2009 Annual Report
August 2010

San Pedro Bay Ports Clean Air Action Plan Technology Advancement Program

Moving towards zero emissions

THE PORT OF LOS ANGELES

Port of LONG BEACH
The Green Port

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Acronyms & Abbreviations

AC	TAP Advisory Committee
ACTI	Advanced Cleanup Technologies Incorporated
AMECS	Advanced Maritime Emissions Control System
APL	Shipping line formerly known as American President Line
CAAP	Clean Air Action Plan
CARB	California Air Resources Board
CEC	California Energy Commission
CHE	Cargo Handling Equipment
CNG	Compressed Natural Gas
CO	Carbon Monoxide
DOC	Diesel Oxidation Catalyst
DPF	Diesel Particulate Filter
DPM	Diesel Particulate Matter
EPA	United States Environmental Protection Agency Region 9
GHG	Green House Gases
HC	Harbor Craft
LNG	Liquefied Natural Gas
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
NO_x	Oxides of Nitrogen
OGV	Ocean Going Vessel
PAQMIP	Port of Los Angeles Air Quality Mitigation Incentive Program
PHL	Pacific Harbor Lines
POLA	Port of Los Angeles
POLB	Port of Long Beach
PM	Particulate Matter
PM_{10}	Particulate matter less than 10 micrometers in diameter
$PM_{2.5}$	Particulate matter less than 2.5 micrometers in diameter
RFI	Request for Information
RFP	Request for Proposals
RL	Railroad Locomotives
RTG	Rubber Tire Gantry Crane
SCR	Selective Catalytic Reduction

ACRONYMS & ABBREVIATIONS (CONT'D.)

SCAQMD	South Coast Air Quality Management District
SCRT	Selective Catalytic Reduction Technology
SoCalGas	Southern California Gas Company
SO_x	Sulfur Oxides
SPBP	San Pedro Bay Ports
TAC	Toxic Air Contaminant
TAP	CAAP Technology Advancement Program
VSR	Vessel Speed Reduction

EXECUTIVE SUMMARY

The ports of Long Beach and Los Angeles comprise one of the world's premier seaport complexes and are recognized as global leaders in environmental stewardship. The ports also serve as a principal economic engine for Southern California, moving $300 billion in trade each year and supporting more than 500,000 jobs in Southern California. Although recent economic conditions have caused a near-term reduction in imports and exports,, the latest economic forecasts still indicate that demand for containerized cargo moving through the Southern California region will increase significantly by the year 2020. The ports recognize that their ability to accommodate the projected growth in trade will depend upon their ability to address adverse environmental impacts that result from such trade. In 2006, the ports of Long Beach and Los Angeles adopted their landmark joint Clean Air Action Plan, which guides the ports in their commitment to reduce the health risks and air emissions associated with port-related operations, while allowing port development and growth to continue.

To ensure effective air pollution reduction strategies are commercially available to enable implementation of CAAP measures, the ports developed and are currently implementing the Technology Advancement Program (TAP). The purpose of the TAP is to identify and demonstrate new technologies or new applications of existing technologies that have a strong potential to reduce air pollution emissions from the CAAP source categories and meet CAAP goals.

The Mission Statement for the Technology Advancement Program is to *"accelerate the verification or commercial availability of new, clean technologies through evaluation and demonstration to move towards an emissions free port".*

TAP is funded on an annual basis by both ports. Each port allocates up to $1.5 million annually to the program. The ports maximize the effectiveness of this investment by leveraging the ports' funding with contributions from stakeholder agencies, including the United States Environmental Protection Agency Region 9 (US EPA Region 9), California Air Resources Board (CARB), and South Coast Air Quality Management District (SCAQMD). A minimum 50 percent co-funding contribution is required by the project implementer for all TAP projects. Table ES-1 summarizes the annual funding amounts, by port or agency stakeholder source, since program inception. These totals do not include the funding contribution by each project partner that is implementing the project; this information is contained in the individual project summaries in Section 2 for each TAP project.

Table ES-1: TAP Project Stakeholder Contributions

TAP Funding Source	2006	2007	2008	2009	Total
POLA	$0	$1,737,420	$830,104	$487,668	$3,055,192
POLB	$0	$1,434,000	$830,104	$107,334	$2,371,438
SCAQMD	$0	$271,500	$1,557,125	$476,250	$2,304,875
CARB	$0	$783,628	$0	$130,130	$913,758
CEC	$0	$500,000	$0	$0	$500,000
USEPA	$0	$375,000	$100,000	$0	$475,000
Total	**$0**	**$4,601,548**	**$3,447,463**	**$1,071,252**	**$9,584,097**

The TAP implementation process adopted by the ports is thoroughly outlined in the TAP Guidelines[1]. TAP offers grant funding to support for the demonstration of advanced technologies that:

a) have a high probability of achieving significant reductions in criteria pollutants as well as CARB-classified air toxic pollutants, specifically, diesel particulate matter (DPM); nitrogen oxides (NO_x) and sulfur oxides (SO_x),

b) are seeking CARB verification for the technology, and

c) present a strong business case for future successful technology commercialization.

In the simplest terms, the purpose of TAP is to faciliate the development of additional, effective air pollution reduction strategies for the CAAP "toolbox".

There are four fundamental areas of focus for the TAP:

1. Specific Control Measure Requirements
2. Emerging Technology Development, Demonstration, and Testing
3. "Green-Container" Transport Systems
4. Emissions Inventory Improvements

[1] *http://www.cleanairactionplan.org/civica/filebank/blobdload.asp?BlobID=2211*

Technology pursuits at the ports in support of CAAP measure implementation extend beyond TAP. However, TAP is complementary to other air pollution reduction efforts at each port. Given TAP's primary focus of identifying, verifying, and commercializing technologies, products proven technically feasible and commercially viable under TAP increase the ports' options and allow the ports to be more aggressive in pursuing CAAP measure implementation.

While TAP primarily focuses on the demonstration of technologies that have a high potential to yield substantial criteria air pollutant reductions, the technologies demonstrated under TAP often reduce greenhouse gases (GHG) and fine particulate matter (i.e., particle size of 2.5 micron in diameter, or smaller). As a matter of practice, GHG emission reduction potential is considered in the evaluation for each technology proposed for TAP demonstration.

The TAP serves as the catalyst for identifying, evaluating, and demonstrating new and emerging emission reduction technologies applicable to the port industry. As envisioned by the ports at the onset of TAP implementation, sucessful TAP technologies are intended to be incorporated into CAAP updates as either new control measures, alternatives to existing emission reduction strategies, or as additional mitigation options to support port growth.

This is the third TAP Annual Report under the CAAP. The 2009 TAP Annual Report documents progress in focus areas 1, Specific Control Measures, and 2, Emerging Technology Development. While important elements of the TAP, "Green Container Transport Systems" and "Emissions Inventory Improvements" are discrete focus areas whose findings and results are documented separate from this Report.

The TAP Advisory Committee (AC) consists of agency partners that include the Port of Long Beach (POLB), Port of Los Angeles (POLA), SCAQMD, CARB, and US EPA Region 9. The AC serves in an advisory capacity to the ports 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 agency that could potentially be used to move projects toward implementation. The AC process also serves as the mechanism for member agencies and the ports to reach consensus on the level of emission reductions achieved by the candidate technologies undergoing evaluation.

This Annual Report includes a summary of the ten (10) projects selected or that continued to be implemented under the TAP during 2009. These include:

Source Category	TAP Project
▪ Harbor Craft	Foss Maritime Green Assist™ Hybrid Tugboat
	OceanAir Environmental ECO Tug™ Tugboat
▪ Cargo Handling Equipment	Hybrid Yard Tractor Development & Demonstration
	Long Beach Container Terminal Eco-Crane™
	Alternative Petroleum Technologies' Emulsified Biodiesel
	Rypos Advanced Diesel Particulate Filter
	Capacity Plug-In Hybrid Yard Tractor (PHETT)
▪ Container Drayage Trucks	Balqon Lithium-Ion Battery Demonstration
	Westport ISX LNG Engine Development
	SoCalGas CNG Drayage Truck Demonstration

Each of the projects listed above is discussed in the following sections of this 2009 Annual Report. In addition to these active projects, Section 3 provides a summary of projects that were cancelled or withdrawn during 2009. These include:

- Crowley Maritime Ultra-Low Emission LNG Tug
- Johnson Matthey SCRT® Diesel Emission Control System Demonstration
- Pacific Harbor Line (PHL) Locomotive Diesel Particulate Filter

Two projects were completed in 2009: The Balqon Electric Class 8 Tractor and the APL Singapore Slide Valve & Water-In-Fuel Emulsion Demonstration Program. Please see Appendix B for complete summaries of these recently completed projects, as well as all other projects completed by the TAP to date.

1.0 Technology Advancement Program

1.1 Introduction

The ports of Long Beach and Los Angeles comprise one of the world's premier seaport complexes and are recognized as global leaders in environmental stewardship. The ports also serve as a principal economic engine for Southern California, moving $300 billion in trade each year and supporting more than 500,000 jobs in Southern California. Although recent economic conditions have resulted in a reduction in imports and exports, the latest economic forecasts still indicate that the demand for containerized cargo moving through the Southern California region will increase significantly by the year 2020. The ports recognize that their ability to accommodate projected growth in trade will depend upon their ability to address adverse environmental impacts that result from such trade.

While the economic benefits of the ports are felt throughout the nation, the environmental impacts of trade are more locally concentrated. The ports are cognizant of the view of environmental groups, local residents, and regulatory agencies that more should be done to address port-related air quality issues. The ports understand that inconsistent or conflicting environmental measures could have unintended and even counterproductive results.

In November 2006, the ports adopted their landmark, joint Clean Air Action Plan (CAAP). The CAAP includes mitigation measures and incentive programs necessary to reduce air emissions and health risks while allowing port development to continue. As both ports have several terminal redevelopment projects that could be approved and implemented in the next five years, there are significant opportunities to implement the measures defined by the CAAP to satisfy the dual goals of clean air and economic growth.

To ensure effective air pollution reduction strategies are commercially available to enable implementation of CAAP mitigation measures, the ports developed and are currently implementing the TAP. The purpose of TAP is to identify and demonstrate new technologies, or new applications of existing technologies, that have a strong potential to reduce air pollution emissions from the CAAP source categories and meet CAAP goals.

This document is the third Technology Advancement Program Annual Report under the CAAP.

1.2 Technology Advancement Program Objectives

The TAP Mission Statement is to "accelerate the verification or commercial availability of new, clean technologies through evaluation and demonstration to move towards an emissions free port".

The TAP thus serves as the catalyst for identifying, evaluating, and demonstrating new and emerging emissions reduction technologies applicable to the port industry. These technologies will be incorporated in future updates to the CAAP as either new control measures, alternatives to existing emission reduction strategies, or as additional mitigation options to support port growth.

The emphasis of the Technology Advancement Program is to facilitate testing or distribution of information on emerging technologies that can be used to reduce emissions associated with the five port-related source categories. These source categories include the following:

- Ocean Going Vessels
- Harbor Craft
- Cargo Handling Equipment
- Heavy-Duty Diesel Trucks
- Railroad Locomotives

1.3 Implementation Process

There are three primary means by which projects are identified for demonstration in the Technology Advancement Program:

1. Port Generated Projects;
2. Solicited Proposals;
3. Unsolicited Proposals.

1. *Port Generated Projects*

Should the ports have specific interest in an emissions reduction technology or project, the ports may elect to develop a project, seek partnerships to demonstrate the technology in port applications, and manage the implementation of the project. The ports may also seek grant funding from other stakeholders to assist with project implementation. As of the end of calendar year 2009, no new port-sponsored projects were generated under TAP.

2. Solicited Proposals

The ports enjoy broad authority under TAP to solicit proposals for a specific technology or for technologies that are applicable to specified source categories. Common methods of soliciting projects include Requests for Proposals (RFP), Requests for Qualifications (RFQ), and Program Opportunity Notices (PON). In 2009, no proposal solicitations were released.

3. Unsolicited Proposals

The ports frequently receive requests to fund various technology advancement projects, either from port tenants working with technology providers, regulatory agencies conducting research or demonstration projects, or from technology providers directly. When an unsolicited proposal is received by port staff, it is evaluated using the following criteria:

- Technology Application – *Is the technology applicable to the port industry? Is the application feasible?*
- CARB Verification – *Is the technology developer currently seeking, or are they willing to seek, CARB verification?*
- Matching Funds – *Is the project supported by in-kind or direct capital matching funds?*
- Emission Reductions – *Are the emission reductions consistent with the CAAP goals? Does the technology reduce some emissions without increasing others?*
- Ability to meet the needs of the port industry – *Will the technology perform effectively in the port environment?*
- Uniqueness of the Proposal – *Has the technology or demonstration been proposed by multiple vendors?*
- Cost – *Is the cost for the technology reasonable?*

Unsolicited proposals that are deemed meritorious by port staff are forwarded to the TAP Advisory Committee for further review.

1.4 Advisory Committee

The TAP Advisory Committee (AC) consists of agency partners that include the Port of Long Beach, Port of Los Angeles, SCAQMD, CARB, and US EPA Region 9. The AC was established by invitation during the first quarter of 2007 and meets every six weeks to deliberate the merits of candidate TAP projects.

The AC serves in an advisory capacity to the ports for screening, evaluating, and recommending projects to be considered for further development or demonstration. The AC process serves as the mechanism for member agencies and the ports to reach consensus on the level of emission reductions achieved by the candidate technologies undergoing evaluation.

The stated goal of the TAP program is to accelerate the development, verification, and commercialization of technologies that reduce source category air pollution emissions. The ports seek participation and funding contributions from other agencies for TAP projects. In this context, the AC members represent their agencies as it relates to the availability of co-funding from their agency that could potentially be used to move projects toward implementation.

In 2009, the ports received a significant number of unsolicited proposals submitted for funding consideration under TAP. Due to the wide range of technologies proposed, the AC membership was augmented on an ad-hoc basis to include additional members with expertise in diverse areas such as fuel additives, diesel emission control systems, and marine vessels. A list of current AC members is included in Appendix A of this Annual Report.

2.0 KEY PROJECTS IN 2009

This third Technology Advancement Program Annual Report includes a summary of the ten (10) projects that were implemented or remained active in 2009. These include:

Source Category	TAP Project
▪ Harbor Craft	Foss Maritime Green Assist™ Hybrid Tugboat
	OceanAir Environmental ECO Tug™ Tugboat
▪ Cargo Handling Equipment	Hybrid Yard Tractor Development & Demonstration
	Long Beach Container Terminal Eco-Crane™
	Alternative Petroleum Technologies' Emulsified Biodiesel
	Rypos Advanced Diesel Particulate Filter
	Capacity Plug-In Hybrid Yard Tractor (PHETT)
▪ Container Drayage Trucks	Balqon Lithium-Ion Battery Demonstration
	Westport ISX LNG Engine Development
	SoCalGas CNG Drayage Truck Demonstration

Each of the projects listed above is discussed in this Annual Report. In addition, a summary of each TAP project completed to date is included in Appendix B. Completed TAP projects include:

1. APL Singapore Slide Valve & Water-In-Fuel Emulsion Demonstration Program
2. Balqon E-30 Electric Terminal Tractor Development & Demonstration Project
3. Advanced Maritime Emission Control System (AMECS) Project
4. VYCON REGEN® System for Rubber-Tired Gantry Cranes Testing & Verification
5. Liquefied Natural Gas Yard Tractor Demonstration

2.1 Harbor Craft

2.1.1 Foss Maritime Diesel Electric Hybrid Tugboat

Foss Maritime achieved several significant milestones in the development of the World's first diesel electric hybrid tugboat. Christened the *Carolyn Dorothy*, the **FOSS Green Assist**™ hybrid tug was unveiled on January 23, 2009 and began working in the harbor immediately, even though some systems were still being commissioned. All system commissioning was complete on March 1, 2009, at which point the Carolyn Dorothy became a full working member of the Foss Maritime tug fleet. From March until the end of the year 2009, the *Carolyn Dorothy* completed 827 ship assist jobs and 320 barge moves. During this time, the hybrid tug demonstrated performance comparable to a conventional Dolphin Class tugboat, but with an anticipated exhaust emissions up to 44 percent lower than a conventional vessel and fuel consumption lowered by 20-30%.

Emission Control Technologies

The Green Assist™ hybrid tug was built by Seattle-based Foss Maritime in partnership with Aspin Kemp & Associates and their affiliate XeroPoint, which developed the unique hybrid power management system. At the heart of the Foss Green Assist™ project is the Dolphin class tug currently operated by Foss at the ports of Long Beach and Los Angeles. The conventional diesel-fueled tugs are powered by Caterpillar main engines producing a total of 5,080 bhp and a bollard pull of 60 tons. Externally, the *Carolyn Dorothy* is quite similar in appearance to its conventionally powered forebears. The only noticeable evidence of its unique power plant is a pair of smaller exhaust stacks.

The tug's diesel-battery-electric propulsion system comprises two fully azimuthing propulsion units powered by batteries, diesel generators and/or two diesel main engines. A modified engine room accommodates two battery packs, producing the equivalent of 670 horsepower, and two 335 horsepower diesel powered generators. The main engines are substantially smaller and less powerful than those in the existing Dolphin class tugs.

Figure 2.1: The World's First Diesel Electric Hybrid Tugboat – *"Carolyn Dorothy"*

An essential feature is the power management system required to produce seamless transition from one power source to another, depending on the duties the tug is undertaking and the power demand. In its various modes of operation the new tug employs battery power idling and no-wake low speed maneuvering and a combination of battery and generators for transiting. When full power is required the diesel main engines start automatically and are coupled by clutches to the drive system in addition to the electric motors. Surplus power generated at any stage is used to recharge the battery packs.

Although the main engines in the new tug are smaller than those of existing vessels, the same total horsepower and the same 60 tons bollard pull is available. The Green Assist Tug has four distinct modes of operation:

1. STOP
   - When tug is docked at the pier.
   - Main engines are off-line; power is provided by batteries for hotel loads (lighting, HVAC, etc.) and can be recharged by shore power.
2. IDLE
   - When the vessel is not secured to a pier but is stopped at sea.
   - Main engines are off-line. Batteries provide power for hotel loads and station keeping. A generator automatically starts up and comes on line to recharge batteries.
3. TRANSIT
   - Continuous slow and fast transit 6-8 knots.
   - One generator for the slower "harbor –speed" transit of approximately 6 knots. The second generator automatically starts when the throttle setting calls for a faster speed transit of about 8 knots. Batteries provide "ride-through" power until the second generator is online. The generators also are providing hotel loads and are recharging the batteries while simultaneously providing the propulsive power.

4. ASSIST
   - Full power ship-assist requirements.
   - Both main engines, generator sets and batteries provide full power.

Based on the operating profile of the conventional Dolphin tugs currently operating in the ports, it is estimated that the hybrid will spend at least 75 percent of its operating hours in the operating modes without main engines. Only batteries and generators are used to emit fewer emissions during idle or low speed/low load operation, but will be able to access full power on demand.

Project Partners & Funding

Foss Maritime is working closely with their project partners to implement the hybrid diesel-electric tugboat project. These partners include POLB, POLA, CARB, and SCAQMD.

Table 2.1: Funding Partners in the Development of the *Carolyn Dorothy* - World's First Hybrid Electric Tug

Project Partners	Contributions
▪ Port of Long Beach	$500,000
▪ Port of Los Angeles (non-TAP Funding)	$889,920

The overall cost for the design, development and commissioning of the Carolyn Dorothy was over $8 million. Remaining costs were covered by Foss Maritime.

Environmental Benefits

The hybrid tugboat is designed to reduce both NO_x and PM by approximately 44% when compared with the Dolphin tugs currently operating in the San Pedro Bay. Fuel consumption is expected to be reduced by approximately 20 to 30%, yielding additional reductions in carbon dioxide (CO_2) and SO_x emissions.

Table 2.2: Projected Emissions Reductions of *Carolyn Dorothy* Relative to a Conventional Dolphin Tugboat

Projected Emission Reductions	NO_x	CO_2	PM	Fuel Consumption
FOSS Green Assist™ Tugboat	44%	25%	44%	20% - 30%

The projected emission levels of the *Carolyn Dorothy* are cleaner than the US EPA's Tier 2 emissions standard for marine engines. Along with less pollution, the Green Assist ™ tug offers improved fuel economy and requires significantly less maintenance. It is also quieter than its Dolphin sister tugs when operating on batteries that can be recharged using environmentally friendly shore power.

Project Status

Foss completed development of the project test plan in September 2009, and formed a Technical Working Group (TWG) with Foss, POLB, POLA, CARB, EPA, SCAQMD, and the Pacific Merchant Shipping Association (PMSA) in the fall of 2009. In late 2009, the UC Riverside College of Engineering – Center for Environmental Research and Technology (CE-CERT) began test equipment acquisition and software code upgrades to prepare for test plan implementation. Full system and emissions testing is scheduled to begin in early 2010.

If the hybrid system proves effective, Foss is looking at the concept to convert, or retrofit, their other Dolphin-class tugs to hybrid electric systems. In addition, this design has applicability to other non-Dolphin class tugs operating at the San Pedro Harbor.

2.1.2 OceanAir Environmental ECO Tug™ Tugboat

OceanAir Environmental LLC (OAE) and Harley Marine are working to demonstrate an emission reduction technology concept that can be retrofitted into an existing tugboat. Harley Marine, a provider of ship assist services, currently operates four tractor tugs at the ports of Long Beach and Los Angeles under their subsidiary Millennium Maritime, Inc.

OceanAir Environmental will retrofit one of Millennium Maritime's existing harbor tugs, the "*Millennium Maverick*", with a smaller displacement, Tier 2-certified third main engine positioned in the center of the tug and equipped with a selective catalytic reduction (SCR) exhaust treatment system. This configuration, named the ECO Tug™, will allow the majority of vessel operations to be performed using this single low emission center engine.

Emission Control Technologies

Harbor tugs typically run at a low horsepower rating for approximately 80% of their operations, operating at high horsepower only when conducting vessel assist. The propulsion system, however, must be designed to deliver the necessary thrust during ship assist, and is thus oversized for the majority of the vessel's duty cycle. This "mismatch" results in the tug's main engines being used inefficiently during most of the tug's daily operation.

To more efficiently match propulsion system capabilities to operational requirements, OceanAir Environmental designed a tugboat retrofit utilizing three complementary technologies:

1. Installation of a third center-mounted engine;
2. Use of SCR exhaust after-treatment on third engine; and
3. Retrofit of existing Tier 1 main propulsion engines to meet Tier 2 emissions levels.

Third Center Engine: The low-power mode that comprises approximately 80% of the tug's daily duty cycle results in the inefficient operation of the vessel's main engines and contributes to a higher level of exhaust emissions. The addition of a smaller displacement, third center engine equipped with a dedicated drive shaft and propeller will better match low-power mode requirements and result in reduced fuel consumption and lower exhaust emissions. When higher horsepower is required, the existing two main engines can be started and, if desired, operated at a reduced load factor in conjunction with the third engine. The center engine originally selected for the ECO Tug™ is the Cummins QSK series marine engine rated at 1,200 horsepower and EPA-certified to the Tier 2 standard. However, recent engineering analyses indicate it may be possible to downsize the engine to 800 horsepower.

Selective Catalytic Reduction System for Third Engine: The new center engine will be operated at a 60% or greater load factor, providing ideal exhaust conditions for the use of an SCR system. SCR will reduce NO_x emissions by an additional 50% as compared to an untreated Tier 2 marine engine. While it is technically feasible to design an SCR system that provides on the order of 95% NO_x reduction, the decision was made to equip the first ECO Tug™ with a marine-grade SCR that has proven performance and durability at a 50% NO_x reduction levels.

Retrofit of Existing Port and Starboard Engines with the Tier 2 Emissions Technology: OceanAir Environmental, under a separately-funded effort, has developed a retrofit kit for Electro-Motive Diesel (EMD) marine engines that converts a mechanically controlled engine to electronic control, with the result that emissions are reduced to EPA Tier 2 levels. Under TAP, the *Millennium Maverick's* existing EMD port and starboard engines will be modified using this retrofit kit, further reducing vessel emissions. The research and development of the Tier 2 Retrofit Program was funded under the Port of Los Angeles Air Quality Mitigation Incentive Program (AQMIP). OceanAir Environmental is currently working with US EPA to certify this retrofit technology for application to all EMD engines of this size.

Project Partners & Funding

The Millennium Maverick's conversion to the ECO Tug™ configuration is made possible by the ports of Los Angeles and Long Beach, with substantial co-funding provided by Harley Marine and OAE. As noted above, the Port of Los Angeles, under their Air Quality Mitigation Incentive Program (AQMIP), helped co-fund development of the main engine Tier 2 upgrade kit. While development of the Tier 2 upgrade/retrofit kit is not a TAP project per se, the Port of Los Angeles' contribution was essential to the development of the ECO Tug™. See Table 2.3 for a summary of partners and assocated contributions.

Table 2.3: Funding Partners in the Development of the ECO Tug™

Project Partners	Contributions
▪ Port of Long Beach	$350,000
▪ Port of Los Angeles (TAP Funding)	$350,000
▪ Harley Marine/OceanAir Co-funding Applied to ECO Tug Development	$815,000

Once successfully demonstrated, the projected cost to retrofit an existing tugboat to a turnkey ECO Tug™ configuration is expected to be on the order of $950,000.

Environmental Benefits

The ECO Tug™ conversion is expected to yield reductions in vessel NO_x and PM of at least 50% as compared to a conventional diesel tugboat equipped with Tier 2 marine engines. Greenhouse gases, in the form of CO_2 emissions, will also be significantly reduced as a result of the vessel's lower fuel consumption. Projected benefits for the ECO Tug™ are shown below in Table 2.4:

Table 2.4: Projected Emissions Reductions for the *Millennium Maverick* ECO Tug™

Projected Emission Reductions	NO_x	CO_2	PM	Fuel Consumption Reduction
ECO Tug	>50%	25%	>50%	20% - 30%`

This equates to annual NO_x and PM reductions in the South Coast Air Basin of approximately 71 tons per year.

Project Status

During 2009, OAE completed a detailed evaluation of the project costs and identified vendors for the center engine. Additionally, vessel modifications required to implement the project were identified and documented. The Naval Architect began the effort to place/locate the third engine, including stability calculations, as well as evaluations of the potential for drag on the other two engines, maneuverability of the vessel on one engine, and control system. OceanAir now believes that the center engine can be downsized to 800 horsepower (hp) from the 1,200 hp that was originally specified.

OceanAir Environmental continues to work toward certification of its Tier 2 upgrade kit for the EMD engines under POLA's Air Quality Mitigation Incentive Program. Emissions testing results for this effort were completed and results showed that the retroift achieved Tier 2 emission levels. The data are currently under review by US EPA.

2.2 Cargo Handling Equipment

2.2.1 Hybrid Yard Tractor

As a follow on to the demonstration of LNG in yard tractors operating at the ports, the TAP is investigating the feasibility and commercial viability of using advanced technology drive systems in cargo handling equipment. The ports' TAP, in partnership with the US EPA's West Coast Collaborative, are working together to develop and test hybrid technology yard tractors for use at container terminals.

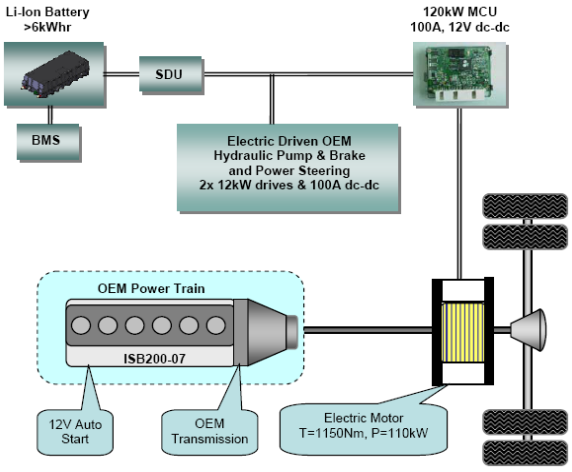
Yard hostlers (also known as yard tractors, terminal tractors, or utility tractor rigs) are common at port terminals, rail yards, and distribution centers. Their function is to move containers around the facility. At a port, containers are loaded off a ship onto a bobtail rig that is pulled by the yard hostler to an intermodal point or to a storage facility. Yard hostlers often sit idling as they wait in queues to pick up or drop off their loads.

The ports of Long Beach and Los Angeles partnered with CALSTART, a non-profit company that focuses on advancing cleaner technologies, to manage the demonstration of three (3) diesel-hybrid yard hostlers at the Long Beach Container Terminal (LBCT). The U.S. EPA is also providing funds for the design and development of the hybrid drive system. Vehicle emissions and performance will be evaluated relative to diesel yard hostlers, and a cost benefit assessment performed to determine the financial viability for hybrid yard hostlers when used in a marine terminal role.

Emission Control Technologies

U.S. Hybrid has been selected as the hybrid drive system supplier and is currently completing their design and testing before integrating the hybrid system into a Kalmar Ottawa 4x2 yard hostler chassis.

Figure 2.2: Hybrid Electric Drive System



Three hybrid yard tractors will be integrated with hybrid drive systems and operate for a six-month period at LBCT at POLB. The hybrid vehicles will use a hybrid-electric drive system to combine the cleanest available diesel or alternative fuel engine technology with an electric motor, shown schematically in Figure 2.2.

Kalmar Industries, manufacturer of the Ottawa 4x2 terminal tractor that will be used in the demonstration, will integrate the selected hybrid drive train systems into the yard tractors.

Project Partners & Funding

The two year demonstration project is valued at $1.2 million. For this project, the ports will contribute $300,000 each and the US EPA will contribute $300,000 through a West Coast Collaborative grant. LBCT and other project suppliers will provide in-kind labor contributions estimated at $300,000. CALSTART is providing technical project management assistance and coordinating the emissions testing component of the program as well as assessing the potential for hybrid yard tractor commercialization.

Table 2.5: Hybrid Yard Tractor Project Partners & Funding Levels

Project Partners	Contributions
▪ Port of Long Beach	$300,000
▪ Port of Los Angeles	$300,000
▪ U.S. Environmental Protection Agency	$300,000
▪ Long Beach Container Terminal, Kalmar & US Hybrid in-kind	$300,000

Environmental Benefits

The hybrid yard hostlers will undergo six months of operation and in-use testing at LBCT. The hybrid drive system is expected to deliver a 67% reduction in smog-forming NO_x and PM compared to conventional diesel yard hostlers. In addition, the hybrid technology is expected to reduce or eliminate emissions during idling, which can represent more than 50% of the yard hostler duty cycle. The estimated reductions in emissions from decreased idling during the six-month test are approximately 19 tons of NO_x and 200 pounds of PM. Table 2.6 shows the anticipated reductions in air pollutant emissions of the hybrid-drive yard tractor as compared to a 2007 model year diesel yard tractor. Also shown is the expected improvement in yard tractor fuel economy, projected to be on the order of 60% or greater.

Table 2.6: Anticipated Emission Reductions as Compared to 2007 Model Year Diesel Yard Tractor

Environmental Benefits	NO_x	CO_2	PM	Fuel Consumption
Hybrid Emission Reduction (No Air Conditioning Load)	67%	72%	50%	62%

Project Status

This project has fallen significantly behind the originally planned schedule. In particular, coordination between different organizations during the Request for Proposal (RFP) development process, as well as review of the RFP responses and supplier selection, took significantly longer than anticipated. As such, delivery of fully integrated hybrid yard tractors to LBCT is expected to begin during the first quarter of 2010. The yard hostlers will be put into service in early 2010 at LBCT for a demonstration period of six months during which vehicle performance will be documented.

2.2.2 Long Beach Container Terminal EcoCrane™

Rubber-tired gantry cranes (RTGs) account for approximately 7% of cargo handling equipment at POLB terminals; however, 25 percent of overall cargo handling equipment air pollutant emissions is attributable to RTGs and other cranes operating at terminals in the POLB. In 2005, RTGs alone produced approximately 9.7 tons of PM, a toxic air contaminant and known carcinogen, and 342 tons of NO_x, an ozone precursor and principal component of smog formation in the South Coast Air Basin. In contrast, all large shore-to-ship gantry cranes at the ports use electric power.

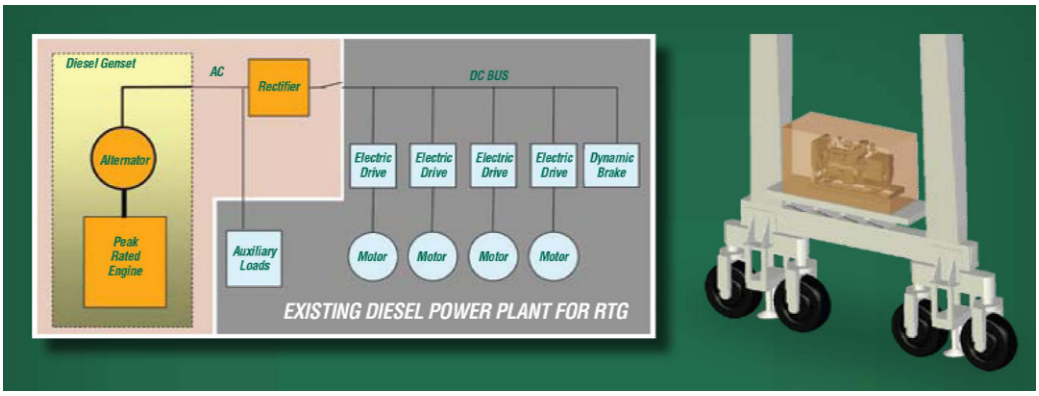
Long Beach Container Terminal, Inc. (LBCT), in partnership with Railpower Technologies, embarked on the demonstration of a retrofit technology that converts a conventional RTG to a "hybrid-electric" configuration. Similar to hybrid automobiles now commonplace on California roadways, the Railpower EcoCrane™ employs a smaller, lower emitting engine coupled with a regenerative braking energy capture and battery storage system. The result is significant crane efficiency improvement and corresponding reduction in air pollutant emissions.

Emission Control Technologies

When applied to cranes, hybrid technology offers the opportunity to reduce fuel consumption by 60% to 85%, simultaneously reducing emissions of both criteria air pollutants as well as greenhouse gases. The use of a Level 3 verified diesel emission control system, such as a diesel particulate filter, results in a reduction in overall air pollutant emissions approaching 90%.

The original design for the EcoCrane™ was based on a locomotive proof of concept. Railpower Technologies has now downsized the design specifically for RTG crane use. The RTG design removes the large diesel engine from the RTG genset and replaces it with a smaller engine that consumes less fuel. The EcoCrane™ then adds a regenerative braking energy capture and battery storage system. This allows the energy that is typically wasted when lowering a container to be captured, stored, and made available for a subsequent container lift. Key differences between a conventional RTG power system and that of the EcoCrane™ system are shown in Figures 2.3 and 2.4.

Figure 2.3: Conventional RTG Power System

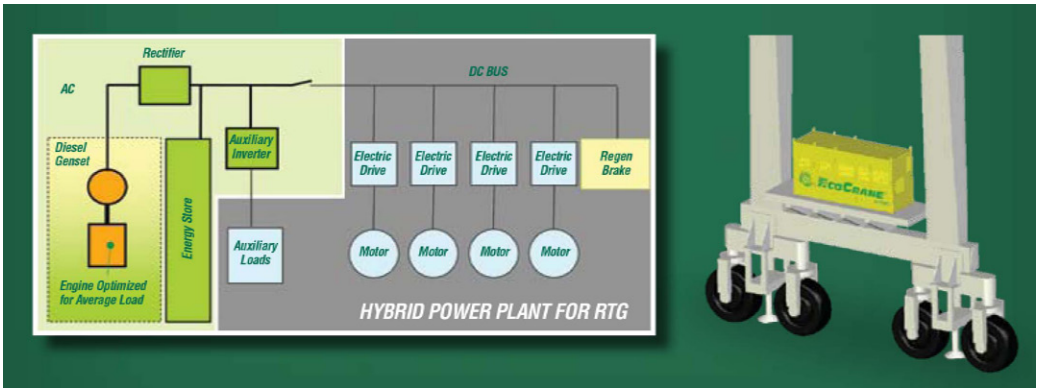


The Railpower Technologies' EcoCrane™ power management system is shown below. Key elements include:

- A Variable Speed Generator, incorporating a Tier 3 diesel engine/alternator optimized for the average lifting load as compared to a conventional RTG whose diesel genset engine is sized for a peak load condition;
- A regenerative braking energy capture system coupled with battery energy storage which allows energy that is otherwise dissipated as heat during container lowering to be captured, stored, and used for a subsequent container lift;
- A Level 3 verified diesel emission control system that will further reduce diesel genset exhaust emissions by a minimum of 85%;
- Automatic shutdown/restart circuitry that will allow the Variable Speed Generator engine to automatically turn off when not in use, achieving additional emission reductions.

LBCT has identified six (6) existing RTG cranes for conversion to the EcoCrane™ hybrid electric configuration. The existing 680 horsepower diesel genset engine will be replaced with a variable speed generator rated at 120 horsepower – this represents an 82% reduction in rated power requirements and associated fuel consumption.

Figure 2.4: EcoCrane™ Hybrid Electric RTG Power System



Project Partners & Funding

LBCT will demonstrate six EcoCranes under the TAP, with POLB and POLA funding one (1) EcoCrane™ conversion at a total cost of $350,000. US EPA also contributed Supplemental Environmental Project funds to the project in the amount of $130,130 to support emissions testing. The balance of project funds will be provided by LBCT.

Table 2.7: EcoCrane™ Funding Partners

Project Partners	Contribution
▪ Port of Long Beach	$175,000
▪ Port of Los Angeles	$175,000
▪ California Air Resources Board	$130,130
▪ Long Beach Container Terminal, Inc.	$1,469,870

Environmental Benefits

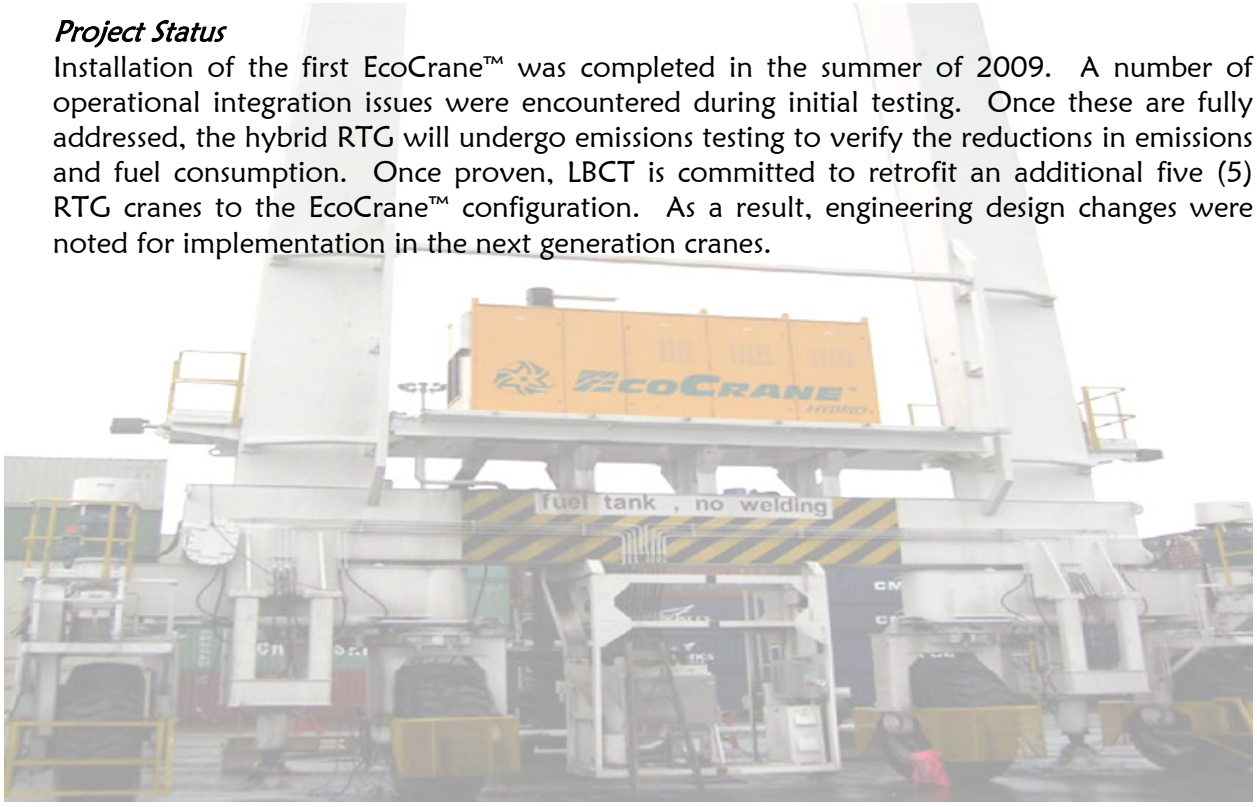
Data obtained by the client showed significant energy savings using the hybrid technology, as well as tremendous opportunity for reducing fuel consumption (60-85%) and thus, emissions.

Table 2.8: Anticipated Benefits of EcoCrane™ as Compared to Conventional RTG Crane

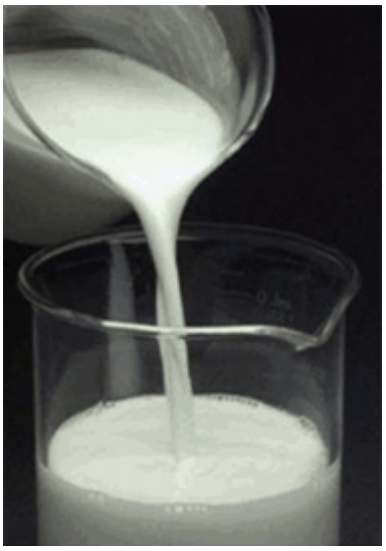
Environmental Benefits	NO_x	CO_2	PM	Fuel Consumption
EcoCrane™ Hybrid RTG	85%	60%	90%	65%

Project Status

Installation of the first EcoCrane™ was completed in the summer of 2009. A number of operational integration issues were encountered during initial testing. Once these are fully addressed, the hybrid RTG will undergo emissions testing to verify the reductions in emissions and fuel consumption. Once proven, LBCT is committed to retrofit an additional five (5) RTG cranes to the EcoCrane™ configuration. As a result, engineering design changes were noted for implementation in the next generation cranes.



2.2.3 Alternative Petroleum Technologies, Inc. Emulsified Biodiesel Fuel

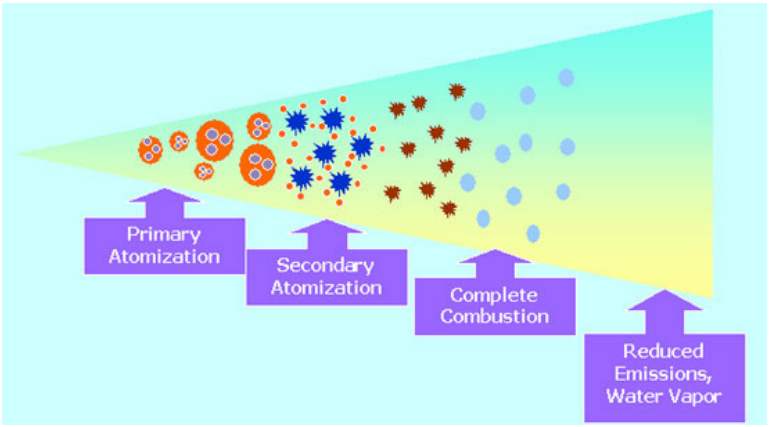


The use of biodiesel fuel blends as a method to reduce diesel particulate matter and greenhouse gas emissions from cargo handling equipment at the ports has been studied extensively. The results consistently show that while biodiesel fuels produced from renewable sources have the potential to effectively reduce hydrocarbon, carbon monoxide, and DPM emissions, there is often a corresponding increase NO_x emissions on the order of 2% or greater. Given the serious nonattainment status for ozone in the South Coast Air Basin, any air pollution reduction strategy that increases NO_x emissions, a principal ozone precursor, is not recommended by state and local air quality regulatory agencies.

The technical community has known for many years that emulsified diesel fuel, made by blending water and additives into diesel fuel, will reduce emissions of particulate matter and NO_x as compared to conventional ultra-low sulfur diesel fuel. However, several issues, including incompatibility with certain diesel engine components and operability concerns due to power loss, have minimized widespread acceptance of diesel-water fuel blends. Many of these problems can be attributed to the high water content (>16%) of previously available emulsified diesel products.

Under the TAP, Alternative Petroleum Technologies, Inc. (APT) is demonstrating the viability and effectiveness of emulsified biodiesel fuel with lower water content as an emerging technololgy. By reducing the water content and using biodiesel derived from sustainable sources, APT believes their emulsified biodiesel fuel will generate PM emissions reduction benefits 50% greater than those anticipated with non-emulsified biodiesel. The addition of a low amount of water, on the order of 8% to 10%, is expected to resolve the NO_x increase issues typically associated with biodiesel, which will allow consideration for its use as a strategy to meet the port's CAAP goals.

Figure 2.5: Combustion of Conventional Diesel Fuel

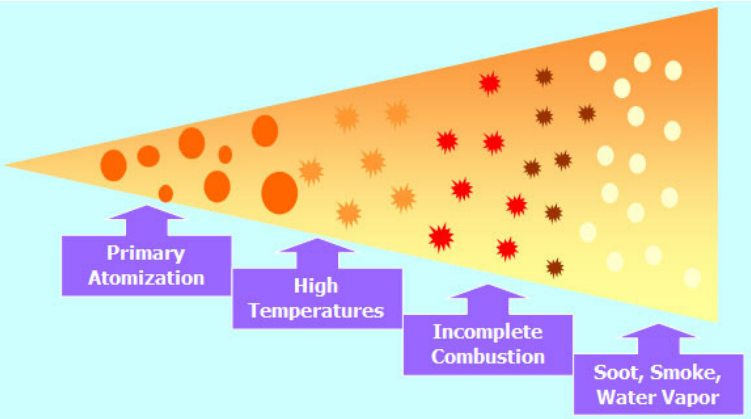


Emission Control Technology

Introducing water to petroleum products for combustion is a concept that has been around for centuries; reference to water as an ancillary combustion control technique can be found as early as 1791 in a gas turbine patent. When diesel fuel is sprayed into the combustion chamber, it is atomized into droplets varying in size from 20 to 100 microns in diameter (approximately 0.001 to 0.004 inches in diameter) (See Figure 2.5).

Since only the surface of each fuel droplet exposed to air can burn, larger liquid fuel droplets do not burn completely, leaving unburned carbon to collect on the surfaces of a combustion chamber or escape as PM in exhaust gases. This reduces overall thermal efficiency and increases harmful emissions, as denoted in Figure 2.6.

Figure 2.6: Combustion of Emulsified Biodiesel Fuel



Unlike conventional diesel fuel, when emulsified fuel droplets are sprayed into the combustion chamber, they are atomized a second time as a result of the violent transformation of their water content into steam. This transformation of water into steam shatters the petroleum surrounding that water into much smaller droplets, shown in Figure 2.6 at left. Smaller droplets have a much greater surface area, significantly improving the efficiency of combustion. This unique combustion characteristic of emulsified fuels is known as "secondary atomization." A secondary effect of water transforming into steam is that peak combustion temperatures are reduced, resulting in the formation of significantly fewer ozone-forming NO_x emissions. The changes in combustion kinetics also significantly reduce PM emissions that result from incomplete combustion.

The focus of the APT emulsified biodiesel demonstration is a B-20 blend (20% biodiesel and 80% ultra-low sulfur diesel) used in off-road heavy-duty cargo handling equipment. In addition to testing the emulsified biodiesel fuel, the project will investigate the potential to achieve additional significant reductions in PM by installing a diesel oxidation catalyst (DOC) on equipment demonstrating the emulsified biodiesel fuel. The manufacturers of numerous verified diesel emission control systems, such as diesel oxidation catalysts and diesel particulate filters, have indicated that their systems are compatible with biodiesel blends at B-20 or less. The combination of emulsified biodiesel fuel and verified diesel emission control system has the potential to provide an economical solution for meeting the emission reduction requirements mandated by CARB as well as the more ambitious goals of the ports' CAAP.

Project Partners & Funding

Ports America is the host site for the emulsified biodiesel demonstration and will provide three top picks for use in the demonstration. The demonstration phase is expected to last approximately six months, during which emissions testing and data collection will occur to support APT's application seeking Level 2 verification from CARB.

Funding for the emulsified biodiesel demonstration is being provided by POLB and POLA, each contributing $44,000 in TAP funding. APT has committed matching funds in the amount of $88,000 towards the demonstration project as well as committed to pursue CARB Level 2 verification for both their emulsified diesel fuel and their fuel in combination with currently verified diesel exhaust after-treatment systems.

Table 2.9: Funding Contribution from Each Project Partner

Project Partners	Contributions
▪ Port of Long Beach	$44,000
▪ Port of Los Angeles	$44,000
▪ APT Co-funding Contribution	$88,000

Environmental Benefits

Table 2.10, below, shows the expected levels of emission reduction from using APT emulsified B-20 in combination with a DOC in off-road cargo handling equipment. It is significant to note that any increase in NO_x emissions resulting from the use of biodiesel is more than offset by the inclusion of water in the fuel blend; the net result is an expected decrease in overall NO_x emissions on the order of seven percent.

Table 2.10: Anticipated Emission Reduction Potential of Emulsified Biodiesel Fuel + DOC

	PM	HC	CO	NO_x	CO_2	SO_2
Reduction (%)	50%	80%	80%	7%	14%	21%

Project Status

During 2009, the project scope of work and contract were finalized. The in-use demonstration is scheduled for 2010, which will be based on a detailed test plan that will support CARB verification efforts. Meanwhile, APT has continued to work with CARB to prepare for emissions verification of the emulsified B-20. While verification is pending, end users can evaluate and demonstrate the benefits of the water-emulsified B-20 under a developmental fuel waiver that APT obtained from the California Division of Measurement Standards in June 2007.

2.2.4 RYPOS Advanced Diesel Particulate Filter for Cargo Handling Equipment

Under TAP, RYPOS will demonstrate the effectiveness of an advanced diesel emission control system on cargo handling equipment operating at the both the Port of Long Beach and Port of Los Angeles. The RYPOS "Hybrid Diesel Particulate Filter/Catalyst" (HDPF/C) is an active-regeneration diesel particulate/diesel oxidation catalyst that is expected to reduce total particulate matter emissions by greater than 85 percent.

The HDPF/C incorporates a microprocessor controlled electric heating element to burn off accumulated diesel particulate matter captured by the filter. A diesel oxidation catalyst attached to the outlet of the particulate filter is used to remove the soluble organic fraction of particulate matter while also significantly reducing hydrocarbon, carbon monoxide, and nitrogen dioxide emissions. Regeneration of the HDPF/C occurs automatically during cargo handling equipment operations and does not require additional actions on behalf of the equipment operator.

The objectives of the RYPOS HDPF/C Demonstration Program are to:

- Successfully demonstrate the RYPOS HDPF/C on a broad range of container handling equipment, including rubber tired gantry cranes, top and side handler mobile lifts;
- Document 85% or greater reduction in cargo handling equipment emissions of total particulate matter (TPM), CO, NO_2, as well as reductions in other pollutants under typical cargo handling equipment operating conditions.

Upon successful demonstration of the above objectives, RYPOS will seek and obtain Level 3 verification for the HDPF/C from CARB for a broad range of cargo handling equipment applications.

Emission Control Technologies

The RYPOS HDPF/C system consists of filter housing, flow control, electrical control circuit, and filter cartridges. The electrical control circuitry automatically monitors and controls the regeneration of the filter cartridges.

The soot diesel particulate filter cartridge (DPF) is composed of sintered metal fibers that are shaped into filter elements and then incorporated into filter cartridges. These sintered metal fiber cartridges are capable of capturing the very fine carbon particles present in the exhaust stream, with high efficiency and high holding capacity.

The diesel oxidation catalyst (DOC) filter cartridge reduces CO, nitrogen dioxide (NO_2), and hydrocarbon emissions, and can act as a sound absorption device, replacing the muffler while occupying the same space.

The operation of the RYPOS HDPF/C is controlled by a microprocessor. The controller monitors the HDPF/C and periodically, as required, an electric current is passed through a filter element, which then acts as a heating element. The filter and heating element are one and the same. Each element, which represents a small fraction of the total filter area, is heated individually to reduce the maximum amount of electrical energy required. A dedicated power source provides the required electrical current to heat the filter element to the temperature required to burn soot.

The regeneration strategy is designed to keep the back pressure below a preset level. The average power consumption required for regeneration is less than one percent of the rated power of the engine.

Project Partners & Funding

The total cost of the RYPOS HDPF/C demonstration is $322,140. Using TAP funds, each port contributed approximately $64,668. The TAP funding is budgeted primarily for emissions testing and verification costs. RYPOS and their participating vendor support team is covering the balance of project costs, $192,804. Project costs are shown below in Table 2.11.

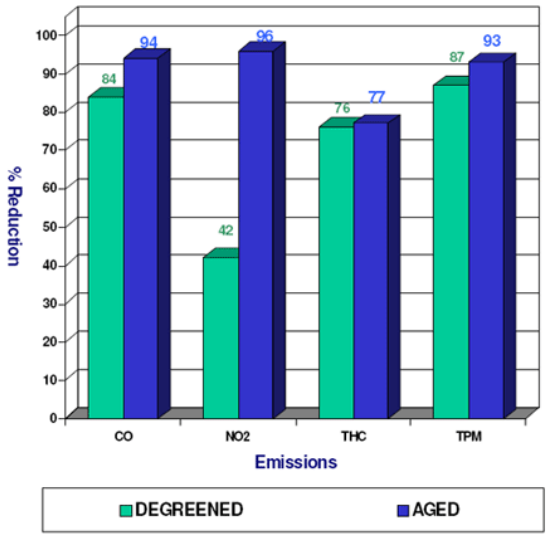
Table 2.11: RYPOS HDPF/C Demonstration Funding Partners

Project Partners	Contributions
Port of Long Beach (TAP Funding)	$64,668
Port of Los Angeles (TAP Funding)	$64,668
RYPOS Inc. & Participating Vendor Co-Funding	$192,804

Environmental Benefits

Exhaust data collected by independent testing laboratory, Environment Canada, show that the RYPOS HDPF/C™ reduces total particulate matter by more than 85% and cuts nitrogen dioxide (NO_2) by up to 96% from the diesel engine exhaust.

Following a break-in or "aging" period, the RYPOS HDPF/C™ achieved the 93% particulate matter (PM), 77% total hydrocarbon (THC), 96% NO_2 and 94% CO reductions with virtually no increase in fuel consumption. One characteristic of RYPOS technology, as shown right, is that the efficiency of emissions reduction actually improves with aging.



Project Status

As of this Annual Report, RYPOS has installed:

- One HDPF/C diesel particulate filtration system, model RH406-L-C on a model year 2004 Mitsui/Paceco rubber tired gantry crane (RTG) at the ITS terminal facility at the Port of Long Beach;
- One RH408-L-C HDPF/C system on a 2003 Mitsui/Paceco RTG at STS Terminal located at the Port of Los Angeles,
- One RH310-M-C HDPF/C system on a top handler lift truck at the STS Terminal; and
- One RH310-M-C HDPF/C on a side handler lift truck at the STS Terminal.

CARB verification emissions testing is scheduled to begin in the fall of 2010, with receipt of Level 3 CARB verification anticipated for December 2010.

2.2.5 Capacity Pluggable Hybrid Electric Terminal Truck (PHETT)

Terminal tractors are essential to the daily operations of a port terminal. However, they also consume large volumes of diesel fuel and generate significant levels of harmful diesel emissions within the ports they serve. The development and deployment of low-emission, high-efficiency terminal tractors are high priorities for the ports under the Clean Air Action Plan.

In response to the need for environmentally friendly yard hostlers, Capacity of Texas, Inc. developed a Pluggable Hybrid Electric Terminal Tractor (PHETT™). The Port of Los Angeles, in partnership with Capacity and Yusen Terminals, Inc. (YTI), conducted a three-week field trial of the PHETT™ at the YTI terminal. The field trial commenced on December 8, 2009 and was completed on December 29, 2009. The objective was to evaluate and document the performance characteristics, emission benefits, and fuel economy improvements of the Capacity PHETT in operation in a Port terminal environment.

The project included an assessment of the PHETT's™ fuel economy, a characterization of its load factors, and a survey of YTI equipment operator opinions regarding PHETT operability as compared to a conventional diesel terminal tractor. The field test consisted of simultaneous operation of a diesel terminal tractor and the PHETT™. Both tractors were equipped with a multi-channeled data logging system to record available data on the vehicle communications bus. Fuel use and operating time information were recorded and supplied by YTI.

Emission Control Technologies

The PHETT™ is a diesel-electric plug-in hybrid terminal tractor that uses a small diesel generator and a large lead-acid battery pack to provide power for vehicle operation. As a plug-in hybrid, the PHETT™ offers a modest all-electric range and higher overall efficiency, which can significantly reduce fuel consumption and emissions compared to a conventional diesel-fueled terminal tractor.

The PHETT™ operates as a series diesel-electric hybrid. In this configuration, all of the energy demands of the vehicle are supplied through the battery; regardless of whether the energy is stored in the battery by a grid-connected charger or the on-board diesel generator. Given a fully charged battery, the PHETT™ will operate entirely from battery power, providing a limited "all-electric range" with zero tailpipe emissions. Once the battery has been depleted to a predetermined state of charge, the diesel generator will start and attempt to sustain the current level of charge in the battery. According to Capacity, this diesel-electric hybrid terminal tractor is a "charge sustaining series hybrid that utilizes a constant and efficient rate generator to supply power, reducing fuel consumption by 60 percent and audible db by 30 percent.

The technical specifications of the PHETT™ are shown below in Table 2.12:

Table 2.12: PHETT Technical Specifications

Feature	Details
Gross Combined Weight Rating	100,000 lbs
Hybrid Configuration	Charge sustaining
All-electric Operation	All electric operation while in battery mode
On-board generator	Cummins Onan diesel, 40 HP, Tier 4i emissions
Traction Motor	225 HP, 3 phase AC
Diesel Fuel Capacity	40 gallons
Battery Type	Lead acid

Three electrical inverters are used to supply the vehicle subsystems with power. The inverters convert the DC voltage of the battery pack into AC voltage that is better suited to operate the numerous AC electrical motors in the PHETT™.

Additionally, several systems on the vehicle use a 12VDC auxiliary power supply including the safety light, radios, and cabin HVAC fan. Capacity estimates a fixed power draw of 500 watts, assumed to be constant while the vehicle is in use.

Project Funding

The total cost of the PHETT™ demonstration and testing was $29,500. This was funded by the Port of Long Beach under the TAP. Additional in-kind contributions were provided by Capacity and YTI; however, the equivalent dollar value of these additional contributions were not quantified.

Environmental Benefits

TIAX, Inc. was retained to assist in the data collection and analysis. Using data recorded by each tractor's data logger TIAX estimated the fuel economy and emissions of both the PHETT™ and the baseline diesel terminal tractor.

Based on the CARB OFFROAD 2007 methodology, preliminary results indicate the PHETT™ will achieve:

- A 44% reduction in NOx, 56% reduction in PM, and a 53% reduction in CO compared to a 2009 diesel yard tractor using a CARB-approved load factor;
- Fuel economy improvements were estimated to be 34% over the baseline fleet.

Project Status

The PHETT demonstration is complete, however, the final field test results and findings will be published in mid-2010. Survey data from the vehicle operators involved with the PHETT™ demonstration were very positive and indicated no significant problems with the PHETT™ and comparable or better performance to diesel yard tractors.

2.3 Container Drayage Trucks

2.3.1 Balqon Lithium-Ion Battery Demonstration

The Balqon Lithium-Ion Battery Demonstration project is a follow-on project to the Balqon Class 8 Electric Truck Demonstration. As background, in 2008, the Port of Los Angeles TAP and the SCAQMD partnered to demonstrate a Class 8 electric truck for port drayage operations. A contract was entered into with Balqon Corporation to develop and demonstrate a heavy duty, zero-emission terminal truck. A Balqon Nautilus Model E30 terminal tractor was delivered to the Port of Los Angeles in February 2008 and successfully completed cargo terminal tests during 2008.

This follow-on TAP project will evaluate and demonstrate a lithium-ion battery as a technological upgrade to the lead-acid battery pack used in the previous TAP demonstration. The advanced technology lithium-ion batteries will more than double the vehicle range without adding additional weight.

Zero-Emission Technologies

Lithium-ion batteries have several important advantages over competing battery technologies. Primarily, lithium is a highly reactive element which translates into a very high energy density in a much lighter package. The electrodes are composed of lightweight lithium and carbon, offering much lighter weight as compared to other rechargeable batteries of a similar size. Lithium-ion batteries retain their charge longer than other battery chemistries, and exhibit no "memory effect" – some high energy density battery chemistries, such as nickel cadmium, can become degraded if recharged before the battery has been fully discharged. Lithium-ion batteries and can be recharged without completely discharging with no battery degradation, and can withstand literally hundreds of charge/discharge cycles, increasing battery lifespan.

Under the TAP demonstration, one electric drayage vehicle and electric yard tractor will be converted from lead acid battery to lithium battery technology. The vehicles to be demonstrated include:

- Balqon Nautilus Model E30, a zero emission all-electric tractor designed to transport containers in terminal or on-road use applications. The 100,000 lb. capacity fifth wheel hydraulic lift can reduce operation time by 70% when compared to a conventional fixed fifth wheel design. E-30 operates at maximum speed of 45 Km/hr and can carry 30 Tons of cargo with a range of 60 miles (unloaded) and 30 miles (fully loaded). The XE30 is equipped with proprietary flux vector control technology equipped with five speed automatic transmission.

- Balqon Corporation Model Nautilus E20, a smaller, all-electric terminal tractor that can carry loads up to 60,000 lb. with a range of 40 miles on a single charge. The vehicle is equipped with fast charge system to allow vehicle to be fully charged in 30-45 minutes. Model XE20 is designed to transport containers at shipping ports and large warehouses and is also equipped with the hydraulic fifth wheel.

The lithium battery cells will be assembled into the battery packs at Balqon's Harbor City facility and fitted with a proprietary Battery Management System (BMS) specifically designed for lithium-ion battery chemistry and characteristics. This TAP project will also develop new charging algorithms to allow fast charge the lithium-ion batteries using the existing Balqon fast charger.

Vehicle range tests will be conducted using both dynamometer and field test protocols. Installation of lithium batteries is expected to increase range by a factor greater than two as compared to the lead acid battery-equipped vehicle. It is anticipated that unloaded range will increase to 180 miles on single charge. Range at a loaded weight of 60,000 lbs at 45 mph during short haul drayage is expected to exceed 100 miles on a single charge.

Project Partners & Funding

The total project cost is $940,000. The Port of Los Angeles, under TAP, is contributing $400,000. Balqon Corporation is providing the two vehicles as well as additional in-kind engineering and test resources; the Balqon contribution is valued in excess of $540,000.

Table 2.13: Funding Partners in the Development of the Lithium Ion Electric Yard Tractor & Drayage Truck

Project Partners	Contributions
▪ Port of Los Angeles (TAP Funding)	$400,000
▪ Balqon Corporation Co-Funding	$540,000

Environmental Benefits

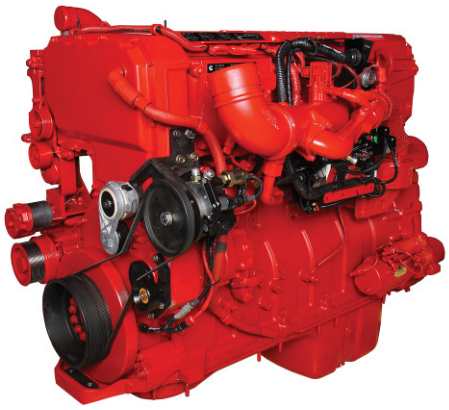
Zero-emission drayage trucks provide significant environmental benefits. However, operational concerns regarding range and charging times limit the applicability of zero-emission technology for the dray industry. Successful completion of this advanced battery demonstration project will support the long-term goal of increasing the use of zero-emission electric truck technologies in the drayage truck sector.

Project Status

In June 2009, Balqon completed assembly of a Nautilus E30 all-electric tractor retrofitted with lithium ion battery packs. Initial testing of the Nautilus E30 demonstrated a range of over 150 miles on a single charge under unloaded conditions at 80% depth of discharge. The new lithium-ion battery packs include the Company's battery management system which allows batteries to be fast charged and self equalize during idle operation. In July 2009, Balqon announced the release of lithium-ion batteries as an alternative to lead acid traction batteries for its entire product line of Class 8 yard tractors and drayage vehicles.

2.3.2 Westport GX LNG Engine Development

Westport Innovations (Westport), developer of the High Pressure/Direct Injection (HPDI) liquefied natural gas (LNG) fuel system technology, is developing an LNG 15-liter heavy-duty truck engine that will meet the 2010 on-road NO_x emission standard of 0.2 grams per brake horsepower-hour (g/bhp-hr).

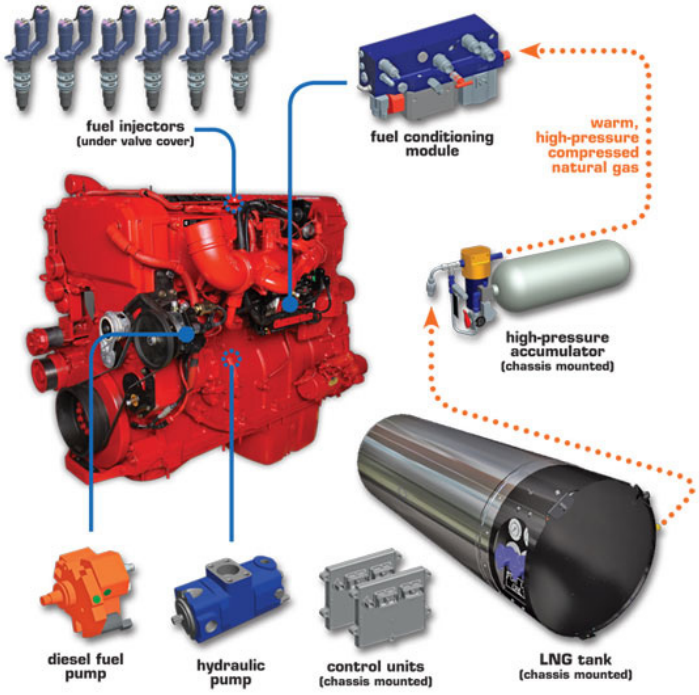


The 400- and 450-horsepower rated heavy-duty engines are based on the 15-liter Cummins ISX diesel engine platform and are designed to satisfy the performance requirements of class 8 tractors that provide drayage service at the ports.

Emission Control Technology

Westport's HPDI technology facilitates the use of natural gas as an engine fuel while retaining typical diesel engine combustion, power, and torque. The technology differs from other natural gas engines through the absence of spark plugs. A patented injector delivers a small amount of diesel fuel (approximately 6% by energy content) and high pressure natural gas directly to the engine combustion chamber, where the diesel fuel acts as the ignition source.

Figure 2.7: Schematic of the Westport GX Engine LNG Fuel System



LNG fuel for the Westport GX engine is stored in the LNG tank mounted to the chassis of the vehicle. The liquid natural gas is drawn from the tank using a proprietary LNG pump that is powered by an engine-driven hydraulic pump. The LNG is then vaporized using excess heat from the engine's coolant system.

Simultaneously, a diesel fuel pump draws and pressurizes diesel fuel from its storage tank. Both the natural gas and diesel are then routed to a fuel conditioning module, where both fuels are pressure regulated, filtered, and sent to the fuel injector nozzles.

HPDI relies on late-cycle high pressure injection of natural gas into the combustion chamber. The natural gas is injected at the end of the compression stroke, similar to the diesel fuel in a diesel engine. Natural gas has a higher ignition temperature compared to diesel, so a diesel pilot injection is used to initiate combustion.

Figure 2.8: Westport GX HPDI High Pressure Injector

A dual concentric needle injector, shown in the photograph at right, allows small quantities of diesel fuel and larger quantities of natural gas to be delivered at high pressure to the cylinder combustion chamber. The diesel fuel is delivered just prior to the piston reaching top dead center, i.e., the maximum height of the stroke, followed by the main fuel injection of natural gas. The diesel fuel acts as a pilot, or "liquid spark plug", which rapidly ignites to produce the hot combustion products that provide the ignition temperature required to ignite the natural gas.

The benefits of the high pressure direct injection cycle include horsepower and torque output similar to a conventional diesel engine and fuel cost savings due to the high substitution of lower cost LNG as compared to diesel.

With the low emissions profile of natural gas and the high efficiency of the diesel combustion cycle, HPDI technology combines high energy efficiency with low emissions. The HPDI system extends beyond the fuel injection equipment, and is developed as a fully integrated system including fuel system management electronics, LNG tanks, and vehicle installation.

The project is being conducted in three parts:

1. Development and certification of a 2007 LNG high-pressure direct-injection engine to 0.6 g/bhp-hr NO_x by early 2008;
2. Establish the manufacturing capacity to produce LNG trucks in a high volume truck production facility;
3. Certification of a 0.2 g/bhp-hr NO_x (2010 standard) compliant truck by early 2010 for deployment in mid-2010.

Project Partners & Funding

The total project cost for development and certification of Westport GX natural gas engine is estimated at $9,894,027. Westport is contributing $7,144,027 of the project development cost (in-kind) and has secured additional funding in the amount of $500,000 from Clean Energy, a provider of LNG fuel, to assist with integration of the engine and related fuel system. The California Energy Commission (CEC) is providing $500,000 under the PIER program. Kenworth Truck Company is a partner in the project and will be providing in-kind contributions to assist with the deployment of the LNG trucks. The SCAQMD is contributing $1.25 million, and the ports of Long Beach and Los Angeles are each contributing $250,000 in TAP funding.

Table 2.14: "0.2 Gram NO_x" GX Engine Development Partnership

Project Partners	Contributions
▪ Port of Los Angeles	$250,000
▪ Port of Long Beach	$250,000
▪ South Coast Air Quality Management District	$1,250,000
▪ California Energy Commission	$500,000
▪ Westport Innovations Co-funding	$7,144,027

Environmental Benefits

The Westport GX LNG engine will accelerate NO_x emission reductions by achieving the final 2010 standard in early 2010. Diesel engines of a comparable displacement are not expected to meet the 2010 standard initially – engine manufacturers will instead use credits generated from family emission level (FEL) engines to offset the higher emissions of their large displacement on-road engines. Westport estimates emission reductions of at least 0.45 tons of NO_x per year per truck above the equivalent model year diesel truck, until the 0.2 standard is phased in for diesel engines. The LNG heavy-duty truck also emits 15 to 20 percent less greenhouse gases compared to diesel engines.

Figure 2.9: Westport GX Engine Undergoing Emissions Certification Testing

Project Status

The Westport GX demonstrated emission levels during certification testing at or below 0.2 g/bhp-hr NO_x in mid-2009. However, Westport is working with US EPA to finalize the deterioration rate for the engine, which has delayed final certification until sometime in 2010.

2.3.3 Southern California Gas Company CNG Drayage Truck Demonstration

The ports are committed to reducing air pollution from drayage operations as exemplified by their respective Clean Truck Programs and research into zero-emission container movement. The TAP program is also supporting the ports' transition to low emission drayage operations by demonstrating technologies that have high potential to be both commercially viable and significantly reduce pollution from container drayage.

Under TAP, the ports embarked upon a collaborative effort with Southern California Gas Company (SoCalGas) and their partners, California Cartage Company (CCC) and Autocar LLC, to develop and demonstrate the nation's first drayage trucks powered by compressed natural gas (CNG). Four trucks were delivered June 2008 and used to move containers between the ports and nearby freight consolidation yards.

Emission Control Technology

The trucks were manufactured by Autocar LLC and are powered by the Cummins Westport ISL G engine. The Cummins Westport ISL G is currently the cleanest heavy-duty internal combustion engine commercially available, with certified NO_x levels one-half that of US EPA's stringent 2010 on-road heavy-duty emissions standard.

To demonstrate the viability of the ISL G CNG engine in port drayage operations, California Cartage Company, the largest trucking company operating at the ports, operated the four CNG-powered trucks in regular revenue drayage operations for a one-year demonstration period. This period covered calendar year 2009. During this period, the trucks underwent continuous monitoring to assess performance capabilities, operability, driver impressions, and vehicle reliability.

Project Partners & Funding

The CNG drayage truck demonstration project cost was approximately $2 million. The combined TAP funding from both ports is $223,155, which was applied to the capital purchase cost of one demonstration vehicle. The remaining three demonstration trucks were purchased by SoCalGas. The SCAQMD co-funded the construction of a temporary CNG refueling station to support the demonstration trucks' daily refueling needs. They also contributed $421,250 towards the purchase of capital equipment for the temporary refueling station, matched with co-funding provided by SoCalGas. Trillium USA designed, constructed, and operated the CNG refueling station on behalf of the project partners.

Table 2.15: SoCalGas CNG Drayage Truck Demonstration Project Funding Partners

Project Partners	Contributions
▪ Port of Los Angeles	$111,578
▪ Port of Long Beach	$111,577
▪ South Coast Air Quality Management District	$421,250
▪ Southern California Gas Company	$1,350,980

Environmental Benefits

The certified NO_x emission levels of the Cummins Westport ISL G engine are about 90 percent lower as compared to a model year 2007 diesel drayage truck. The use of "low carbon content" natural gas will also help California achieve its goals under its Low-Carbon Fuel Standard and reduce greenhouse gas emissions by approximately 20 percent as compared to diesel fuel.

Project Status

The CNG trucks operated throughout 2009. Initially, the trucks were used exclusively in local drayage service around the ports in an effort to familiarize the drivers with the new vehicles and to build confidence in the local, public CNG infrastructure. In early May 2009, CCC's management decided they had the comfort level with the TAP-funded CNG truck to begin running it on longer inland routes. Beginning on May 4, 2009, the TAP-funded CNG truck began running one inland route from CCC to Ontario each morning. The truck ran local routes each afternoon. The CNG truck continued running this single daily inland route for most of May 2009 through September 2009. After September, the CNG truck returned to running two local shifts per day.

The original program called for the truck to use public CNG infrastructure initially and then transition over to a small private CNG station that was going to be installed at CCC by Southern California Gas Company using a grant from the South Coast Air Quality Management District (SCAQMD). Permitting was not granted for this station and temporary fueling was utilized instead.

A final report discussing the demonstration results is expected early 2010.

3.0 Projects That Were Cancelled or Withdrawn In 2009

Unfortunately, there are situations that arise where a project previously approved, and sometimes implemented by the TAP, can not be carried out to completion. This occurred in the case of three TAP projects as discussed below.

3.1 Crowley Maritime Ultra-Low Emission LNG Harbor Tug

As background, Crowley Maritime Corporation (Crowley) and its project team designed a next generation of ultra-low emissions ship assist tug for service at the ports. The ultra-low emission (ULE) tug design, which relies on liquefied natural gas-fueled lean burn engines, has the potential to substantially reduce both regulated air pollutants and greenhouse gas emissions compared to the conventional diesel fueled tugs operated in similar service.

Funding to allow the LNG tug to be constructed and demonstrated at the ports was approved and programmed in 2008. The Port of Los Angeles planned to contribute a total of $1,000,000 through the TAP as well as their Air Quality Mitigation Incentive Program (AQMIP) and the Port of Long Beach planned to contribute $250,000 of their TAP resources. These contributions were to be matched with substantial co-funding from Crowley, in the amount of over $13 million.

In late 2009, Crowley notified the TAP that the ULE tug project needed to be placed in a holding pattern. The primary reason for this was the decrease in work load for tugs at the ports and the limited grant funding that has been secured to date ($1.25 out of the $5 million in grant funding that Crowley targeted for the ULE tug project). Crowley and its partners invested heavily in this project and feel the design is quite viable and would provide substantial emissions reductions for the ports of California. Crowley will continue to keep abreast of the latest technologies associated with the design of the ULE tug in the hopes that sometime in the future this project can reach fruition. At such time that Crowley feels the project can be successfully implemented, it is anticipated Crowley would then submit an updated project proposal for TAP grant funding consideration.

3.2 Johnson Matthey SCRT® Diesel Emission Control System Demonstration

As background, Johnson Matthey, Inc., proposed to demonstrate their Selective Catalytic Regenerating Technology (SCRT®). This technology has the potential to allow 1998 model year port drayage trucks to cost-effectively meet 2007 EPA emission standards for particulate matter and NO_x.

During 2009, the ports worked closely with Johnson Matthey to identify candidate class 8 drayage trucks to retrofit with the SCRT® system. The desire was to have a mix of engine manufacturers, models, and displacements demonstrated so that the resulting CARB Executive Order granting Level 3+ NO_x verification is applicable to a broad range of engine families. Unfortunately, it turned out that the duty cycle for candidate trucks did not meet operational requirements of the system (could not meet required temperatures) and Johnson Matthey withdrew their project from the program.

3.3 Pacific Harbor Line (PHL) Locomotive Diesel Particulate Filter

The goal of this project was to demonstrate the effectiveness and durability of DPFs as a strategy to reduce diesel particulate matter from switch locomotives operating at the ports. Under this project, a MobiClean™ active regeneration DPF was to be installed on a Pacific Harbor Line switch locomotive.

In an effort to accelerate locomotive emission reductions, the ports worked over the past year with PHL to scope out a project plan to upgrade its current fleet of sixteen EPA Tier 2 switcher locomotives with engines meeting "Tier 3-plus"emission standards. The new "Tier 3-plus" engines will reduce NOx emissions by 38% and PM emissions by 85% compared to the existing Tier 2 engines. As a result of this new fleet upgrade plan, the original DPF retrofit project has been cancelled, since the new project will address the PM reduction needs from this source category.

4.0 2009 TAP Funding Awards

The TAP is supported by both ports as an element of the CAAP at an annual level of $1,500,000 from each port. Additional funding is contributed by participating agencies, including but not limited to the SCAQMD, CARB, US EPA, and California Energy Commission (CEC). Project co-funding is also contributed by the project proponent as either cash or in-kind contribution, or some combination of both.

The port and agency stakeholder investment for each TAP project is shown in Table 4.1, below. Contributions from participating agencies other than the ports are typically made on a project-by-project basis. In addition to the funding amounts reflected below, TAP contractors are required to provide a minumum of 50 percent co-funding in the form of cash and/or in-kind contributions to each project. Required match contributions are not included in Table 4.1, but are noted within each project summary in Section 2.

Table 4.1: TAP Projects Funded from Program Inception through December 31, 2009

Project Cateogy	POLB	POLA	AQMD	CARB	US EPA	CEC	Total Port & Agency Stakeholder Investment
Ocean Going Vessels							
APL Singapore Slide Valve/Wife	$22,500	$22,500		$783,628			$828,628
ACTI AMECS Emissions Testing	$149,527	$149,527	$55,000				$354,054
Harbor Craft							
Foss Maritime Hybrid Tugboat	$500,000	$889,920*					$1,389,920
OceanAir Environmental Eco-Tug	$350,000	$350,000					$700,000
Cargo Handling Equipment							
Vycon RTG REGEN Flywheel	$11,500	$11,500	$8,000				$31,000
LNG Yard Tractor	$350,000				$75,000		$425,000
Diesel Hybrid Yard Tractor	$300,000*	$300,000*			$300,000		$900,000
LBCT Eco-Crane	$175,000	$175,000		$130,130			$480,130
EES Emulsified Biodiesel	$44,000	$44,000					$88,000
Capacity Plug-In Hybrid Tractor	$29,500						$29,500
Rypos Diesel Emission Control	$64,668	$64,668					$129,336
Container Drayage Trucks							
Balqon Electric Class 8 Tractor		$263,500	$263,500				$527,000
Balqon Lithium Battery Upgrade		$400,000					$400,000
Westport ISX LNG Engine	$250,000	$250,000	$1,250,000			$500,000	$2,250,000
SoCalGas CNG Drayage Truck	$111,577	$111,577	$421,250				$644,404
Locomotives							
PHL Locomotive DPF	$0	$0	$307,125		$100,000		$407,125
Total Investment	$2,358,272	$3,032,192	$2,304,875	$913,758	$475,000	$500,000	$9,584,097
Total TAP Investment	$2,071,438	$1,842,272					

*This funding amount is a non-TAP, port funding contribution to the project.

5.0 TAP Priorities for 2010

To support next year's 2010 CAAP Update, port staff set important goals for the TAP in 2010. The TAP will continue to support the identification, development and demonstration, and, ultimately, CARB verification of lower emitting technologies applicable to the source categories and focus areas identified in the CAAP. Therefore, TAP funding priorities for 2010 will continue to be based on the technology needs identified in the CAAP to improve air quality at the ports and protect the health of residents of the South Coast Air Basin. The technical and programmatic TAP priorities for 2010 are summarized below:

2010 Technical Priorities:

For 2010, the ports will continue the effort to identify and develop TAP technologies for the key source catgories that contribute to port emissions. This includes targeting emission reductions from locomotives, on-road and off-road trucks, and a focus on zero or near-zero emission technologies.

Specifically, 2010 will emphasize the identification and demonstration of technologies that target emission reductions from ocean going vessels and locomotives. Numerous emission reduction technologies will be evaluated for integration into vessel new builds and use of these technologies as a retrofit for existing vessels will be explored. The ports intend to work cooperatively with vessel owners and engine and technology manufacturers to advance these efforts. For example, the feasibility and cost-effectiveness of using onboard systems such as exhaust scrubbers, selective catalytic reduction and other technologies that have the potential to significantly reduce OGV and locomotive emissions beyond regulatory requirements will be evaluated.

2010 Programmatic Priorities:

For 2010, the ports will continue their effort to launch the comprehensive TAP Database, which will allow the seamless sharing of data between both ports and, as appropriate, project implementers. A key feature of the TAP Databse is the Online Proposal Submittal feature. This template-driven feature will significantly reduce the administrative burden on both project applicants as well as port staff. In addition, the ports will continue their efforts in the following areas:

- Increase coordination and the level of communication with other domestic and world ports as it relates to air quality improvement technologies and the potential for inclusion in the CAAP;
- Partner with TAP Advisory Committee member agencies, other agency stakeholders, and project proponents in an effort to leverage TAP funding and maximize the effectiveness of the TAP.
- Ensure that port equipment operators are aware of grant program eligibility, and when appropriate, facilitate application to such programs.

APPENDIX A
TECHNOLOGY ADVANCEMENT PROGRAM ADVISORY COMMITTEE MEMBERSHIP

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Appendix B

Summary Reports for Projects Completed to Date

The following Technology Advancement Program projects are complete:

1. APL Singapore Slide Valve & Water-In-Fuel Emulsion Demonstration Program
2. Balqon E-30 Electric Terminal Tractor Development & Demonstration Project
3. Advanced Maritime Emission Control System (AMECS) Project
4. VYCON REGEN® System for Rubber-Tired Gantry Cranes Testing & Verification
5. Liquefied Natural Gas Yard Tractor Demonstration

Summaries of the Final Reports submitted for these projects are included herein.

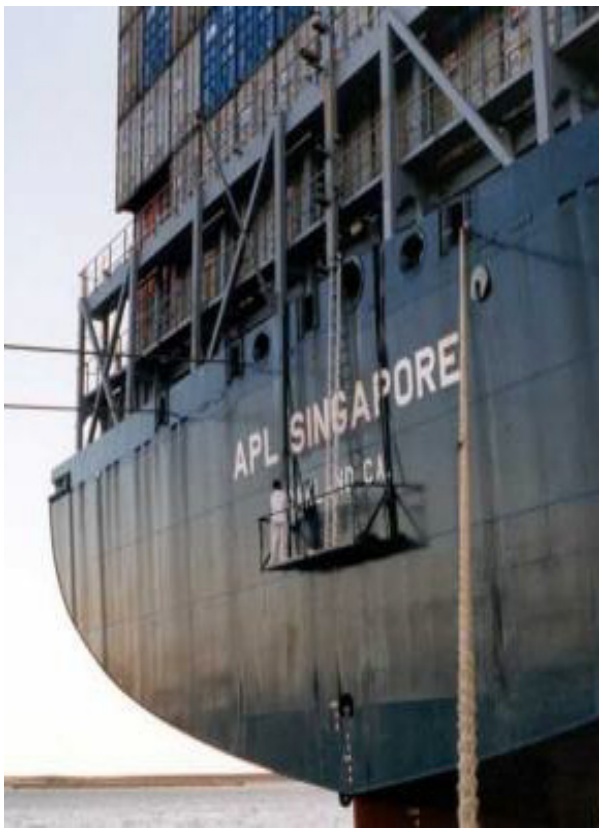
APL Singapore Slide Valve & Water-In-Fuel Emulsion Demonstration Project

Technology Manufacturer
MAN B&W Diesel
Sea to Sky Pollution Solutions

Co-Participants
Port of Long Beach, Port of Los Angeles, University of California-Riverside CE-CERT, Bay Area AQMD, Ventura County APCD, San Luis Obispo County APCD, Santa Barbara County APCD, California Air Resources Board, US EPA Region 9

Background

The Technology Advancement Program has completed participation in a three-year demonstration of emission reduction technologies aboard the container ship *APL Singapore.* Two emission control technologies were demonstrated - the use of slide valves in the vessel's main engines, and water-emulsified bunker fuel using an innovative onboard water in fuel emulsifier.



Project Objective

To investigate the technical feasibility, engineering requirements, and potential for replication in other ocean going-vessels (OGVs), the San Pedro Bay Ports partnered with the US EPA, CARB, and Air Districts to demonstrate two retrofit technologies that have the potential to significantly reduce both particulate matter and oxides of nitrogen (NO_x) emissions. The primary objectives of the demonstration project were to:

- Evaluate the particulate matter (PM) emission reduction effectiveness of retrofitting OGV main engines with an improved injector design known as a slide valve;
- Demonstrate demand-based onboard water in fuel emulsification system and measure the NO_x reduction effectiveness of varying the water content.

Technology Demonstration

Water-in-Fuel Emulsification (WiFE) – WiFE is the process of introducing water into fuel prior to injection into the combustion cylinder. The fuel-water emulsion technology is provided by Sea to Sky Pollution Solutions. A fuel homogenizer was installed in the APL Singapore's engine room to produce the emulsification. Fuel and water are carried by separate lines into a mixing chamber called a "homogenizer/emulsifier" which is essentially a large funnel. Inside the funnel is a rotor that spins with a very small clearance next to the funnel's walls. The spinning rotor draws in the fuel and water, mixes them together and squeezes the mixture out of the funnel with water present in the fuel as tiny droplets. The water droplets, as small as one micron (0.000001 meter in diameter) are fully contained within the fuel.

The fuel/water mixture is immediately injected and atomized within the engine's combustion chamber. The heat inside the combustion chamber causes the water droplets to vaporize into steam – this requires energy from the combustion process and results in lower peak combustion temperatures. The lower combustion temperatures reduce NO_x formation.

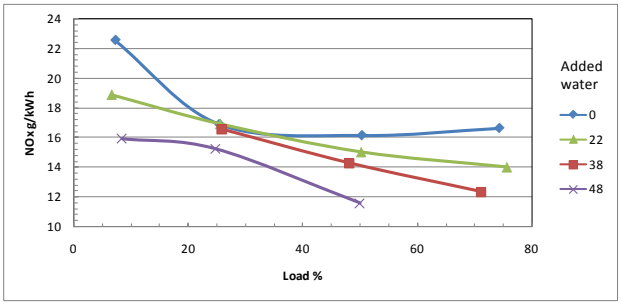
Slide Valve Injectors – Slide valves installed on the APL Singapore's main engine differ from conventional valves in their spray patterns and are designed to reduce dripping of fuel from the injector during the combustion process. As particulate matter (PM) is a product of incomplete combustion and unburned fuel, optimization of the fuel injection system is expected to result in a reduction in fuel consumption and a reduction of PM emissions on the order of 10% to 25%. The slide valve technology is provided by MAN B&W Diesel (MAN).

Status

The first emissions tests were conducted during a 15-day transpacific voyage from Kaohsiung Taiwan to the San Pedro harbor. Testing was conducted in parallel by University of California-Riverside and MAN B&W. A second test protocol was performed in spring 2008, also conducted by the University of California-Riverside in cooperation with engine manufacturer MAN B&W Diesel. Data analysis and publication of the emissions test results are expected to be finalized in 2009.

Results

Testing of the WiFE system aboard the APL Singapore yielded the results shown below in the figure below. As shown, water concentrations as high as 48% were successfully demonstrated, yielding NO_x reductions on the order of 30%.



Benefits

Optimization of the fuel injection system using slide valve retrofit technology is expected to result in a reduction in fuel consumption and a reduction of PM emissions on the order of 10% to 25%.

Project Costs

Seven funding partners contributed approximately $1.3 million toward this demonstration and evaluation project. The San Pedro Bay Ports, the Bay Area, Ventura County, San Luis Obispo County, and Santa Barbara County Air Pollution Control Districts contributed funds towards the emissions testing element of the project. The San Pedro Bay Ports contributed $45,000 in TAP funding toward emissions testing.

Commercialization and Applications

This project demonstrated the substantial NO_x and PM reductions that can be achieved through OGV retrofit using commercially available technology.

Now that marine distillate oil (MDO) is required to be used by OGVs when within 24 nautical miles of the California Coast, the ports are currently evaluating possible future demonstration projects to address the feasibility of making a stable emulsion of MGO and water and the compatibility of slide valves with MDO as compared to bunker fuel.

Balqon E-30 Electric Terminal Tractor Development & Demonstration Project

Technology Manufacturer
Balqon Corporation

Co-Participants
Port of Los Angeles
South Coast Air Quality Management District (SCAQMD)

Background

The Balqon E-30 Electric Terminal Tractor was built as a demonstration vehicle, co-funded by the Port of Los Angeles and SCAQMD, and designed specifically for drayage operations. Developed by the Balqon Corporation as a Port of Los Angeles initiative, the prototype E-30 all-electric terminal tractor successfully completed cargo terminal tests during 2008.

Project Objective

Today, fleets of hundreds of hostlers - which are mostly diesel vehicles and a small number of LNG test units - move thousands of containers each day between the port's docks and terminal backland. The objective of the E-30 Electric Terminal Tractor demonstration project was to prove the performance capabilities and commercialization feasibility and practicality of using zero-emission electric terminal tractors to perform this function.

Results

Following the successful completion of cargo terminal tests during 2008, the Los Angeles Harbor Commission approved the purchase of 20 electric trucks from the manufacturer as part of the "green terminal" program. These trucks will be deployed as a zero emissions alternative to fossil fuel-powered yard tractors, or "hostlers." Currently, fleets of thousands of hostlers - which are mostly diesel vehicles and a small number of LNG test units - move thousands of containers a day between the port's docks and terminal backland. They could eventually be replaced by electric vehicles.

Technology Description

Designed specifically for short-haul or "drayage" operations, this heavy-duty terminal tractor can pull a 60,000 pound cargo container at a top speed of 40 mph, and has a range between 30 to 60 miles per battery charge. The battery charger can charge up to four electric trucks simultaneously in four hours and can also provide up to 60 percent of the charge in one hour to meet peak demands during daily operations. Key design and performance attributes of the Balqon E-30 electric terminal tractor are highlighted below:

Vehicle Performance	Maximum speed 45 mph; unloaded grade 10%, loaded 5%; Max GCWR 125,000 lbs; Range: unloaded 150 miles; fully loaded range 90 miles
Vehicle Dimensions (inches)	Overall – 210" X 96" X 120"; wheelbase 135"; fifth wheel height 46"; front wheel overhang 44", rear wheel overhang 31"
Electric Motor	300 hp rated 230 volt AC electric motor connected to flux vector variable frequency controller; 300% peak load rating
Traction Controller	Proprietary flux vector motor controller 240 KW liquid cooled; integrated CAN BUS and self diagnostic system
Traction Battery	280 kW-hr lead acid battery pack, 336 Volt; battery management system monitors battery cell performance
Battery Charger	100 KW multi-vehicle fast charger; 4 charging ports standard; priority smart charge algorithm based on vehicle state of charge

Benefits

The Balqon E-30 is a zero emission electric vehicle using electric motors for motive power and batteries for energy storage; thus, "tailpipe emissions" for this low-speed electric terminal tractor are zero. Based on the average emissions generated by the existing fleet of drayage trucks that serve the San Pedro Bay ports, POLA estimated the average pollution discharge generated by the estimated 1.2 million truck trips that occurred in 2006 between the ports and the Intermodal Container Transfer Facility or ICTF. If those 1.2 million truck trips were to be made with zero emission electric trucks, an estimated **35,605.6 tons** of tailpipe emissions would be eliminated, including:

- 21.8 tons per year of Diesel PM
- 427.7 tons of localized NOx
- 168.5 tons of carbon monoxide (CO)
- 34,987.6 tons of CO_2

On a "kilowatt-hour of energy" cost basis, the Balqon electric truck costs approximately 20 cents per mile to operate. A typical class 8 diesel truck could cost anywhere from four to nine times as much, depending on the cost of diesel fuel and truck duty cycle.

Status

Following the completion of cargo terminal tests during 2008, the Los Angeles Harbor Commission approved the purchase of 20 electric trucks from the manufacturer as part of the "Green Terminal" program. These trucks will be deployed as a zero emissions alternative to fossil fuel-powered yard tractors. The Green Terminal program will also include the production of five on-road electric trucks. In total, the port is investing more than $5.6 million to demonstrate the viability of electric drayage trucks.

Project Costs

The development and demonstration of the Balqon electric terminal tractor was co-funded by the Port of Los Angeles and South Coast Air Quality Management District at a total cost of $527,000.

Project Partners	Contributions
▪ Port of Los Angeles	$263,500
▪ South Coast AQMD	$263,500

Commercialization and Applications

As a provision of future electric truck orders, POLA required Balqon to locate its manufacturing facility in the City of Los Angeles and pay the Port a royalty for every electric truck it sells or leases worldwide. Those funds will be used to advance other Port TAP initiatives. The new Balqon manufacturing plant will support the creation of approximately 50 new "green collar" jobs.

Advanced Maritime Emission Control System (AMECS) Project

Technology Manufacturer
Advanced Cleanup Technologies, Inc. (ACTI)

Co-Participants
Port of Long Beach, Port of Los Angeles, South Coast Air Quality Management District, Metropolitan Stevedore Company, Engine Fuel & Emissions Engineering, Inc., Professional Environmental Services

Background

Advanced Cleanup Technologies, Inc. (ACTI) is a professional full service firm specializing in environmental emergency response, hazardous waste cleanup, and air pollution control technology. ACTI developed the Advanced Maritime Emissions Control System, or AMECS, as an alternative pollution control method for ocean-going vessels that are not configured to use shore power, also known as "cold ironing", while at berth.

Project Objective

To investigate the technical and commercial feasibility of reducing emissions from ocean-going vessels not configured to use shore power while at berth. The goal was to demonstrate pollution reduction efficiencies equal to cold ironing for nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matter (PM).

Technology Demonstration

The AMECS uses a shroud lifted over the vessel exhaust stack by means of a specially designed crane and deployment arm. The shroud is then lowered over the stack and then cinched to provide a soft attachment between the shroud and the ship's stack. A seal closes the open area between the perimeters of the bonnet and ship's stack to limit the amount of air entering the bonnet as well as to prevent exhaust gases from escaping. The exhaust gases from the ship's auxiliary engines and the boilers are routed through a flexible duct to an Emission

Treatment System (ETS) located on the dock adjacent to the vessel's berth. The ETS uses multiple exhaust gas treatment technologies to remove both gaseous and particulate pollution:

1. The **Pre-Conditioning Chamber** (PCC), which uses a counter-flow spray system to remove PM and water soluble organic gases. The spray water is treated with sodium hydroxide to simultaneously remove sulfur oxide pollution. The water spray also cools the exhaust gas, allowing smaller particles to coalesce such that they are more efficiently captured in subsequent phases of exhaust gas treatment;

2. **Cloud Chamber Scrubbers** (CCS) remove the remaining exhaust PM. Three separate units generate a fog of very fine water droplets with a high electrical charge. The charged water droplets attract and capture multiple PM particles. The PM laden water is circulated through filters where the PM is removed. The three cloud chambers are identical except for the polarity of the charge imparted to the water droplets. Sodium hydroxide is also injected into the water streams of the cloud chambers to remove any remaining sulfur oxides;

3. **Selective Catalytic Reduction** (SCR) **Reactor** removes NO_x emissions. Liquid urea is injected into the hot gas stream ahead of the SCR where it is converted to ammonia. The ammonia reacts with the NO_x while passing through the catalyst to form nitrogen and water vapor, which are then vented to atmosphere. The SCR Reactor is designed to remove at least 99% of the NO_x emitted by the vessel while at berth;

4. The **Continuous Emissions Monitoring System** (CEMS) is used to measure exhaust gas pollution levels both into and out of the ETS. This system is used to gauge pollutant removal efficiency, as well as control the injection rates of sodium hydroxide and urea used during exhaust treatment.

Status

The TAP-sponsored AMECS demonstration and testing project was completed as of July, 2008. The Final Report documenting the test protocols and measured emission reduction efficiency levels was prepared by TIAX LLC on behalf of ACTI and submitted to the ports and South Coast AQMD for review and comment. The demonstration results were also provided to and underwent an independent evaluation by the California Air Resources Board (CARB). As a result of their evaluation, CARB submitted a letter on December 15, 2008, stating their concurrence with the AMECS emissions efficiency testing results.

Results

The AMECS was demonstrated at Metropolitan Stevedore/Port of Long Beach on multiple vessels with varying exhaust stack configurations. During the demonstration period, two full-scale emission reduction efficiency tests where conducted, the results of which were independently verified by two testing laboratories.

Benefits

During emissions testing, NO_x and PM emissions were reduced by 99% and 95.5%, respectively. In addition, sulfur oxides (SOx) were reduced by 99%, and volatile organic compound (VOC) emissions were reduced by greater than 97 percent.

Project Costs

The total project cost was $603,211. Funding included $149,527 from each port's TAP budget and a $55,000 contribution from the South Coast AQMD.

Commercialization and Applications

The successful demonstration of the AMECS at the Port of Long Beach and the recognition by CARB of its pollution reduction efficiencies has positioned ACTI to offer this system on a commercial basis. This technology has the potential to be replicated at other ports as a viable alternative to shore power to reduce vessel hotelling emissions.

Vycon REGEN® System for Rubber-Tired Gantry Cranes Project

Technology Manufacturer
VYCON Energy

Co-Participants
Port of Los Angeles, Port of Long Beach, South Coast Air Quality Management District, California Air Resources Board, ITS, Evergreen and VYCON

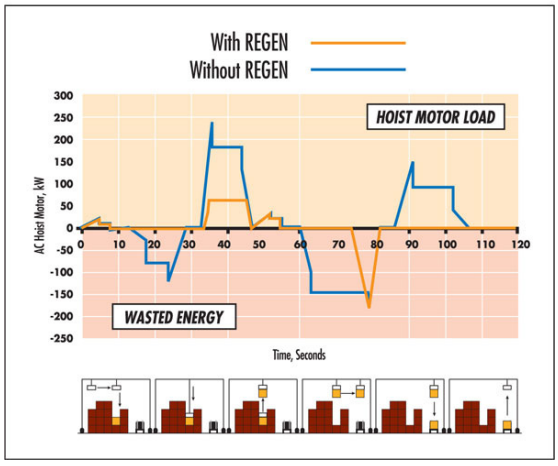
Background

The VYCON REGEN® system supports the goal of clean air and a healthier environment through the reduction of air pollution from port equipment. Specifically for this project, a rubber tire gantry (RTG) crane operating at each port was retrofit with the VYCON system.

Project Objective

Two marine terminals, ITS in the Port of Long Beach and Evergreen in the Port of Los Angeles, installed VYCON's REGEN system onto one of the terminals' rubber tire gantry (RTG) cranes.

Typical Load Profile vs. Load Profile with REGEN



Technology Description

VYCON's REGEN system is an energy storage system that is also capable of supplying the stored energy on demand.

Basically, the REGEN system is re-charged each time the AC motor in the hoist regenerates power (i.e., on the down cycle). This stored energy is then quickly released back to the AC motors during the "up" cycle, resulting in increased efficiency during each lift cycle. The transitions are seamless and instantaneous.

This conserves energy, increases fuel efficiency, and reduces emissions as well as operating costs. The REGEN System can be retrofitted onto in-use cranes or installed at the factory as part of a new crane.

Status

VYCON recently achieved Level 1 verification from the California Air Resources Board.

Results

The primary TAP role in this project was to co-fund emissions testing in support of CARB verification. This work was completed and VYCON received its Level 1 CARB verification in October, 2007.

Benefits

VYCON's REGEN system is verified to reduce particulate matter (PM) emissions by a minimum of 25 percent and is estimated to reduce oxides of nitrogen (NOx) emissions by 30 percent. Emissions of carbon dioxide (CO2) are estimated to be reduced by about 30 percent, resulting from the associated reduction in diesel fuel consumption (up to 35 percent).

Project Costs

The TAP supported the VYCON verification effort by co-funding emissions testing of the project equipment. Each port committed $11,500 for a total cost of $23,000.

Commercialization and Applications

The VYCON flywheel regeneration system already has a number of applications. In addition to the Level 1 RTG crane application, VYCON's REGEN system is also used in rail, uninteruptable power supply (UPS) and wind power applications.

Liquefied Natural Gas (LNG) Yard Tractor Project

Technology Manufacturer
Kalmar Industries
Cummins Engine Company

Co-Participants
Port of Long Beach, US EPA Region 9, Long Beach Container Terminal, CALSTART

Background

Yard tractors, also referred to as yard hostlers, terminal tractors, and yard goats, are heavy-duty off-road truck tractors designed for moving cargo containers within port container terminals and other off-road areas. These vehicles are the most common type of cargo handling equipment (CHE) used at container terminals at the ports. According to emission inventories compiled by the Ports of Long Beach and Los Angeles, yard tractors emit approximately 64% of the particulate matter (PM) and 59% of the nitrogen oxides (NO_x) emissions for all cargo handling equipment, as shown in Figures 2.3-1 and 2.3-2, below. Further, yard tractors are the single largest landside source of PM and NO_x emissions at the Ports.

Project Objective

To investigate the technical and commercial feasibility of reducing emissions from yard tractors, the Port of Long Beach, in partnership with the US EPA, funded the demonstration of yard tractors retrofitted with low-emission liquefied natural gas (LNG) engines. The primary objectives of the demonstration project were to:

- Evaluate the in-use performance of LNG yard tractors in a demanding, marine terminal environment;
- Evaluate the emissions of LNG yard tractors as compared to conventional diesel-fueled hostlers used at the port;
- Assess the business case for LNG yard tractors at ports and similar applications such as rail yards and distribution centers.

Technology Demonstration

The project was divided into three phases:

1. Development of LNG yard tractor specifications, vehicle procurement, and installation of temporary LNG refueling;

2. Operation of LNG yard tractors at a marine terminal for a period of eight months. Demonstration commenced in June 2006 and was completed in January 2007. During this time, data were collected on the performance of the LNG yard tractors compared to a group of baseline diesel vehicles. Emissions testing was also conducted at the conclusion of the second phase;

3. The third phase of the project was the development of a business case assessment to determine the cost-effectiveness and return on investment of using LNG equipment as opposed to diesel.

The project team consisted of the Port of Long Beach, US EPA Region 9, Sound Energy Solutions, CALSTART, and Long Beach Container Terminal (LBCT). LBCT volunteered to test the LNG yard tractors in their container terminal operations during the eight month evaluation period.

A total of three LNG yard tractors were deployed for performance testing and evaluation. Specifications for the LNG yard tractors were based on the Ottawa Commando 50 4x2 off-road terminal tractor performance specifications. The LNG engine specified for the demonstration was the model year 2005 Cummins C Gas Plus 8.3 liter natural gas engine, rated at 250 hp and certified to the CARB on-road Optional NO_x standard.

Eight diesel yard tractors were selected from LBCT's fleet to serve as the baseline yard tractor group for comparative purposes. The baseline vehicles were equipped with various off-road diesel engines, ranging from model year 2001 to 2003 Cummins 8.3 liter 6CT engines rated at 205-215 hp and certified at Tier 1 or Tier2, to model year 2005 Cummins 5.9 liter ISB engines certified to the on-road emissions standard. All baseline diesel engines were equipped with diesel oxidation catalysts and closed crankcase ventilation (CCV) to reduce particulate matter emissions. Data was collected on the baseline yard tractor group in parallel with the LNG tractors under similar operating conditions.

Status

This project is complete and the Final Report was received Augus 2008.

Results

Data collection was performed for quantitative parameters, such as fuel consumption and exhaust emissions, as well as qualitative attributes, such as operator perceptions of vehicle drivability. With respect to fuel economy, the LNG yard tractors used approximately 30% more fuel, on a diesel equivalent gallon basis, as compared to the average for baseline diesel vehicles. This result is consistent with expectations for the relative efficiency of a spark-ignited natural gas engine compared to a compression-ignited diesel engine.

Operator acceptance was assessed via surveys given to all LNG yard tractor drivers. Drivers were asked to rate the LNG yard tractor as 'better", "same", or "worse" in key performance areas compared to a typical diesel tractor. The areas covered by the survey included maneuverability, pulling power, acceleration, shifting, steering, in-cab visibility, ride comfort, etc. Based on the driver surveys, 97% of the drivers found the LNG yard tractors to have the same or better performance compared to the diesel tractors; 67% of the drivers rated the LNG tractors as having superior performance in general.

Benefits

During emissions testing, the lowest NO_x and PM emissions were produced by the 2005 on-road diesel engine-equipped tractor and the 2005 LNG tractor, respectively. NOx emissions from the LNG yard tractor were approximately 21% higher than NO_x emissions from the on-road diesel engine equipped with a diesel oxidation catalyst and closed crankcase ventilation system.

Project Costs

The total project cost was $425,000. Funding included $350,000 from the Port of Long Beach TAP Program and a $75,000 contribution from US EPA Region 9.

Commercialization and Applications

The successful demonstration of LNG in yard tractor operations, especially as it pertains to driver acceptance, has created a market for LNG yard tractors at the Ports. Original Equipment Manufacturer (OEM) yard tractor chassis manufacturers now offer LNG yard tractors equipped with the Cummins Westport ISL G natural gas engine. This 8.9 liter heavy-duty on-road engine is certified at the 2010 emission standard of 0.2 g/bhp-hr, and is the lowest emitting heavy-duty engine certified by the California Air Resources Board.