021 Milestones

The following activities are expected in 2021:

- Complete demonstration of the Taylor top handlers.
- Complete terminal redevelopment construction.
- Deliver three next-generation BYD battery-electric yard tractors and Cavotec SCS to Everport.
- Commission and begin demonstration of the yard tractors and SCS.

5.7 Nett Technologies Inc. BlueMAX™ NOVA 320e Harbor Craft Demonstration

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 (ADPF) with upstream diesel oxidation catalyst (DOC) in front of a selective catalytic reduction (SCR) 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 DPM, NOx, and CO (with small increases in greenhouse gases due to the use of carbon fuel injection). This 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 8 summarizes the project funding contributions.

Table 8: 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 During 2020

With design and fabrication complete in 2019, the project team proceeded with shipping the aftertreatment system to California in early 2020 for installation on the candidate vessel, the *Bass*. Due to COVID-19 travel restrictions, the Nett Technologies team was unable to travel to conduct the installation but was able to walk through the installation procedures with Pacific Tugboat personnel who completed the installation of the aftertreatment hardware. All that remains is for the SCR system to be activated through calibrations conducted during sea trials, which can only occur once travel restrictions are lifted.

2021 Milestones

The following activities are expected in 2021:

- Calibrate and install the system into the demonstration vessel. This is not yet scheduled due to travel restrictions.
- Obtain CARB approval for all emissions testing procedures.
- Begin the demonstration of the BlueMAX™ NOVA 320e in the *S.Bass* harbor craft.

Figure 5: Nett Technologies Demonstration Vessel and BlueMAX NOVA System



Left: The demonstration vessel, S. Bass. Right: 3D model of the BlueMAX™ NOVA 320e

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

Project Description

This POLA demonstration project has several components including: two battery-electric yard tractors from BYD Motors; two battery-electric yard tractors and two battery-electric on-road trucks from TransPower, one battery electric Kalmar yard tractor, electrification of three 21-ton forklifts from TransPower; 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 9 summarizes the funding contributions.

Table 9: 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

Accomplishments in 2020

In 2020, the project agreement was modified to extend the project term by 12 months to December 2021, remove the carbon treatment component of the ShoreKat demonstration, and acquire another battery electric yard tractor. In 2020, the BYD EVSE were permitted and energized. The BYD yard tractors were placed in service and are used in operation when ships are being offloaded. The TransPower yard tractors, forklifts, and on-road trucks were all located at the terminal, but not in use for most of 2020 due to Occupational Safety and Health Administration (OSHA) regulations that require vehicles to be certified by either the manufacturer or an engineer if significant modifications are made and placards must be upgraded prior to placing vehicles in service. The terminal presented a formal request to TransPower to comply with this OSHA requirement and upon receipt of the appropriate certifications, the equipment will be returned to service. The BYD battery storage system received third-party certification and was installed in its permanent location but has not yet received final permitting due to Los Angeles City Fire Department requirements for an enhanced fire suppression system, which is being replaced by the Harbor Department. The ShoreKat at-berth emissions control system demonstration was completed in March 2020. The carbon capture component of this system was deemed infeasible and removed from the project scope. Funding was reallocated to purchase a battery electric yard tractor from Kalmar for demonstration.

2021 Milestones

The following activities are expected in 2021:

- TransPower to resolve vehicle use approval and put equipment into service.
- Kalmar yard tractor will be commissioned and demonstrated.
- The solar panels are expected to be installed on the warehouse.
- Harbor Department will install a new fire suppression system to replace the one provided by BYD, and the battery storage system will be commissioned and begin demonstration.
- Data collection and final report will be completed.

5.9 Pasha Hawaii Ohana Class LNG-Powered Container Ships Project

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 10. TAP funding will support the initial repower design and documentation of the demonstration and emission reduction benefits.

Table 10: 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 2020

The contract agreements were finalized in late 2020 and design work was completed. Construction of the first vessel began, and progress was slower than anticipated due to restrictions related to the COVID-19 pandemic. Pasha received approval for the LNG fueling process for the ships, which will call at the Port of Long Beach. The project team will use a series of LNG fuel trucks, contracted from Clean Energy, to fuel the ships.

2021 Milestones

The following activities are expected in 2021:

- The first new LNG vessel is expected to be delivered in the 1st quarter of 2021.
- Data collection plan will be approved and emissions data collected from LNG-powered trip(s).
- The second new LNG vessel will be completed and delivered in the 4th quarter 2021.

5.10 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 high pressure in a 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 11. TAP funding will support the initial repower design and documentation of the demonstration and emission reduction benefits.

Table 11: 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 2020

The contract agreements were finalized in late 2020 and design work was initiated. The anticipated repower schedule initially proposed has been heavily delayed by contract negotiations and the COVID-19 pandemic.

2021 Milestones

The following activities are expected in 2021:

- The designs for the repower of the vessel will be completed.
- Data collection plan will be approved.
- The ship will be dry-docked, and the engine repower will begin in 3rd quarter, 2021.

5.11 Port Advanced Vehicle Electrification (PAVE) Project (Port of Long Beach)

Project Description

The Port of Long Beach's Port Advanced Vehicle Electrification (PAVE) Project which was originally planned to take place at Total Terminal International's facility at Pier T, will design, install, and deploy electrical charging infrastructure, including electrical conduit, wires, switchboards, transformers, and switchgears, to support zero-emission cargo handling equipment. The project will also develop a comprehensive port-wide Dynamic Energy Forecasting Tool in partnership with the Electric Power Research Institute (EPRI) to predict how much energy and supportive infrastructure seaports will need to support zero-emissions terminal equipment.

Unfortunately, this project will not move forward at Pier T. After months of re-engineering and evaluation, the cost associated with integrating the selected charging system with the charging connector and battery-electric yard tractor was determined to be prohibitive - exceeding the project's original budget by \$6 million. The decision from Total Terminals International to not move forward with the project came at the peak of pandemic when cargo volumes hit record lows and the terminal faced significant uncertainty.

Project Partners & Budget

The project is funded in part by an \$8,000,000 grant from CEC. Due to the project's uncertainty and ongoing budget discussions, additional details will be provided in future reports.

Accomplishments in 2020

In spite of the challenges described above, the team was able to continue the development of the Dynamic Energy Forecasting Tool (DEFT) in 2020. DEFT is an open-source software tool for evaluating the financial and operational impacts of transitioning to zero-emission stevedoring operations. The Electric Power Research Institute is contracted as a subgrantee for its development. Alpha-testing of the software was conducted among Port of Long Beach stakeholders in May 2020. Beta-testing, for which the testing group was expanded to include prospective marine terminal operator end-users, was conducted in December 2020. DEFT is expected to be published and released for public use in 2021.

2021 Milestones

The following activities are expected in 2021:

- Identify a new site for project implementation
- Execute a new grant agreement with the CEC and South Coast AQMD
- Select and execute agreements with new project partners
- Complete infrastructure design
- Publish the DEFT tool for public use in 2021.

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

Project Description

This project, being led by South Coast AQMD, manufactured and is now demonstrating 20 heavy-duty battery-electric trucks with Daimler Trucks North America (DTNA): 15 Class 8 eCascadia and five Class 6 eM2 trucks. The project includes 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 and Black Horse Carriers. PTL is also engaging with customers, like Costco, 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-led projects can be found at www.aqmd.gov/technology.

Regarding infrastructure, the project includes ten DC Fast Charge (DCFC) locations comprising 20 chargers, 30 plugs and a total of 2550 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 1112.5 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 and much smaller NFI station is located closer to the Ports in Wilmington. Finally, and a smaller station 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 Environmental Protection Agency Region 9. Table 12 summarizes the funding contributions.

Table 12: Daimler Zero-Emissions 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
Environmental Protection Agency Region 9	\$1,000,000

Accomplishments During 2020

It has now been 18 months since the first Class 8 eCascadia rolled out and one year since the first Class 6 eM2 rolled out. Overall, the demonstration units have accumulated over 400,000 miles and continue to be used daily. The Class 8 trucks are averaging 2.1 kWh/mile, with average loads around 36,000 pounds and peak loads up to 60,000 pounds. The Class 6 trucks are averaging 1.4 kWh/mile.

All infrastructure is now fully commissioned. 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 units rated at 62.5kW, and 50 kW. Daimler experienced issues with the Siemens 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 energy storage system (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



2021 Milestones

The following activities are expected in 2021:

- Commission the Ontario site’s energy storage system in March 2021.
- Continue the two-year demonstration, which is scheduled to be complete in Q4, 2021.
- Collect and analyze vehicle operation data.

5.13 South Coast AQMD Development of a Near-Zero Emissions Diesel Engine for On-Road HDVs

Project Description

The objective of this project, which was a joint effort by South Coast AQMD, CARB, U.S.EPA and industry stakeholders was to advance engine and aftertreatment technologies in current heavy-duty diesel engines to achieve NOx emission levels that are at least 90% lower than 2010 heavy-duty NOx emissions standards. Under this project, technologies were developed to ensure that the engines also may be fueled with renewable diesel fuels, helping to address the GHG emissions reduction needs throughout California. More information about this and other South Coast AQMD-led projects can be found at www.aqmd.gov/technology.

Project Partners & Budget

The Port of Los Angeles contributed \$287,500 in co-funding to this project with a total project budget of \$1 million. Table 13 summarizes the project funding contributions.

Table 13: Ultra-Low Emissions Diesel Engine Development Project Funding Partners

Project Partners	Contributions
Port of Los Angeles	\$287,500
California Air Resources Board	\$425,000
South Coast Air Quality Management District	\$287,500

Accomplishments During 2020

The project objective was to achieve 0.02 gm/bhp-hr NO_x from a diesel engine, while minimizing CO₂ emissions. The project team developed a number of modified engine calibrations and screened and selected aftertreatment hardware options in order to develop a down-selected technology package for the engine-aftertreatment system that will be used in future testing. The project was completed in early 2020 and a final report is available on South Coast AQMD's website⁴.

To recap, the project team evaluated a number of aftertreatment technologies at Southwest Research Institute, with three standing out as the most promising for low-NO_x/reduced CO₂ diesel engines, including:

- Cylinder deactivation, found to be one of the most effective options,
- A light-off SCR that is close-coupled (located near the turbo charger on the engine under the hood), and
- Heated dosing, where the diesel exhaust fluid is heated, which helps reduce emissions during low load engine operation.

The USEPA is continuing the project as part of the Clean Trucks Initiative program. The goals are set to achieve 0.01 g/ bhp-hr NO_x levels at aftertreatment life of 800,000 miles. As a separately-funded follow-on to this project, South Coast AQMD plans to develop a proposal and finalize partners and funding to integrate the final design in a Class 8 heavy-duty truck for operation in demonstration service, including real-world emissions testing.

5.14 South Coast AQMD Retrofit Technology Development – Water-in-Fuel Technology

Project Description

Led by South Coast AQMD, the objective of this project is to design, manufacture, and demonstrate ocean-going vessel 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 the CARB approval via an Executive Order (or equivalent) for this technology's application to other vessels.

The NO_x reduction effect, which is based on a significant reduction in the peak combustion cylinder temperature due to the added water is highly dependent on a high-quality, stable emulsion. The mixing ratio will be subject to an optimization during the 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 engine room where the system will be installed.

⁴<http://www.aqmd.gov/docs/default-source/Agendas/Governing-Board/2021/2021-mar5-032.pdf?sfvrsn=2>
(page 159 of 193)

Project Partners & Budget

The Ports contributed \$1 million in co-funding to this project with a total project budget of \$3.2 million. Table 14 summarizes the project funding contributions.

Table 14: 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 During 2020

This project is well underway with completion of the engineering and design in 2020. MAN submitted its initial test plan to CARB for initial consideration. In late 2020, the project team initiated a contract amendment for a four-month no-cost term extension, which was necessary as a result of travel delays caused by the COVID-19 pandemic.

2021 Milestones

The following activities are expected in 2021:

- The contract amendment to provide additional time to address COVID-19 delays was executed in January 2021.
- MAN will continue to work with CARB to finalize the test plan.
- MAN will also work with the Det Norske Veritas Germanischer Lloyd (DNV) Class Society to obtain system plan approval.
- MAN and its subcontractor will complete the manufacturing of the WiF system by the end of March 2021.
- The system will be shipped to a European port (TBD) for installation by the end of March 2021. Partial system installation will be conducted while the vessel is at berth, with the balance to be completed while in operation (during voyage).
- The vessel will arrive in the San Pedro Bay Ports in Fall 2021 for commissioning and testing.

Figure 9: Demonstration Vessel MSC Anzu



Figure 10: Water-in-Fuel Emulsifier



Figure 11: Engine Room Layout for WiF Installation



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

Project Description

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

- Transportation Power, Inc. (TransPower) developed two battery electric trucks with hydrogen fuel cell range extenders.
- US Hybrid developed two battery electric trucks, 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 battery electric truck 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 emissions (all-electric) mode and in a 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 15 summarizes the project funding contributions.

Table 15: South Coast AQMD ZECT II Demonstration Funding Partners

Project Partners	Contributions
U.S. 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 During 2020

During 2020, 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 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 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 submitted this request to US DOE and the approval is pending. This truck will begin its demonstration service in late 2021.

2021 Milestones

The following activities are expected in 2021:

- Six project trucks shall complete demonstration service in early 2021, with final demonstration results expected in mid-2021.
- The data collected from 6 trucks that completed demonstration will be analyzed for drive performance, efficiency, etc.
- Hydrogenics (Cummins) will deploy its demonstration truck in late 2021, with final demonstration results expected in early 2024.

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

Project Description

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

- Ten zero-emissions hydrogen fuel-cell-electric Class 8 on-road trucks (Figure 12) on the Kenworth T680 platform are being 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, and eventually to Merced. The trucks will be operated by Toyota Logistics Services (4), United Parcel Services (3), Total Transportation Services Inc. (2), and Southern Counties Express (1).
- Two hydrogen fueling stations that fuel heavy-duty trucks will be constructed by Shell in Wilmington and Ontario, California. The new stations will join three additional stations located at Toyota facilities around Los Angeles to form an integrated, five-station heavy-duty hydrogen fueling network.
- Expanded use of zero-emissions technology in off-road and warehouse equipment, including the first two zero-emissions yard tractors to be operated at Port of Hueneme, 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



Project Partners & Budget

In late 2018, CARB awarded roughly \$41 million to POLA for the Zero- and Near Zero-Emission Freight Facilities (ZANZEFF) project. Project partners, including Toyota, Shell, Kenworth, South Coast AQMD, and Port of Hueneme (POH) are providing \$41,446,612 in match funding. Table 16 summarizes the funding contributions.

Table 16: 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 2020

The first five hydrogen trucks designed and built and then proceeded through the process of shakedown, reliability assessment, and local drive evaluation. Since trucks #3 and #4 were furthest along in the validation process, they were transported in October to Colorado to drive up and down Pike’s Peak for high altitude validation testing (Figure 11). The 14,115’ altitude had no impact on the performance, per the drivers, and there were no significant issues. The trucks continued to undergo fuel cell system evaluation and overall fault resolution at the Toyota facility for the remainder of the year. Trucks #1, #2, and #5 continued with reliability testing and local drive evaluation at the Kenworth facilities. Trucks #6 - #10 were approximately 60% through major assembly by the end of 2020.

The Ontario hydrogen fueling station reached mechanical completion, completed the punch list from the prestart-up safety review, activated power to the site, and continued working through commissioning activities. The system evacuated nitrogen and introduced hydrogen for circulation through the equipment, ground storage, and dispensers. Five light-duty fills were completed in December.

The Wilmington hydrogen fueling station achieved mechanical completion, with the exception of power from the Los Angeles Department of Water and Power (LADWP). The poles were erected, wires pulled, transformer set, and readied for the next phase of pulling the secondary lines from the transformer to the switchgear. LADWP crews will bring in the secondary lines, pull the lines through the conduit, energize, and switch over the power. The station was expected to be energized in August; but due to LADWP delays, power to the station is anticipated Q1 2021.

The Port of Hueneme moved forward with the infrastructure development process. Kalmar yard tractors were ordered, with an additional battery bank box, necessary to ensure operational endurance through the complete duty shift.

The Data Collection Test Plan was proposed by NREL and finalized. The fleet baseline characterization data collection was completed in December with 253 gigabytes of data, from 71 vehicles in the baseline fleets, downloaded and imported. The analysis will be used to inform vehicle deployment, as well as providing a solid baseline data set for comparison to the advanced vehicles.

2021 Milestones

The following activities are expected in 2021:

- Ten (10) hydrogen fuel-cell trucks will be deployed throughout the year and the demonstration will begin.
- The hydrogen fueling stations in Ontario and Wilmington will be fully operational.
- The Port of Hueneme will complete the 480 volt infrastructure project to support the battery-electric yard tractors. The Kalmar yard tractors will be delivered, commissioned, and begin demonstration.
- At least one ZE forklift will begin demonstration.

5.17 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-emissions supply chain in and around its Matson Navigation Co. Pier C terminal. The Sustainable Terminals Accelerating Regional Transformation (START) Project, expected to be completed by 2022, will demonstrate more than 100 pieces of zero-emissions terminal equipment and trucks at three California seaports, develop a better-than-Tier IV emissions tugboat (see Section 5.3), 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 six 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-emissions yard tractors and one zero-emissions top handler 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;
- An electric-drive tugboat;
- Five electric trucks at an off-dock container yard; and
- Two charging heavy-duty truck 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 17 summarizes the funding contributions.

Table 17: 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 2020

In 2020, production began for the electric yard tractors, electric top handlers, and electric drayage trucks. Additionally, Port of Stockton began taking delivery of the heavy-duty forklifts and commissioned the rail-car mover for its port-run operations. Port of Oakland began the infrastructure construction for the charging equipment to support the heavy-duty on-road trucks, which themselves completed production and are being stored by Peterbilt until infrastructure is commissioned.

The first of two Tier III container ships was commissioned and made its first voyages to Long Beach and Oakland in January 2020, and the second Tier 3 vessel completed sea trials and was delivered to Matson in December 2020. Centerline Logistics completed final design on the better-than-Tier IV emissions tugboat and put the project out to bid for construction of the vessel (see Section 5.3 for more details on the status of this design project).

Charging infrastructure development in Long Beach has encountered delays due to demonstration requirements from the Southern California Edison (SCE) Charge Ready Transport program and difficulty in setting up a temporary EVSE installation to charge the first of the DINA and TransPower/Meritor electric yard tractors produced.

2021 Milestones

The following activities are expected in 2021:

- Delivery of the heavy-duty trucks in Long Beach and Oakland, pending charging infrastructure completion.
- Complete yard tractor charging demonstration for SCE, which allows infrastructure design and development to proceed, with infrastructure potentially being complete by Q4 2021.
- Delivery and commissioning of the electric top handlers at the Port of Long Beach and Port of Oakland.
- Commission and begin demonstration of the second Tier III vessel.
- Delivery of the remaining electric forklifts in Stockton, with demonstration commencing potentially as early as Q1 2021.
- Construction and delivery of the Tier 4+ tugboat

5.18 Zero-Emissions 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-emissions cargo-handling equipment projects at three container terminals. In addition, the Port is partnering with Total Transportation Services, Inc. (TTSI) to demonstrate near-zero emissions 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 at a single terminal.
- Developing and deploying a total of 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, will be designed to automatically charge using the Cavotec Smart Plug System.
- Converting four LNG trucks to plug-in hybrid electric trucks (PHET) LNG trucks at TTSI with zero-emissions capability developed by US Hybrid.

Project Partners & Budget

The Port received \$9,755,000 in CEC funding, which is matched by over \$9.6 million in project partner funding, for a total project investment of \$19,370,948. Table 18 summarizes the funding contributions.

Table 18: Zero-Emissions Terminal Transition Funding Partners

Project Partners	Contributions
Port of Long Beach	\$3,345,609
California Energy Commission	\$9,755,000
Southern California Edison	\$3,950,000
OEMs and Demonstration Partners	\$2,320,339

Accomplishments in 2020

eRTG Crane Demonstration – SSA, Pier J

In November 2020, SSA placed the first eRTG crane into revenue service at Pier J. Prior to commissioning the first eRTG crane, SSA worked with a consultant to build the guidance system, which ensured the eRTG traveled in the intended path and kept the cable within the trench during operations. Unfortunately, completing the required tests on the guidance system was delayed due to temporary terminal closures as a result of COVID-19. Due to the complexity of the guidance system as well as issues with the vendor’s mounted laser system, SSA installed a new guidance system that was built in-house by their mechanics. The SSA guidance system is made up of five proximity switches attached to an arm extending from the crane that is positioned over a metal bar attached to the concrete. The eRTG crane and the new guidance system have been operating well, and the datalogger installed has begun to track monthly usage. Conversion of the remaining eight RTG cranes to eRTG cranes will begin early 2021.

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

In April 2020, TTSI decided to temporarily suspend work on the demonstration due to low cargo volumes impacted by the COVID-19. In the meantime, US Hybrid continued to build out the trucks at the facility with limited staff present to ensure safe distancing protocols were practiced. In the months that followed, US Hybrid installed on-board chargers in all four demonstration trucks and delivered the first LNG PHET to TTSI in July 2020. By then, container volumes at TTSI increased and the demonstration resumed. The first LNG PHET is currently at TTSI and operating in revenue service. Data collection has commenced on the truck's performance. The second LNG PHET was delivered to TTSI in November 2020, and delivery of the two remaining units is set for 1st Quarter 2021.

BYD Battery-Electric Yard Tractors Demonstration – ITS, Pier G **Figure 13: Electric Yard Tractor**

Six BYD EVSE systems and one Cavotec smart-plug system (SPS) were officially commissioned at ITS, Pier G, in 2020. Prior EVSE issues involving charge interruption were resolved through a series of software updates on both the EVSE and yard tractors. By August 2020, all seven BYD yard tractors were delivered to ITS, including one adapted for the Cavotec smart-plug system (SPS), which allowed for the yard tractor to charge using a robotic arm. The BYD yard tractors have performed well and have operated the entire 7-hour shift on a single charge with 20-30% state of charge remaining. As the demonstration progressed, minor issues related to equipment operation and cab functionality were addressed and resolved with on-site support. ITS and BYD plan to train ITS mechanics to perform general maintenance and troubleshoot minor issues on the yard tractors in 1st Quarter 2021. See Figure 13.



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

Four BYD EVSE systems and one Cavotec SPS were officially commissioned at LBCT, Pier E, in 2020. The lessons learned from the Pier G demonstration were transferred to this demonstration. Due to the specific requirement for an automated coupling system in conjunction with an attached 5th wheel, BYD performed modifications on the boom platform of the yard tractor to accommodate the system. Initial trial runs proved successful and testing will continue into 1st Quarter 2021, prior to outfitting each yard tractor with the required navigation system needed for revenue service at the terminal.

2021 Milestones

The following activities are expected in 2021:

- Continue operating the first eRTG crane at SSA, and begin conversion on the remaining eight RTG cranes;
- Continue revenue service with the first two LNG PHETs and deliver the remaining two trucks before the end of Q1 2021;
- Continue demonstrating all seven BYD yard tractors at ITS with associated charging systems; and
- Deliver all five BYD yard tractors at LBCT and begin demonstration.

6 2020 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, including but 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.

The Ports and agency stakeholder investments for all past and current technology advancement projects approved to date are shown in 19 below. Three new technology projects were approved and funded in 2020, including:

- Pasha Hawaii Ohana Class LNG-Powered Container Ships Project (Section 5.9)
- Pasha Horizon C9 Vessel LNG Engine Repower Demonstration Project (Section 5.10)
- South Coast AQMD OGV Retrofit Technology Development - Water-in-Fuel Technology (Section 5.14)

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 port may utilize the project costs from a related or synergistic project to leverage additional grant funds to expand technology development and demonstration.

Table 19: Ports' Technology Advancement Funding Investments as of December 31, 2020

Project Category	POLB	POLA	South Coast AQMD	CARB	CEC	USEPA / USDOE & Other Agencies	Total Port & Agency Stakeholder	OEMs & Demonstration Partners	Total Project Budget
Ocean-Going Vessels									
APL Singapore Slide Valve/WIFE	\$22,500	\$22,500		\$783,628			\$828,628	\$471,372	\$1,300,000
ACTI AMECS Emissions Testing	\$149,527	\$149,527	\$55,000				\$354,054	\$249,157	\$603,211
Bluefield Holdings Krystallon OGV Scrubber	\$825,000	\$825,000					\$1,650,000	\$1,740,000	\$3,390,000
OGV Slide Valve Low-Load Emissions Evaluation	\$108,000	\$108,000					\$216,000		\$216,000
ACTI At-Berth Emissions Reductions for Ships	\$703,388						\$703,388		\$703,388
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
Maersk OGV Energy Efficiency Measurement Demonstration (completed in 2019)	\$500,000	\$500,000					\$1,000,000	\$1,860,000	\$2,860,000
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
Harbor Craft									
Centerline Logistics (formerly Harley Marine) Electric Drive Tugboat Design Project	\$117,500	\$117,500					\$235,000	\$364,000	\$599,000
Nett Technologies Inc. BlueMAXTM NOVA 320e	\$250,000	\$250,000					\$500,000	\$700,000	\$1,200,000
Foss Maritime Hybrid Tugboat	\$500,000	\$889,920		\$1,000,000			\$2,389,920	\$5,610,080	\$8,000,000
Cargo Handling Equipment and Port Terminal Projects									
LNG Yard Tractor*	\$350,000					\$75,000	\$425,000.00		\$425,000
Balqon Electric Terminal Tractor		\$263,500.00	\$263,500				\$527,000.00		\$527,000
Vycon RTG REGEN Flywheel	\$11,500	\$11,500.00	\$8,000				\$31,000.00		\$31,000
Balqon Lithium Battery Upgrade		\$400,000.00					\$400,000.00	\$540,000	\$940,000

San Pedro Bay Ports Technology Advancement Report
2020 Annual Report and 2021 Priorities

Project Category	POLB	POLA	South Coast AQMD	CARB	CEC	USEPA / USDOE & Other Agencies	Total Port & Agency Stakeholder	OEMs & Demonstration Partners	Total Project Budget
Hybrid Yard Tractor*	\$300,000	\$300,000.00				\$300,000	\$900,000.00	\$300,000	\$1,200,000
LBCT Eco-Crane	\$42,468	\$42,467.50				\$130,130	\$215,065.00	\$265,065	\$480,130
Capacity Plug-In Hybrid Tractor	\$29,500	\$32,000.00					\$61,500.00		\$61,500
APT Emulsified Biodiesel	\$44,000	\$44,000.00					\$88,000.00	\$88,000	\$176,000
<i>RYPOS Diesel Emissions Control (L2+)</i>	<i>\$64,668</i>	<i>\$64,668.42</i>					<i>\$129,336.84</i>		<i>\$129,337</i>
Hybrid Yard Tractor Development & Demonstration – Beta Test	\$13,000	\$13,000.00					\$26,000.00		\$26,000
RYPOS Adv. L3+ DPF – RTG Cranes	\$36,130	\$36,130.00					\$72,260.00	\$249,880	\$322,140
Port of Long Beach Zero Emissions Terminal Equipment Transition Project	\$3,345,609				\$9,755,000	\$3,950,000	\$17,050,609.24	\$2,320,339	\$19,370,948
Advanced Yard Tractor Deployment and Eco-FRATIS Drayage Truck Efficiency Project					\$5,833,000		\$5,833,000	\$2,808,007	\$8,641,007
Pasha Green Omni Terminal Demonstration Project				\$14,510,400			\$14,510,400	\$12,092,000	\$26,602,400
Everport Advanced CHE Demonstration		\$1,071,428.00			\$4,524,000.00		\$5,595,428.00	\$1,166,903	\$6,762,331
Commercialization of Off-Road Technology Demonstration	\$1,373,000		\$350,000	\$5,339,820			\$6,972,820	\$1,388,066	\$8,450,886
Port Advanced Vehicle Electrification***	TBD		TBD		\$8,000,000		\$8,000,000	TBD	TBD
Sustainable Terminals Accelerating Regional Transformation	\$3,531,157		\$500,000	\$50,000,000		\$3,250,000	\$57,281,157	\$43,237,585	\$100,518,742
Effenco Rapid Deployment of Electric Active Stop-Start™ Technology for Zero-Emission Idling from Port Yard Tractors Project	\$90,000	\$90,000.00					\$180,000	\$445,163	\$625,163
Advanced Infrastructure Demonstration Project		\$392,500.00	\$442,750		7842270	\$1,344,750	\$10,022,270	\$1,326,885	\$11,349,155
Container Drayage Trucks									
Westport ISX LNG Engine	\$250,000	\$250,000	\$1,250,000		\$500,000		\$2,250,000	\$7,644,027	\$9,894,027
SoCalGas CNG Drayage Truck	\$111,577.50	\$111,577.50	\$421,250				\$644,405	\$1,355,595	\$2,000,000
<i>Vision Motor Corp. Hydrogen Fuel Cell Plug-In Hybrid Electric Truck</i>	<i>\$95,625</i>	<i>\$95,625</i>					<i>\$191,250</i>		<i>\$191,250</i>
US Hybrid On-Board Charger for Zero Emissions Cargo Transport Demonstration	\$37,500	\$37,500	\$75,000				\$150,000		\$150,000

San Pedro Bay Ports Technology Advancement Report
2020 Annual Report and 2021 Priorities

Project Category	POLB	POLA	South Coast AQMD	CARB	CEC	USEPA / USDOE & Other Agencies	Total Port & Agency Stakeholder	OEMs & Demonstration Partners	Total Project Budget
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
<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>
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
Development of a Near-Zero Emissions Diesel Engine for On-Road Heavy-Duty Vehicles		\$287,500	\$287,500	\$425,000			\$1,000,000		\$1,000,000
SCAQMD 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
Develop and Demonstrate Catenary Zero Emissions Goods Movement System	\$2,000,000	\$4,000,000	\$2,500,000		\$3,000,000	\$2,000,000	\$13,500,000		\$13,500,000
Daimler Truck North America/AQMD 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
Shore-to-Store Project		\$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>	<i>\$25,000</i>	<i>\$25,000</i>					<i>\$50,000</i>		<i>\$50,000</i>
Technology Advancement Support Efforts									
Heavy-Duty Drayage Truck Duty Cycle Characterization	\$12,681	\$13,000					\$25,681		\$25,681
Development of Drayage Truck Chassis Dynamometer Test Cycle	\$12,000	\$11,466					\$23,466		\$23,466
AQMD HDV In-Use Emissions Testing Program	\$153,276	\$153,276	\$1,701,156				\$2,007,708		\$2,007,708
Total Investment (Includes Funding Outside TAP)	\$18,409,096.16	\$29,254,905.92	\$25,924,228	\$113,527,286	\$44,150,887	\$24,217,064	\$255,393,467.08	\$148,149,663.40	\$403,543,130.48
Total Port TAP Investment	\$47,664,002.08								

*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 U.S. EPA West Coast Collaborative (pre-dating the TAP).

***Port, OEM and partner match will depend on the final scope of work; see Section 5.11 for additional detail.

Italics denotes projects that were modified during implementation in a manner that changed the original budget; **Blue** denotes projects or project elements that were introduced in 2020.

APPENDIX A: TECHNOLOGY ADVANCEMENT PROGRAM CONTACTS

Technology Advancement Program Advisory Committee Membership

- | | |
|--|--------------------------|
| ▪ Naveen Berry, South Coast AQMD | nberry@aqmd.gov |
| ▪ John Lee, California Air Resources Board | jlee@arb.ca.gov |
| ▪ Francisco Doney, USEPA Region 9 | doney.francisco@epa.gov |
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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: <http://www.cleanairactionplan.org/technology-advancement-program/final-reports/>

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