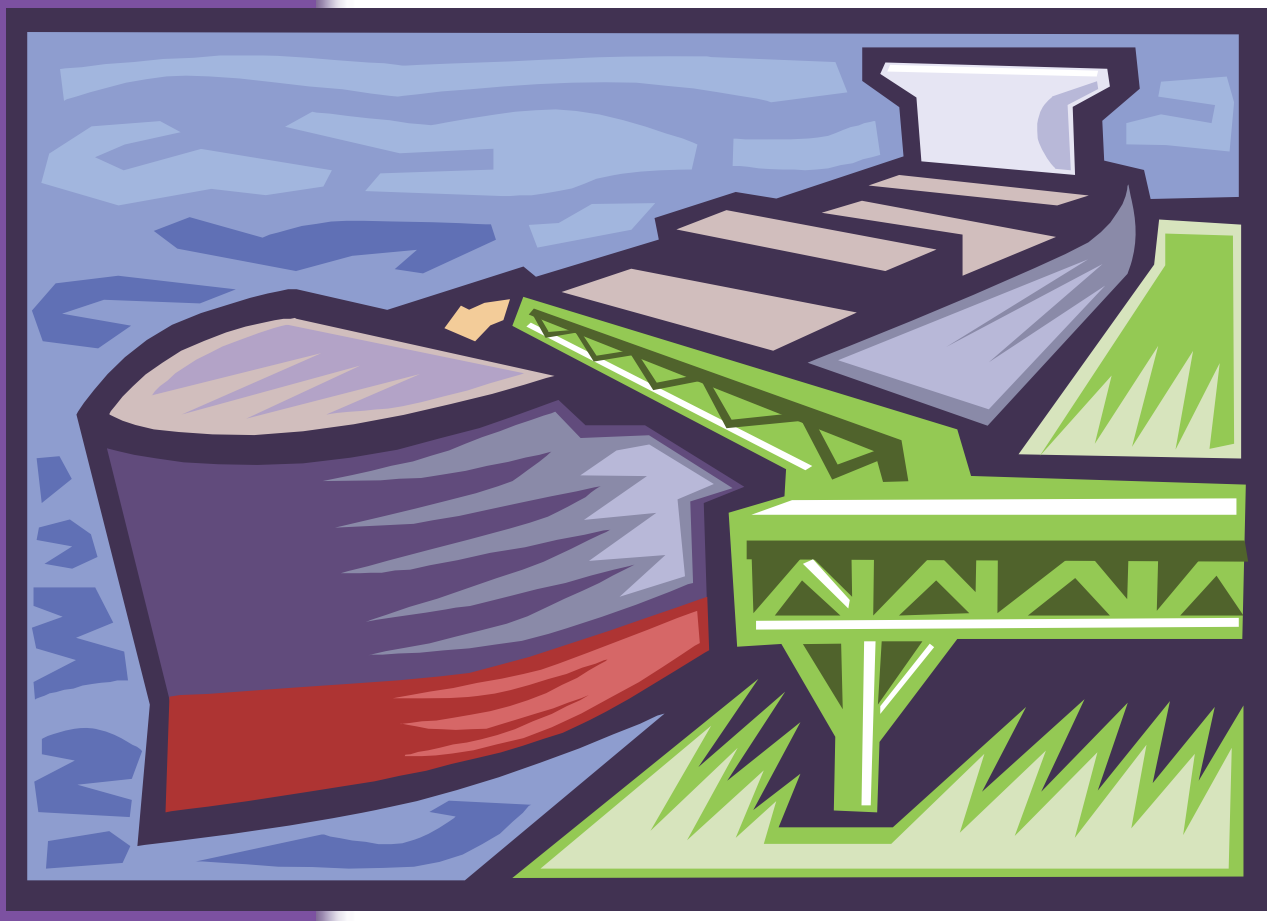
2008 Annual Report
April 2010

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	Advisory Committee
ACTI	Advanced Cleanup Technologies Incorporated
AMECS	Advanced Maritime Emissions Control System
APL	Shipping line formerly known as American President Line
AQMD	South Coast Air Quality Management District
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.)

SCRT	Selective Catalytic Reduction Technology
SoCalGas	Southern California Gas Company
SO_x	Sulfur Oxides
SPBP	San Pedro Bay Ports
TAC	Toxic Air Contaminant
TAP	SPBP 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 resulted in a reduction in imports and exports, the latest economic forecasts indicate that the demand for containerized cargo moving through the Southern California region will increase significantly over the next two decades. 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 November 2006, the ports of Long Beach and Los Angeles adopted their landmark, joint Clean Air Action Plan (CAAP), which is designed to reduce the air health risks and emissions associated with port-related operations, while allowing port development 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. The annual minimum contribution from each port is $1.5M. 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). Co-funding contributions are required by the project implementer for all proposed TAP projects.

The TAP implementation process adopted by the ports is thoroughly outlined in the TAP Guidelines[1]. TAP offers financial support for the demonstration of advanced technologies that: a) have a high probability of achieving significant reductions in criteria pollutants as well CARB-classified air toxic pollutants, specifically, diesel particulate matter (DPM); nitrogen oxides (NO_x) and sulfur oxides (SO_x), and b) are seeking verified technology status from the CARB; and c) present a strong business case for future successful technology commercialization. In the simplest terms, the purpose of TAP is to include additional, effective air pollution reduction strategies to the CAAP "toolbox".

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 ports' options and allow the ports to be more aggressive in pursuing CAAP measure implementation. In certain cases, technologies initially targeted for TAP funding consideration have been developed into separate and distinct technology implementation programs. Notable examples include the Port of Los Angeles' electric Class 8 drayage truck program and electrified rubber tired gantry cranes at the Port of Long Beach.

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 sizes on the order 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 thus serves as the catalyst for identifying, evaluating, and demonstrating new and emerging emission 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.

There are four fundamental areas of focus for the TAP:

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

This document is the second Technology Advancement Program (TAP) Annual Report under the CAAP. This second Annual Report will primarily document 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.

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

The TAP Advisory Committee (TAP 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 Advisory Committee serves in an advisory capacity to the ports for screening, evaluating, and recommending projects that merit further development or demonstration. In addition, the Advisory Committee members provide information as it pertains to co-funding from their agency that could potentially be used to move projects toward implementation. The TAP 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 second Technology Advancement Program Annual Report includes a summary of the thirteen (13) projects selected or implemented under the TAP during 2008. These include:

Source Category	TAP Project
▪ Ocean Going Vessels	APL Singapore Slide Valve & Water-In-Fuel Emulsion ACTI Advanced Maritime Emissions Control System
▪ Harbor Craft	Foss Maritime Green Assist™ Hybrid Tugboat OceanAir Environmental ECO Tug™ Tugboat Crowley Maritime Corporation Ultra-Low Emission Harbor Tug
▪ Cargo Handling Equipment	Hybrid Yard Tractor Development & Demonstration Long Beach Container Terminal Eco-Crane Alternative Petroleum Technologies' Emulsified Biodiesel
▪ Container Drayage Trucks	Balqon Electric Class 8 Tractor Westport ISX LNG Engine Development Johnson Matthey Selective Catalytic Reduction Technology (SCRT) Diesel Emission Control System SoCalGas CNG Drayage Truck Demonstration
▪ Locomotives	Pacific Harbor Line Locomotive Diesel Particulate Filter

Each of the projects listed above is discussed in the following sections of this 2008 Annual Report

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The annual minimum funding levels for the TAP are shown below Table ES.1. Note that contributions from participating agencies other than the ports are typically made on a project-by-project basis. While Table ES.1 illustrates the current five-year TAP funding commitment, it is important to note that the TAP program has a term that mirrors the CAAP. Similar to the CAAP, TAP has a five year technology advancement perspective; however, it is fully anticipated that TAP will adopt a moving five-year technology horizon.

Table ES.1: Technology Advancement Program Funding by Fiscal Year & Participating Agency

Fiscal Year	2006/07	2007/08	2008/09	2009/10	2010/11	TOTAL
POLA	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$7,500,000
POLB	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$7,500,000
AQMD	$271,500	$1,557,125	$476,250	TBD	TBD	≥ $2,304,875
CARB	$783,628	$0	$130,130	TBD	TBD	≥ $913,758
EPA	$375,000	$100,000	$0	TBD	TBD	≥ $475,000
CEC	$0	$500,000	$0	TBD	TBD	≥ $500,000
Other	$889,920*					≥ $889,920
Totals	**$5,320,048**	**$5,157,125**	**$3,606,380**	**$3,000,000**	**$3,000,000**	**$20,101,553**

* Additional POLA funding from residual funds from the "NO_x and PM Emission Reduction Credit Program"

Total FY 2008-2009 revenue for the Technology Advancement Program equates to $3,606,380. Table ES.2, below, provides an accounting by fiscal year for the Technology Advancement Program. As shown in Table ES.2, the current TAP balance for fiscal year 2008-'09 is $4,230,989.

Table ES.2: Technology Advancement Program Balance Sheet

	POLB	POLA	Other Agencies
FY 2006-'07 Appropriations	$1,500,000	$1,500,000	$1,430,128
FY 2006-'07 Encumbrances	$1,217,035	$630,535	$1,430,128
FY 2007-'08 Appropriations	$1,500,000	$1,500,000	$2,157,125
FY2007-'08 Encumbrances	$250,000	$250,000	$2,157,125
FY 2008-'09 Appropriations	$1,500,000	$1,500,000	$606,380
FY2008-'09 Encumbrances	$1,210,720	$1,210,721	$606,380

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 indicate that the demand for containerized cargo moving through the southern California region will increase significantly over the next two decades. 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.

While the economic benefits of the ports are felt throughout the nation, the environmental impacts of trade are more locally concentrated. Both ports have adopted and are implementing a wide range of new environmental initiatives. 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 effects.

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 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 second Technology Advancement Program Annual Report under the CAAP.

1.2 Technology Advancement Program Objectives

The Mission Statement for the TAP 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.

Since the TAP is a component of the CAAP, it is anticipated that the TAP will undergo a review and update during the periodic CAAP update process in order to ensure that the TAP continues to support attainment of the overall CAAP goals.

There are four fundamental areas of focus for the Technology Advancement Program:

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

This second Annual Report will document 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 emphasis of the *Specific Control Measure* and *Emerging Technology Testing* elements 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 are as follows:

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

Specific Control Measure Requirements

As identified in the CAAP, several measures included in the CAAP require additional technical information in order to be fully implemented and to properly estimate the emissions reductions achieved in the ports' emissions inventories. Specific Control Measures identified in the CAAP that require additional demonstration, evaluation, and testing include:

- SPBP-OGV1: Emissions source testing of ships participating in the Vessel Speed Reduction (VSR) program to determine the magnitude of DPM, NO_x, and SO_x reductions associated with the measure;
- SPBP-OGV2: Demonstration and testing of Advanced Maritime Emissions Control System (AMECS) with respect to at-berth emissions reductions. The Port of Long Beach is leading this effort with the demonstration scheduled at one of their bulk facilities;
- SPBP-OGV3&4: Evaluation of technical, logistical, and fuel supply issues associated with use of cleaner fuels in main engines;
- SPBP-OGV5: Demonstration and emissions source testing of main and auxiliary engine emissions reduction strategies;
- SPBP-OGV5: Development of "Clean Ocean-Going Vessel" guidelines with respect to air quality for both existing vessels and new builds;
- SPBP-CHE1: Development of fact sheets identifying clean technologies for cargo handling equipment;
- SPBP-HC1: Demonstration, emissions source testing, and evaluation of emission reduction technologies for harbor craft, focusing on the transfer of successful control strategies from other land-based sources that use similar engines, such as diesel particulate filters (DPF) and diesel oxidation catalysts (DOC);
- SPBP-HC1: Development of "Clean Harbor Craft" guidelines with respect to air quality for both existing vessels and new builds;
- SPBP-RL1: Demonstration, emissions source testing, and evaluation of emissions reduction technologies for switcher locomotives including DPFs, hybrid electric, and alternative fueled liquefied natural gas (LNG) locomotives;
- SPBP-RL2: Demonstration, emissions source testing, and evaluation of emissions reduction technologies for long-haul locomotives including DOCs, DPFs, selective catalytic reduction (SCR), and other emerging technologies that could be utilized by these locomotives.

Much progress has been made by the ports and the regulatory agencies on many of these efforts since the CAAP was published in late 2006.

Emerging Technology Development, Demonstration & Testing

In addition to the Specific Control Measure Requirements listed above, additional demonstration, testing, and evaluation will be conducted on emerging emission reduction strategies that could be incorporated into the CAAP. As these strategies are identified, successfully demonstrated, and evaluated, they will be incorporated into new or alternative control measures as an element of a future CAAP update.

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. While the ports have implemented several technology development projects during 2008, such as increased availability of shore power for ocean going vessel cold ironing, these initiatives have been funded using port resources other than TAP. As of the end of calendar year 2008, no new port-sponsored projects have been 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 2008, the ports developed and released two (2) *Request for Qualifications* documents seeking innovative concepts for the development of hybrid electric and hydraulic hybrid class 8 drayage tractors.

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 relative to 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 while 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

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

The Advisory Committee serves in an advisory capacity to the ports for screening, evaluating, and recommending projects to be considered for further development or demonstration. The Advisory Committee 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 Advisory Committee 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 2008, the ports saw a significant increase in the number of unsolicited proposals submitted for funding consideration under TAP. Due to the wide range of technologies proposed, the Advisory Committee membership was augmented to include additional members with expertise in diverse areas such as fuel additives, diesel emission control systems, and marine vessels. A list of current Advisory Committee members is included in Appendix A of this Annual Report.

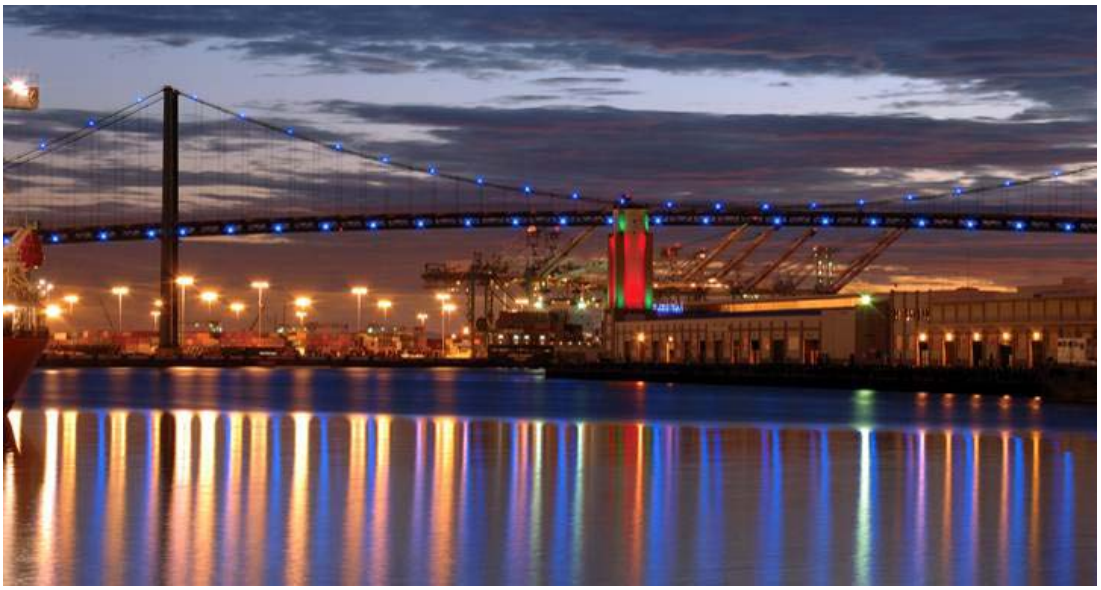
2.0 Key Projects in 2008

At the second complete year of Technology Advancement Program implementation, 2008 proved to be a very productive year for the ports, with technology demonstration projects initiated in prior years completed, new projects initiated, and technologies identified for pursuit in 2009.

This second Technology Advancement Program Annual Report includes a summary of the thirteen (13) projects active in 2008. These include:

Source Category	TAP Project
▪ Ocean Going Vessels	APL Singapore Slide Valve & Water-In-Fuel Emulsion
	ACTI Advanced Maritime Emissions Control System
▪ Harbor Craft	Foss Maritime Green Assist™ Hybrid Tugboat
	OceanAir Environmental ECO Tug™ Tugboat
	Crowley Maritime Corporation Ultra-Low Emission Harbor Tug
▪ Cargo Handling Equipment	Hybrid Yard Tractor Development & Demonstration
	Long Beach Container Terminal Eco-Crane
	Alternative Petroleum Technologies' Emulsified Biodiesel
▪ Container Drayage Trucks	Balqon Electric Class 8 Tractor
	Westport ISX LNG Engine Development
	Johnson Matthey Selective Catalytic Reduction Technology (SCRT) Diesel Emission Control System
	SoCalGas CNG Drayage Truck Demonstration
▪ Locomotives	Pacific Harbor Line Locomotive Diesel Particulate Filter

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.



2.1 Ocean Going Vessels

2.1.1 APL Singapore Slide Valve & Water-In-Fuel Emulsion Demonstration Program

Under the Technology Advancement Program, the ports have recently completed participation in a three-year demonstration of emission reduction technologies aboard the container ship *APL Singapore.* The APL Singapore, which can carry the equivalent of 5,100 20-foot containers, travels monthly to the San Pedro Bay and Oakland Ports from ports in China, Japan, Korea and Taiwan.

Two emission control technologies were demonstrated - and water-emulsified bunker fuel using an innovative onboard water-in-fuel emulsifier, and the use of Slide Valves in lieu of mini sac fuel injectors for the vessel main engines.

Figure 2.1: Specifications of the APL Container Ship Singapore

Vessel Information	
Vessel Name	APL Singapore
Ship type	Post-Panamax Container ship
Flag	United States
Built	1995
Gross Tonnage	64,502
TEU Capacity	5,108 TEU
Length/Breadth/Depth	863' / 131' / 66'
Engine Information	
Engine	MAN B&W
Model	11K90MC-C
Type	2-Stroke Engine
Power	66,398 hp

Emission Control Technologies

Water-in-Fuel Emulsification (WiFE) – WiFE is the process of introducing water into the fuel prior to injection into the combustion cylinder. The fuel-water emulsion technology was 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 nitrogen oxide (NO_x) formation.

At the same time, when the water droplets vaporize, they produce "micro-explosions" inside the surrounding fuel droplets. The micro-explosions expose more of the fuel's surface area to the air, which increases combustion. The micro-explosions also release the water's two elements – hydrogen and oxygen. The additional oxygen inhibits the formation of polycyclic aromatic hydrocarbons (PAH), which when left unburned in the combustion process are a principal component of particulate matter (PM). The reduction is anticipated to be on the order of two to three times the water content of the water-in-fuel emulsion (i.e., a 20% water content would reduce PAH-generated particulate matter by 40% to 60%).

Even without adding water, the fuel homogenizer improves the consistency of combustion. Bunker fuel typically consists of an uneven mixture of heavy fuel oil, asphalt-related substances, and lighter marine diesel oil. When the mixture is burned, the combustion is unstable, which increases engine stress and results in higher emissions. The bunker fuel mixture created by the homogenizer burns more evenly, resulting in reduced emissions.

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 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).

Figure 2.2: Conventional "Mini-Sac" Injector (left) Compared to the Slide Valve (right)

Project Partners & Funding

Seven partners contributed a total of $1.3 million to fund the fuel emulsification and slide valve demonstration. They include:

- Port of Long Beach
- Port of Los Angeles
- US EPA
- CARB
- Bay Area Air Quality Management District
- Santa Barbara Air Pollution Control District
- Ventura County Air Pollution Control District
- San Luis Obispo Air Pollution Control District

The ports, the Bay Area Air Quality Management District, and the Ventura County, San Luis Obispo County, and Santa Barbara County Air Pollution Control Districts are contributing funds towards the emissions testing element of the project. The ports contributed $45,000 in TAP funding towards emissions testing.

Project 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 late 2009.

Ongoing Research

NO_x reduction is highly relevant in the coastal areas, and as a result of recently enacted rules marine diesel oil (MDO) is now required to be used when within 24 nautical miles of the California Coast.

This requirement presents additional challenges: 1) the feasibility of making a stable emulsion of MDO and water; and 2) the compatibility of slide valves with MDO as compared to bunker fuel. The ports are currently evaluating future demonstration projects to address these challenges.

2.1.2 Advanced Maritime Emissions Control System (AMECS) Demonstration and Emissions Testing

Advanced Cleanup Technologies, Inc. (ACTI) specializes 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.

The AMECS uses a bonnet lifted over the vessel exhaust stack using a specially designed crane and deployment arm. The bonnet is then lowered over the stack and then cinched to provide a soft attachment between the bonnet 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 Emissions Treatment System located on the dock adjacent to the vessel's berth.

Emission Control Technologies

The AMECS Emissions Treatment System (ETS) is shown in below. The ETS uses multiple exhaust gas treatment technologies to remove both gaseous and particulate pollution.

Figure 2.3: AMECS Emission Treatment System Installed Dockside

The major elements of the ETS include:

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. A **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.

Project Partners & Funding

Under TAP, the ports of Long Beach and Los Angeles, in partnership with ACTI, the SCAQMD, and the Metropolitan Stevedore Company, designed and implemented a demonstration and testing project to prove the viability and effectiveness of the AMECS as an alternative to cold ironing.

Metropolitan Stevedore Company served as the demonstration host site, providing dock space at Berth G214 for installation of the AMECS emissions capture bonnet, crane, and emissions treatment system. Metropolitan Stevedore also provided substantial in-kind contributions in the form of utility services, the accommodation of press events, as well as unrestricted access to their facilities during the entire demonstration period. Metropolitan Stevedore also assisted ACTI in coordinating the availability of vessels to participate in the demonstration project.

Emissions testing validation was performed by two independent testing firms; Engine Fuel & Emissions Engineering, Inc., and Professional Environmental Services, Inc. Funding for the emissions testing project component was provided by the TAP and the South Coast AQMD. The monetary contributions made to the project are shown below in Table 2.1.

Table 2.1: Funding Partners for the AMECS Demonstration & Testing Project

Project Partners	Contributions
▪ Port of Long Beach	$149,527
▪ Port of Los Angeles	$149,527
▪ South Coast Air Quality Management District	$55,000
▪ ACTI Co-funding Applied to Demonstration	$249,157
Total Demonstration & Emissions Testing Cost	**$603,211**

It is important to note that the development of the AMECS was funded solely by ACTI over a period of five years. To date, ACTI has invested over $8,000,000 in the development and demonstration of the AMECS technology.

Environmental Benefits

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. AMECS demonstrated the minimum efficiencies, shown below in Table 2.2, in removing pollutants from the auxiliary engines and boilers of ocean-going vessels while at berth:

Table 2.2: Pollution Removal Efficiency of the AMECS

Exhaust Pollutant	Pollutant Removal Efficiency
▪ Sulfur dioxide (SO_2)	> 99%
▪ Particulate matter (PM)	>95.5%
▪ Nitrogen oxides (NO_x)	99%
▪ Volatile organic compounds (VOC)	>97%

Project 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 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.

The acknowledgment by CARB of the effectiveness of the AMECS is significant in that it allows the ports to recognize AMECS as an effective air pollution reduction strategy for ships hotelling at berth. Recognition of the emission reduction potential of AMECS by CARB also allows the ports to quantify the emission reductions attributable to AMECS and apply these reductions to port emissions inventories.

2.2 Harbor Craft

2.2.1 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 is anticipated to offer performance comparable to a conventional Dolphin Class tugboat, but with an anticipated exhaust emissions and fuel consumption reduction up to 44 percent lower than a conventional vessel.

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 Robert Allan-designed Dolphin class tug currently operated by Foss at the ports of Long Beach and Los Angeles. Only 23.77m in length, the existing tugs are powered by Caterpillar main engines producing a total of 5,080 bhp and a bollard pull of 65 tons. Externally, the *Carolyn Dorothy* is quite similar in appearance to its conventionally powered forebears. The only noticeable evidence of its unique powerplant 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 2.4: Construction of the Carolyn Dorothy – the World's First Diesel Electric Hybrid Tugboat

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 for low speeds and light running, and a combination of battery and generators for medium power operation. 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 65 tons bollard pull will be available. Data collected from conventional Dolphin tugs revealed that only 7% of operational cycle utilized full power.

The Green Assist Tug has four distinct modes of operation:

1. Minimal Emissions (0-5% load)
    - When tug is at the pier or idle in harbor awaiting vessel
    - Main engines are off-line; power is provided by batteries and one motor generator set as needed to recharge the batteries
2. Eco-Cruise (6-19% load)
    - Continuous slow transit (6 knots)
    - Main engines are off-line. Motor generators provide power to the propulsion system and batteries provide "buffer" for transient load changes
3. Mid-Range (20-65% load)
    - Continuous fast transit and the majority of ship-assist work
    - One main engine, two motor generators and battery storage provide power up to 70% of full power.
4. Full Power (66-100%)
    - Full power ship-assist requirements
    - Both main engines, one or two motor generator sets and batteries provide full power.

Based on the operating profile of the conventional Dolphin tugs currently operating in the San Pedro Harbor, it is estimated that the hybrid will spend at least 75 percent of its operating hours in the two lowest emission modes of operation. In both low emission modes, the main engine will not operate; only batteries and generators will be 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 Diesel/Electric Tugboat project. These partners include POLB, POLA, CARB, and SCAQMD.

Table 2.3: 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 development of the Carolyn Dorothy was over $8 million. Remaining costs were covered by Foss.

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 2.4: Projected Emissions 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%

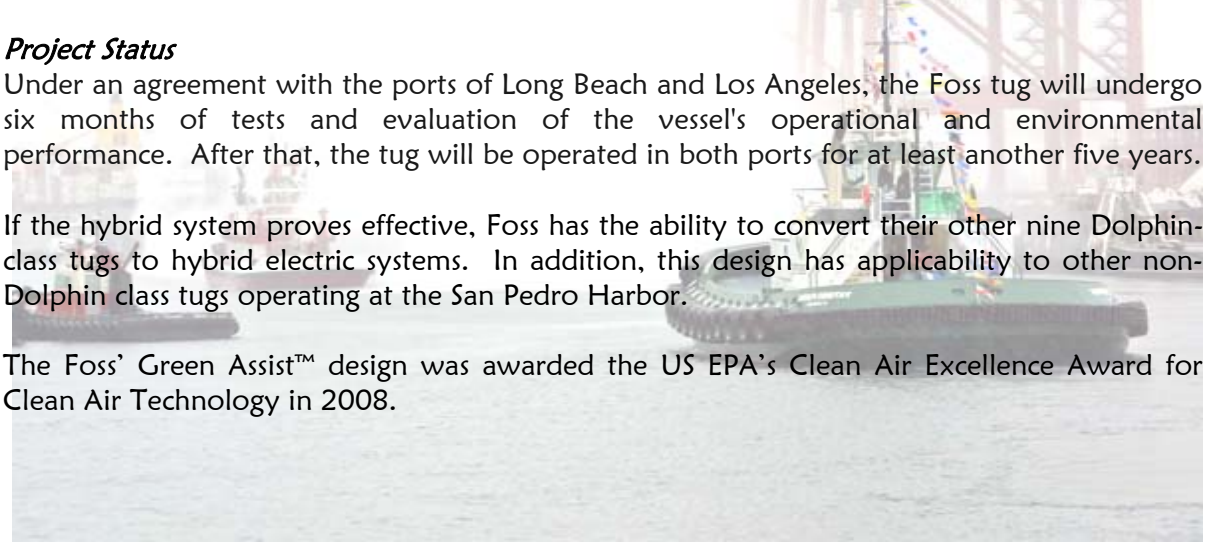
The projected emission levels of the *Carolyn Dorothy* exceed the US EPA's Tier 2 emissions standard for marine engines. Along with less pollution, the Green Assist ™ tug offers improved fuel economy and is anticipated to require less maintenance. It is also quieter than its Dolphin sister tugs when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

Project Status

Under an agreement with the ports of Long Beach and Los Angeles, the Foss tug will undergo six months of tests and evaluation of the vessel's operational and environmental performance. After that, the tug will be operated in both ports for at least another five years.

If the hybrid system proves effective, Foss has the ability to convert their other nine 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.

The Foss' Green Assist™ design was awarded the US EPA's Clean Air Excellence Award for Clean Air Technology in 2008.



2.2.2 OceanAir Environmental ECO Tug™ Tugboat

The ports continue to invest in the development and demonstration of technologies that reduce air pollution from harbor craft. Under TAP, the ports have partnered with OceanAir Environmental LLC and Harley Marine to demonstrate emission reduction technologies 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 all 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:

Length	Beam	Depth	Built	Total HP	Engines
96.0'	38.0'	18.0'	1996	4,300	EMD

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

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 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 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 is being funded under the Port of Los Angeles Air Quality Mitigation Incentive Program.

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 OceanAir Environmental. As noted above, the Port of Los Angeles, under their Port Air Quality Mitigation Improvement Program (PAQMIP), helped co-fund development of the main engine Tier 2 upgrade kit. While development of the Tier 2 upgrade 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 2.5 for a summary of partners and assocated contributions.

Table 2.5: 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 carbon dioxide (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 2.6:

Table 2.6: 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

This project is currently in the contract negotiation phase. In the meantime OceanAir Environmental is working toward certification of its Tier 2 upgrade kit for the EMD engines under POLA's Air Quality Mitigation Incentive Program. Once certified, the existing engines on the Eco Tug will be upgraded using the Tier 2 kit. Procurement of key conversion components, including the Cummins QSK center engine, is anticipated to begin in late 2009 and vessel conversion is expected to commence in early 2010.

2.2.3 Crowley Maritime Ultra-Low Emission LNG Harbor Tug

Crowley Maritime Corporation has designed a next generation of ultra-low emissions ship assist tug for service at the ports. The tug would substantially reduce both regulated air pollutants and greenhouse gas emissions compared to the conventional diesel fueled tugs operated in similar service. At the heart of this ultra-low emissions tug design are two Rolls Royce lean-burn spark ignited engines that would operate on liquefied natural gas (LNG).

Emission Control Technologies

Reduction in harbor craft emissions of nitrogen oxides, sulfur oxides, and toxic particulate matter are the principal objectives of the ports' CAAP. While the US EPA and CARB have established programs for incremental reductions in emissions from marine diesel engines, the viability of other options must be explored to ensure long term increases in marine shipping traffic are not associated with increased levels of air pollutant emissions.

Crowley Maritime Corp. is looking to LNG as the most effective way to reduce harbor tug emissions. Working with naval architects from Seattle-based Glosten Associates, they have designed a DNV-classed 90-foot tug with 72.5 tons of bollard pull that uses LNG as its primary fuel. Designed to meet the requirements of the Los Angeles and Long Beach ports, the tug will utilize a pair of medium-speed 2,600-kW (3,487 hp) Rolls-Royce lean-burn KVMS-12G4 natural gas engines mechanically coupled to Rolls-Royce US255 CP Z-drives.

Space and weight limitations create a unique design challenge for locating large LNG tanks. The LNG will be stored as a liquid in two 5,500-gallon double-walled tanks in the front of the hull. Because the tug will operate in a harbor where LNG fuel will be readily available, large onboard fuel capacity is not required. The vessel will bunker LNG fuel while at dock using a portable LNG refueling tanker truck.

Project Partners & Funding

The design of the Ultra-Low Emission LNG Harbor Tug was a collaborative effort drawing upon the expertise of Crowley's project partners. Key contributors to the design of the LNG tug include:

- *The Glosten Associates* – principal naval architect for vessel design;
- *Rolls Royce* - supplier of the ultra-low emission LNG marine engines and Z-drive propulsion system;
- *Hamworthy Gas Systems of Norway* – engineering consultancy for the vessel natural gas system and supplier of the vacuum insulated low-pressure LNG fuel tanks; and
- *Clean Energy* - supplier of liquefied natural gas once deployed at the ports.

Funding to allow the LNG tug to be constructed and demonstrated at the ports was also a collaborative effort between both ports and Crowley Maritime. The Port of Los Angeles is contributing a total of $1,000,000 through the TAP as well as their PAQMIP. The Port of Long Beach is contributing funds using their TAP resources. These contributions are matched with substantial co-funding from Crowley Maritime, as shown below in Table 2.7:

Table 2.7: Funding Partners in the Development of the Ultra-Low Emission LNG Tug

Project Partners	Contributions
▪ Port of Long Beach	$250,000
▪ Port of Los Angeles (TAP Funding)	$250,000
▪ Port of Los Angeles (Port Air Quality Mitigation Improvement Program)	$750,000
▪ Crowley Maritime Corporation Co-Funding	$13,602,929

Environmental Benefits

A comprehensive emission reduction analysis was conducted as part of vessel design and engineering. Compared to a comparable diesel tugboat equipped with EPA Tier 2 marine engines and ultra-low sulfur diesel, the Crowley LNG tug is projected to yield the substantial emission reductions shown below in Table 2.8.

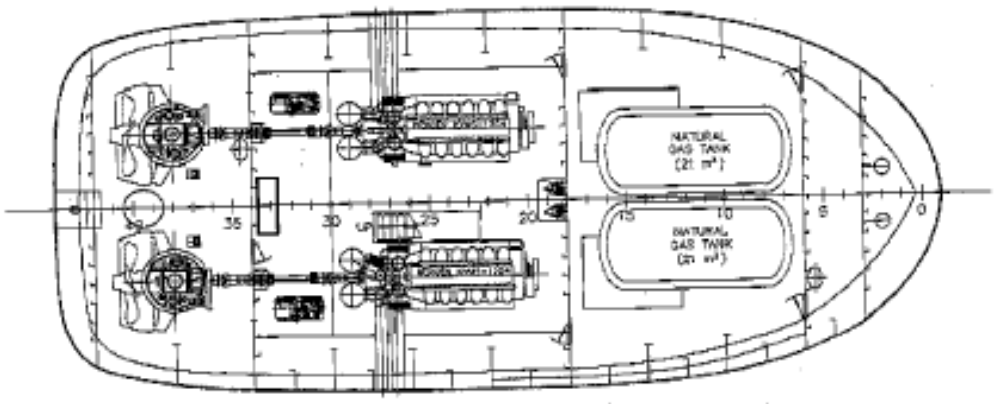
Table 2.8: Emission Reductions for the Ultra-Low Emissions Tug Compared to a Tier 2 Diesel Vessel

Emission Reductions	NO_x	PM	CO_2	SO_2
Crowley Ultra Low Tug	89%	90%	24%	94%

The use of natural gas allows the LNG tug to achieve significant reductions in carbon dioxide, the primary combustion greenhouse gas, in addition to the approximately 90 percent reduction in both ozone precursor and toxic air contaminant emissions.

Project Status

While Crowley and their engineering partners have completed preliminary vessel design, no TAP contract has yet been executed.



2.3 Cargo Handling Equipment

2.3.1 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.

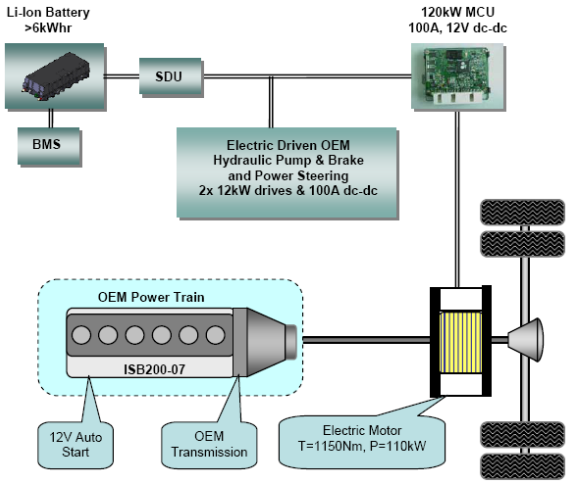
Yard hostlers (also known as yard tractors, terminal tractors, or utility tractor rigs) are common at port terminals, rail yards, and distribution centers. Their function is to move containers around the facility. At a port, containers are loaded off a ship onto a bobtail rig that is pulled by the yard 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 have partnered with CALSTART, a non-profit company that focuses on advancing cleaner technologies, to manage a project that will demonstrate 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 2.5: 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 2.5.

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 in-kind. 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 2.9: 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 2.10 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 2.10: 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

Delivery of fully integrated hybrid yard tractors to LBCT is expected 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.

2.3.2 Long Beach Container Terminal EcoCrane™

Rubber-tired gantry cranes (RTG) 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 POLB use electric power. A similar situation exists at POLA.

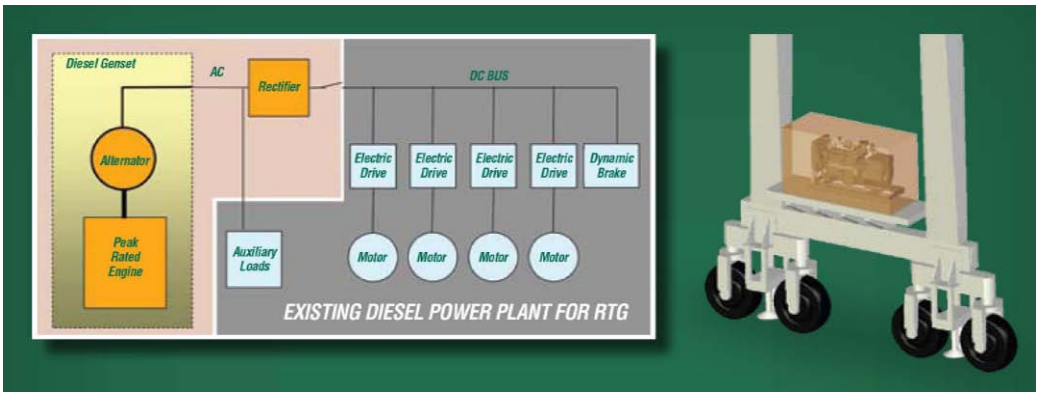
Long Beach Container Terminal, Inc. (LBCT), in partnership with Railpower Technologies, has proposed the demonstration of a retrofit technology that converts a conventional RTG to a "hybrid-electric" configuration. Similar to hybrid automobiles now commonplace on California roadways, the Railpower EcoCrane™ 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 2.6 and 2.7.

Figure 2.6: Conventional RTG Power System

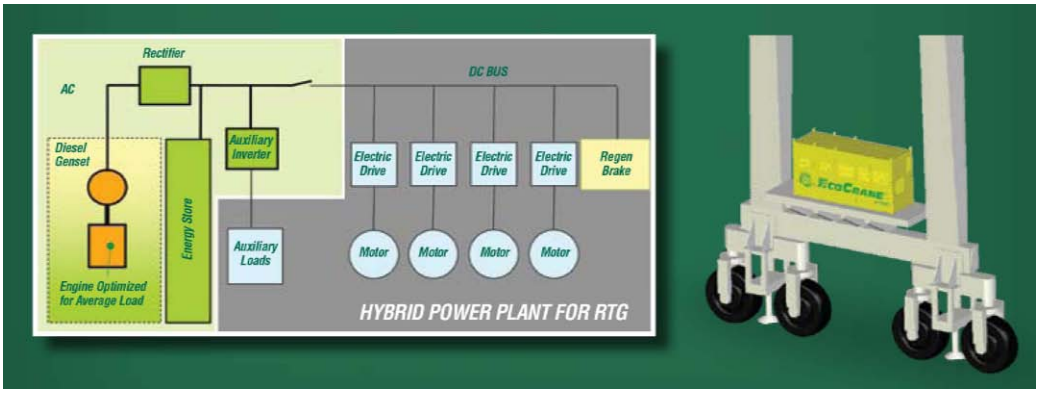


The Railpower Technologies' EcoCrane™ power management system is shown below. Key elements include:

- 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 2.7: 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 2.11: 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

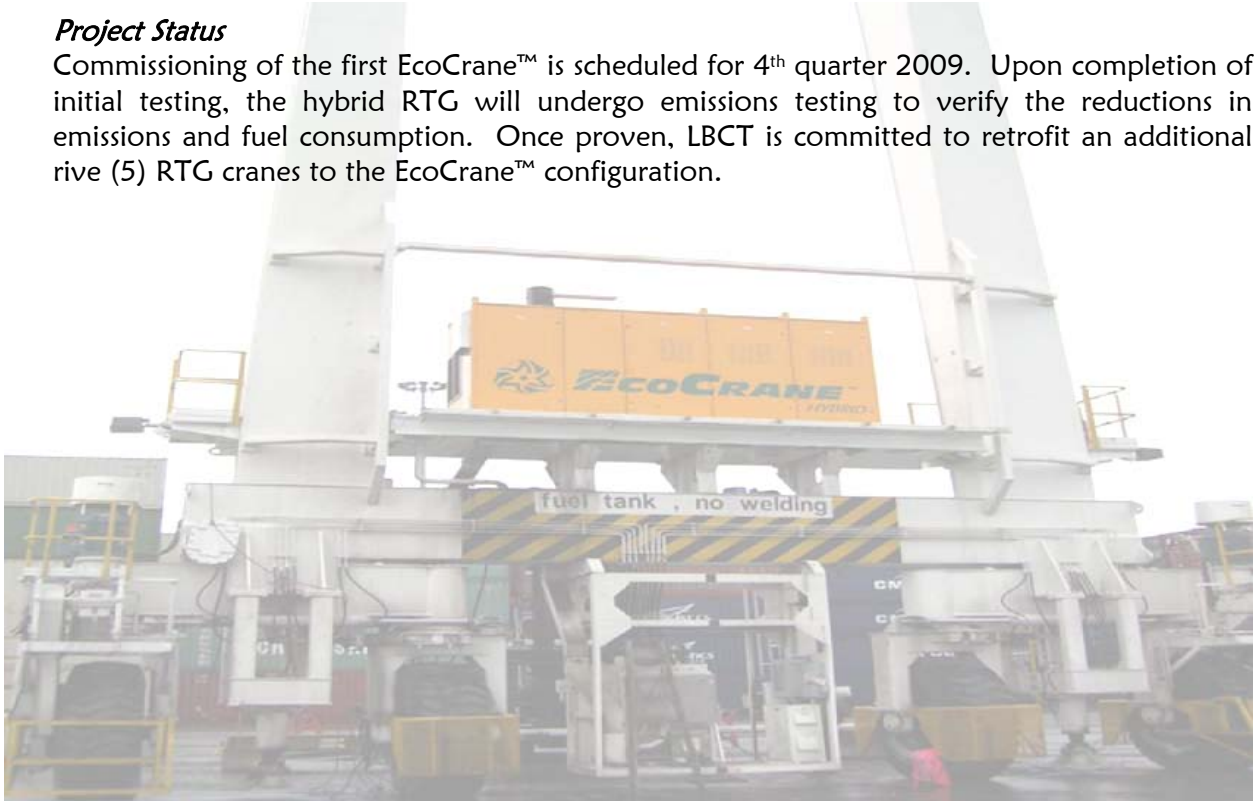
Data obtained by the client showed significant energy savings using the hybrid technology, as well as tremendous opportunity for reducing fuel consumption (60-85%) and thus, emissions.

Table 2.12: 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

Commissioning of the first EcoCrane™ is scheduled for 4th quarter 2009. Upon completion of initial testing, 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 rive (5) RTG cranes to the EcoCrane™ configuration.



2.3.3 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.

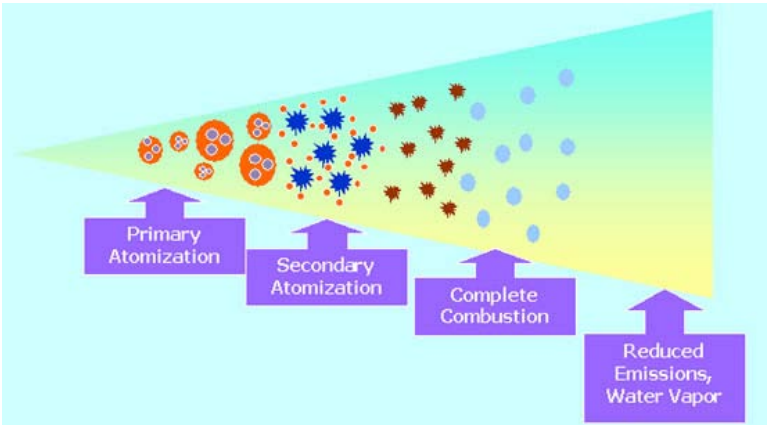
The technical community has known for many years that emulsified diesel fuel, made by blending water and additives into diesel fuel, will reduce emissions of particulate matter and NO_x as compared to conventional ultra-low sulfur diesel fuel. However, several issues, including incompatibility with certain 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.

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 of greater than 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 2.8: Combustion of Conventional Diesel Fuel

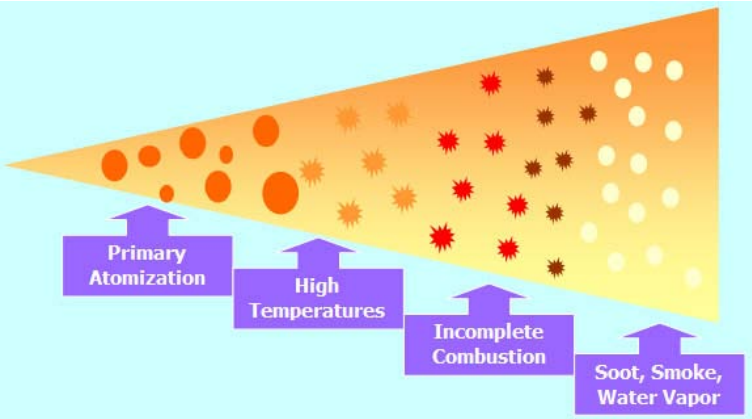
Emission Control Technology

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 2.8).



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 2.9.

Figure 2.9: 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 2.10 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 will be 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 will be 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 2.13: 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 2.14, 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.

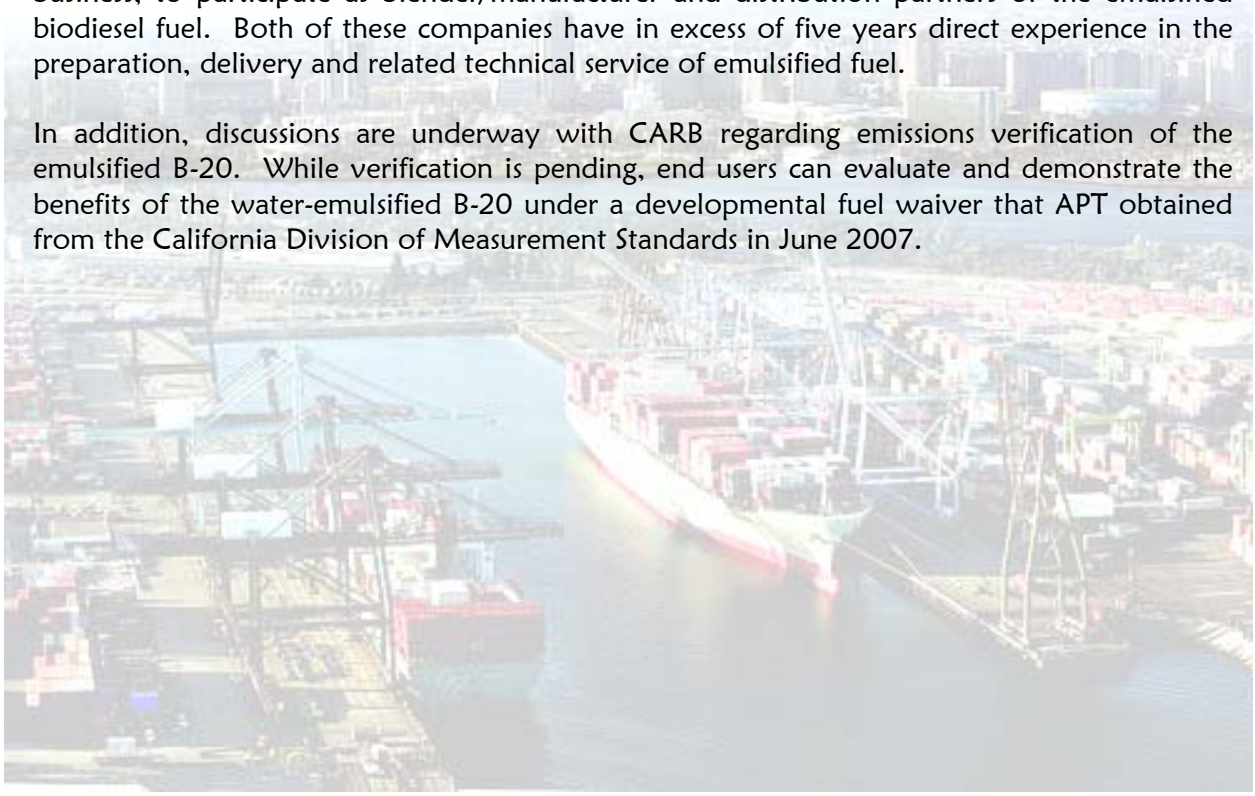
Table 2.14: Anticipated Emission Reduction Potential of Emulsified Biodiesel Fuel + DOC

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

Project Status

While awaiting contract execution, APT has established interest and potential commitment from two fuel distributors, both with 50-plus years of experience in the California fuels business, to participate as blender/manufacturer and distribution partners of the emulsified biodiesel fuel. Both of these companies have in excess of five years direct experience in the preparation, delivery and related technical service of emulsified fuel.

In addition, discussions are underway with CARB regarding 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.



2.4 Container Drayage Trucks

2.4.1 Balqon E-30 Electric Terminal Tractor

The Balqon E-30 Electric Terminal Tractor was built as a demonstration vehicle, which was co-funded by the Port of Los Angeles and South Coast AQMD, 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. As a result, the Los Angeles Board of Harbor Commissioners approved the purchase of 20 Balqon electric trucks as part of the Port's "Green Terminal" program.

Emission Control Technology

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 tractor are highlighted below:

Table 2.15: Balqon Electric Terminal Tractor Technical Specification

Vehicle Performance	Max speed 45 mph; unloaded grade 10%, loaded 5%; Max GCWR 125,000 lbs; Range unloaded 150 miles fully loaded range 90 miles. 6 hour full charge time, 1 hour fast charge cycle for 60% charge
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 vector duty electric motor connected to flux vector variable frequency controller; full continuous torque at zero speeds; 300% peak load rating; laminated square frame design allows for more hp in smaller frame; 1000:1 constant torque in vector mode; built in thermostats on each phase; connected directly to automatic transmission; low rotor inertia for faster acceleration; fully enclosed zero maintenance
Traction Controller	Proprietary flux vector motor controller 240 KW liquid cooled; integrated CAN BUS and self diagnostic system; solid state switching controls 600 amp rated; independent switching controls for accessory drives, auto shut-off during idling operation; USB or wireless data acquisition ports; built in energy management system and battery life calculator
Traction Battery	280 kW-hr lead acid battery pack, 336 Volt; automatic low voltage shutdown during operations; battery management system monitors each battery cell performance; on-board battery energy usage meter and life calculator
Battery Charger	100 KW multi-vehicle fast charger; 4 charging ports standard; priority smart charge algorithm based on vehicle state of charge; 60 KW max output at each charge port; 3.5 hour charge time from 80% depth of discharge; 480 VAC, 3 phase input voltage

Project Partners & Funding

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.

Table 2.16: Funding Contribution from Each Project Partner

Project Partners	Contributions
▪ Port of Los Angeles	$263,500
▪ South Coast Air Quality Management District	$263,500

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.

Environmental 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 ports, POLA estimated the average pollution discharge generated by the estimated 1.2 million truck trips that occurred in 2006 between the ports and a local near-dock railyard (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 PM, 427.7 tons per year of localized NOx emissions, 168.5 tons per year of carbon monoxide (CO), and 34,987.6 tons per year of CO2.

Table 2.17: Potential Emission Benefits of Electric Truck Proliferation

	PM	CO	NO_x	CO_2
Net Reduction in Port Drayage Truck Emissions if all port Trucks were Electric (Tons Reduced per Year)	21.8	168.5	427.7	34,987.6

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.

Project 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, 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.

The green terminal program will also include the production of five on-road electric trucks. Balqon will work with POLA and the Department of Transportation to obtain the appropriate certification for on-road use. In total, the port is investing more than $5.6 million to demonstrate the viability of electric drayage trucks.

2.4.2 Westport GX LNG Engine Development

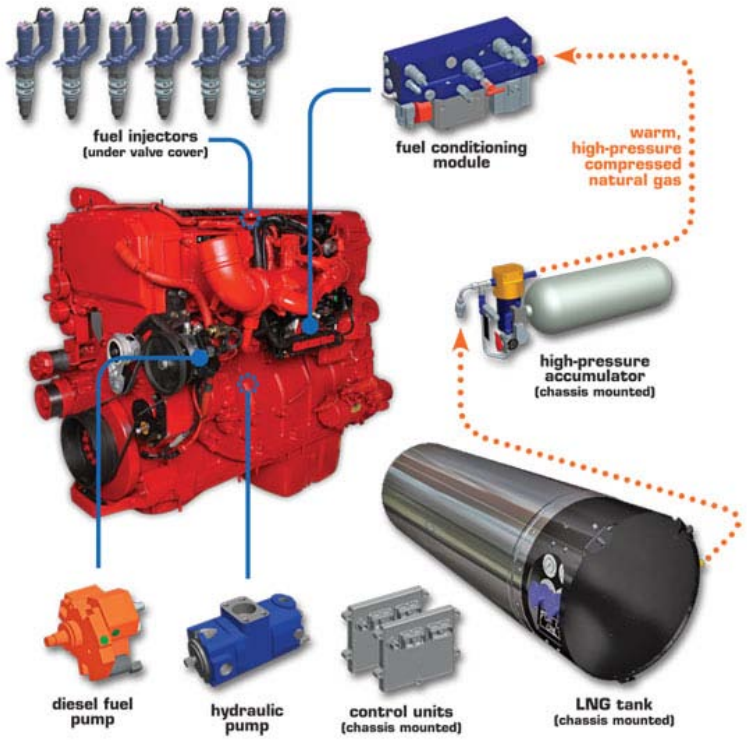
Westport Innovations (Westport), developer of the High Pressure/Direct Injection (HPDI) liquefied natural gas (LNG) fuel system technology, is developing an LNG 15-liter heavy-duty truck engine that will meet the 2010 on-road NO_x emission standard of 0.2 grams per brake horsepower-hour (g/bhp-hr).

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 2.10: 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 2.11: 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 South Coast AQMD is contributing $1.25 million, and the ports of Long Beach and Los Angeles are each contributing $250,000 in TAP funding.

Table 2.18: "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 2.12: Westport GX Engine Undergoing Emissions Certification Testing

Project Status

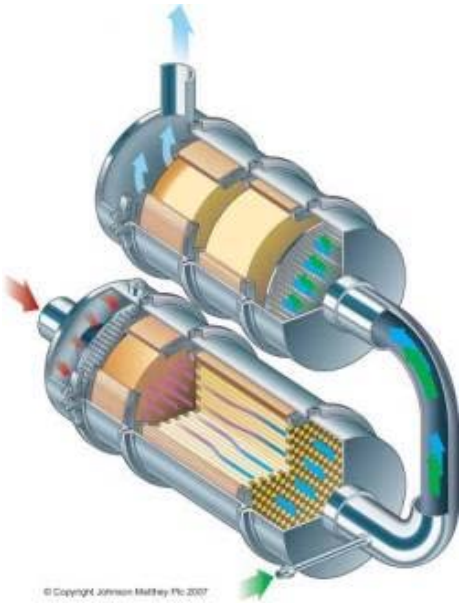
The Westport GX demonstrated continued progress toward its goal by reducing its NO_x certification level to 0.74 g/bhp-hr for model year 2008. With the addition of exhaust after-treatment and continued fuel system refinement, Westport is confident that the GX engine will achieve certification at or below 0.2 g/bhp-hr NO_x in mid-2009.

2.4.3 Johnson Matthey SCCRT® Diesel Emission Control System Demonstration

The ports of Long Beach and Los Angeles have each adopted a Clean Trucks Program to reduce emissions from heavy-duty trucks used in container drayage. Multiple emission reduction strategies are currently being demonstrated, including the use of alternative fuels such as compressed and liquefied natural gas. While alterative fuels are a viable strategy when replacing a vehicle, typically it is not cost-effective to retrofit an existing diesel truck to operate on fuels such as natural gas.

Emission Control Technology

Johnson Matthey, Inc., a leading manufacturer of catalytic emission control technologies, proposed a demonstration of their Selective Catalytic Regenerating Technology (SCRT®). This technology has the potential to allow 1998 model year trucks to meet 2007 EPA emission standards for particulate matter and NO_x, and can be cost-effectively retrofitted to existing port drayage trucks.



Selective catalytic reduction (SCR) systems and diesel particulate filter (DPF) technologies are currently available and capable of significantly reducing NO_x and PM emissions, respectively. Johnson Matthey proposes to demonstrate both emission reduction technologies in an optimized design configured for retrofit into a class 8 diesel drayage tractor.

In this integrated design, Johnson Matthey's proprietary SCRT® particulate filter system performs two functions: it provides high efficiency reduction of carbon monoxide, hydrocarbon, and particulate matter emissions, while enhancing the nitrogen dioxide (NO_2) content of the gases that pass into the SCR system. A controlled amount of urea is injected into the exhaust before it enters the SCR catalyst modules - urea provides the necessary chemical conditions for the SCR catalyst to reduce NO_x. The Johnson Matthey-developed control system precisely delivers the urea without generating ammonia emissions, referred to as "ammonia slip". By optimizing the gas mix supplied to the SCR catalysts and the amount and rate of urea injection, significant NO_x emission reductions are achieved.

Project Partners & Funding

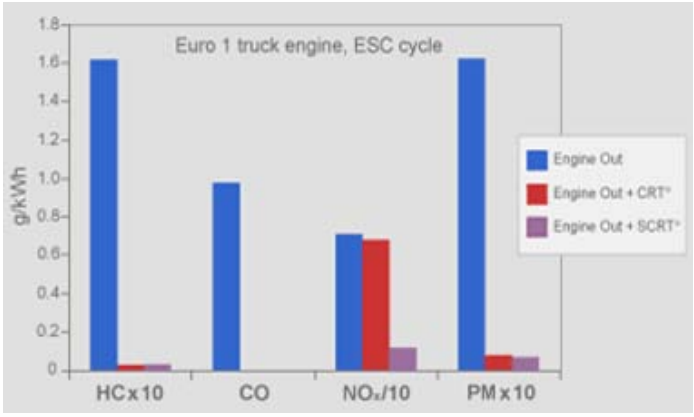
Under the TAP, Johnson Matthey will retrofit up to ten existing class 8 drayage trucks with their SCRT® technology. The project goals are two-fold: firstly, to demonstrate the applicability of the SCRT® system to the port fleet, and secondly, to achieve CARB verification of the SCRT® system for a broader range of diesel engine manufacturers, engine models, and model years.

The project partners include the ports of Los Angeles and Long Beach, with additional in-kind contributions provided by Johnston Matthey (See Table 2.19). The ports are also providing assistance to Johnson Matthey relative to identification of potential demonstration fleets.

Table 2.19: SCCRT® Demonstration Project Funding Partners

Project Partners	Contributions
▪ Port of Los Angeles	$130,616
▪ Port of Long Beach	$130,616
▪ Johnson Matthey Co-Funding Applied to Project	$261,232

Figure 2.13: SCRT® system



Environmental Benefits

Figure 2.13 at right shows the emissions reduction achieved by a SCRT® system fitted to a heavy-duty diesel truck engine over a 13-mode test cycle. The results are compared to the emission levels of and engine equipped with a diesel particulate filter only as well as the engine with no exhaust after-treatment.

Based on these and similar test results compiled by Johnson Matthey, the SCRT® has been placed on the US EPA's National Clean Diesel Campaign's Emerging Technologies List and is approved for use in Emerging Technology funding applications. Table 2.20, shows the projected emission reduction levels as currently assigned by the US EPA:

Table 2.20: Projected Emission Reduction Levels for Johnson Matthey SCCRT®

	PM	HC	CO	NO_x
Reduction (%)	90%	95%	85%	65%

Project Status

The ports continue to work closely with Johnson Matthey to identify candidate class 8 drayage trucks to retrofit with the SCCRT® system. The desire is 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.

2.4.4 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 Trucks 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 have embarked upon a collaborative effort with Southern California Gas Company (SoCalGas) and their partners, California Cartage Company 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 will be 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.

Approximately two-thirds of the 15 million container units coming into the ports annually are moved by truck within a 25-mile radius of the docks. To demonstrate the viability of the ISL G CNG engine in port drayage operations, Cal Cartage, the largest trucking company operating at the ports, will operate the four CNG-powered trucks in regular revenue drayage operations for one year. During this period, the trucks will undergo continuous monitoring to assess performance capabilities, operability, driver impressions, and vehicle reliability. From a programmatic perspective, the cost of operating the four CNG drayage trucks will be documented and compared to operating costs for other fuels, including both conventional diesel and alternative fuel such as LNG and battery-electric.

Project Partners & Funding

The CNG drayage truck demonstration overall cost is 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 South Coast AQMD is co-funding 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 will design, construct, and operate the CNG refueling station on behalf of the project partners.

Table 2.21: 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.

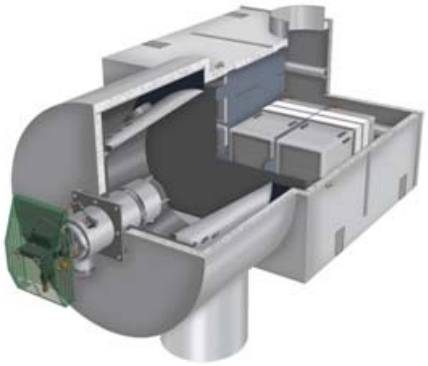
Project Status

Since being placed into drayage service in December 2008, the CNG drayage trucks have performed exceedingly well in day-to-day drayage operations, with no CNG fuel-related technical issues experienced to date. Following successful completion of the initial one year demonstration, SoCalGas intends to continue the demonstration using a fuel of blended CNG and hydrogen gas. This CNG/hydrogen fuel blend is widely regarded as an important gateway to a hydrogen future for the transportation sector; the fuel has been shown to reduce nitrogen-oxides emissions from the cleanest natural gas engines by an additional 30 to 50 percent.

2.5 Locomotives

2.5.1 Pacific Harbor Line (PHL) Locomotive Diesel Particulate Filter

This project will 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 will be installed on a Pacific Harbor Line switch locomotive. Pacific Harbor Line is the exclusive provider of rail switching services at the ports of Long Beach and Los Angeles.



For this TAP project, a Tier 2-compliant PHL switch locomotive will be retrofitted with a MobiClean™ Active Regeneration Diesel Particulate Filter. This project is the first demonstration of a DPF in the US on a switch locomotive with a four cycle engine. This technology application is expected to reduce PM by approximately 90 percent. Citizens living near the Ports of Los Angeles and Long Beach, as well as along the Alameda Corridor will benefit from these emission reductions. Should the DPF be demonstrated as a viable technology, this project could be replicated both regionally and nationally, resulting in significant emission reductions nationwide. Pacific Harbor Line would be the first company in the United States to demonstrate a diesel particulate filter on a full-sized switch locomotive equipped with a four-cycle engine.

Project Funding

The principal funding partners for the PHL DPF demonstration project are the South Coast AQMD, Miratech Corporation, Pacific Harbor Line, and the US EPA, through the West Coast Collaborative,

Table 2.22: PHL Locomotive DPF Demonstration Project Funding Partners

Project Partners	Contributions
▪ Port of Los Angeles	$33,035
▪ Port of Long Beach	$33,035
▪ South Coast Air Quality Management District	$307,125
▪ US EPA West Coast Collaborative	$100,000
▪ Miratech Corporation Co-Funding (In-Kind)	$60,875

The total project cost is $534,070. The South Coast AQMD is contributing $307,125. Miratech Corporation is contributing $60,875 in in-kind services for engineering, project management, installation, and commissioning of the project. Pacific Harbor Line's in-kind contribution includes the use of the switch locomotive for demonstration. Finally, the Port of Los Angeles and Port of Long Beach each contributed $33,035 in TAP funding to the project.

Environmental Benefits

The MobiClean™ Active Regeneration DPF system is expected to reduce switch locomotive PM emissions by 90%, or 0.14 tons per year per locomotive. This technology, once proven successful, can be retrofitted on 15 PHL switch locomotives operating at the ports as well as other locomotives that operate within the South Coast Air Basin.

Project Status

Installation of the DPF has been placed on temporary hold pending the outcome of additional technical and programmatic evaluations.

3.0 2008 Project Expenditures & Budget Status

The TAP is funded 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 South Coast AQMD, CARB, US EPA, and California Energy Commission (CEC). Project co-funding is also contributed in the majority of cases by the project proponent as either cash or in-kind contribution.

The annual minimum funding levels for the TAP are shown in Table 3.1, below. While the first five years of the TAP are shown, it is important to note that the TAP program has a term that mirrors the CAAP. Similar to the CAAP, TAP has a five year technology advancement perspective; however, it is fully anticipated that TAP will adopt a moving five-year technology horizon.

Contributions from participating agencies other than the ports are typically made on a project-by-project basis; thus, the total amount of funding available for fiscal years 2008-'09 and beyond is likely to be greater than the minimum values shown in Table 3.1.

Table 3.1: Technology Advancement Program Funding by Fiscal Year & Participating Agency

Fiscal Year	2006/07	2007/08	2008/09	2009/10	2010/11	TOTAL
POLA	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$7,500,000
POLB	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$1,500,000	$7,500,000
AQMD	$271,500	$1,557,125	$471,250	TBD	TBD	≥ $2,299,875
CARB	$783,628	$0	$130,130	TBD	TBD	≥ $913,758
EPA	$375,000	$100,000	$0	TBD	TBD	≥ $475,000
CEC	$0	$500,000	$0	TBD	TBD	≥ $500,000
Other	$889,920*					≥ $889,920
Totals	**$5,320,048**	**$5,157,125**	**$3,601,380**	**$3,000,000**	**$3,000,000**	**$20,096,553**

* Additional POLA funding from residual funds from the "NO_x and PM Emission Reduction Credit Program"

3.1 Financial Report

Table 3.2, below, provides an accounting by fiscal year for the TAP. As shown, the ports have contributed a total of $9.0M, matched with contributions from other participating agencies totaling $4,193,633, yielding a total investment in the TAP in excess of $13.19M as of December 31, 2008.

Table 3.2: Technology Advancement Program Balance Sheet

	POLB	POLA	Other Agencies
FY 2006-'07 Appropriations	$1,500,000	$1,500,000	$1,430,128
FY 2006-'07 Encumbrances	$1,217,035	$630,535	$1,430,128
FY 2007-'08 Appropriations	$1,500,000	$1,500,000	$2,157,125
FY2007-'08 Encumbrances	$250,000	$250,000	$2,157,125
FY 2008-'09 Appropriations	$1,500,000	$1,500,000	$606,380
FY2008-'09 Encumbrances	$1,210,720	$1,210,721	$606,380

Of this total investment, $8,962,644 has been encumbered for TAP projects. The port encumbrance is $4,769,011. The port TAP balance moving forward to fiscal year 2009-2010 is $4,230,989. Please note that this value is the *minimum balance*, as future TAP projects may also include funding contributions by other participating agencies as well as the project proponents.

3.2 Summary of Encumbrances by Project

TAP projects approved and encumbered from program inception through December 31, 2008 are shown below in Table 3.3.

Table 3.3: TAP Projects Funded from Program Inception through December 31, 2008

PROJECT CATEGORY	Technology Advancement Program Funding Contributions						
	POLB	POLA	AQMD	CARB	US EPA	CEC	Total TAP & 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[2]					$1,389,920
OceanAir Environmental Eco-Tug	$350,000	$350,000					$700,000
Crowley LNG Tug	$250,000	$250,000					$500,000
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[3]	$300,000[3]			$300,000		$900,000
LBCT Eco-Crane	$175,000	$175,000		$130,130			$480,130
EES Emulsified Biodiesel	$44,000	$44,000					$88,000
Container Drayage Trucks							
Balqon Electric Class 8 Tractor		$263,500	$263,500				$527,000
Westport ISX LNG Engine	$250,000	$250,000	$1,250,000			$500,000	$2,250,000
Johnson Matthey SCRT	$130,616	$130,616					$261,232
SoCalGas CNG Drayage Truck	$111,577	$111,577	$421,250				$644,404
Locomotives							
PHL Locomotive DPF	$33,035	$33,035	$307,125		$100,000		$473,195
Total Project Investments to Date	**$2,677,755**	**$2,981,175**	**$2,304,875**	**$913,758**	**$475,000**	**$500,000**	**$9,852,563**

[2] POLA funding from residual funds from the "NO_x and PM Emission Reduction Credit Program"; not included in TAP budget accounting

[3] Non-TAP Funding Source – not included in TAP budget accounting

4.0 Funding Priorities for 2009

The TAP had made significant progress in 2008 in achieving goals set forth in 2007. Relative to 2008 Programmatic Priorities addressed in the 2007 TAP Annual Report, the ports have accomplished the following noteworthy achievements:

2008 Programmatic Priority: Streamline TAP implementation and identify strategies to improve the efficiency of reviewing candidate technologies and processing proposals. In 2008, the port initiated the following:

- Development of a comprehensive TAP Database. The software requirements and specifications were completed and software development initiated. The new TAP Database is anticipated to completed in the 4th quarter of 2009;
- Development of an Online Proposal Submittal portal to the TAP Database. This feature will streamline the proposal submittal process for both port-solicited and unsolicited proposals. This "paperless management" tool will also allow port staff to more efficiently review and disseminate proposals. The online proposal submittal feature is integrated within the comprehensive TAP Database, allowing for seamless data storage.

2008 Programmatic Priority: 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. In 2008, the ports established relationships with technology stakeholders to further the goals of the TAP, including:

- Partnering with the Southern California Gas Company and South Coast AQMD to demonstrate the viability and cost-effectiveness of using compressed natural gas in a heavy-duty drayage truck application;
- Coordination with Calstart's Hybrid Truck User's Forum (HTUF). This ensures port staff has access to the latest information regarding the state of the art of low- and zero-emission heavy-duty trucks.

With respect to Technology Priorities established for 2008, the ports met these challenges as well, including:

2008 Technical Priority: *Identify and Demonstrate technologies that target emission reductions from on-road trucks.* In 2008, the TAP:

- Solicited qualifications statements from manufacturers of heavy-duty hybrid electric and hydraulic hybrid Class 8 trucks;
- Partnered with SoCalGas to demonstrate low-emission, heavy-duty drayage trucks that run on clean burning compressed natural gas;
- Partnered with Johnson Matthey, a leading manufacturer of diesel emission control systems, to verify a Level 3 particulate matter filter plus selective catalytic NOx reduction device for application to existing diesel drayage trucks operating at the ports.

2008 Technical Priority: Identify and demonstrate technologies that target emission reductions from ocean going vessels. In 2008, the TAP:

- Partnered with Advanced Cleanup Technologies, Inc. to demonstrate and quantify the effectiveness of the Advanced Maritime Emissions Control System (AMECS). This system demonstrated emission reduction efficiencies of greater than 95% for particulate matter and 99% for NO_x.

The ports continually seek to support the identification, 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 2009 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.

4.1 Summary of Technical & Programmatic Priorities for 2009

Not known to rest on their laurels, port staff has set aggressive goals for the TAP in 2009. While the TAP will continue to seek emission reductions from all source categories identified in the CAAP, the programmatic and technical TAP priorities for 2009 are as follows:

2009 Programmatic Priorities:

- Launch the comprehensive TAP Database, which will allow the seamless sharing of data between both ports and, as appropriate, project implementers. This is anticipated to be completed by the 4th quarter of 2009;
- Launch the Online Proposal Submittal feature of the TAP Database. 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.

2009 Technical Priorities:

- Identify and demonstrate technologies that target emission reductions from on-road and off-road trucks, with a focus on zero or near-zero emission technologies;
- Identify and demonstrate technologies that target emission reductions from ocean going vessels, including the feasibility and cost-effectiveness of using onboard systems such as exhaust scrubbers;
- Identify and demonstrate technologies that target emission reductions from locomotives.

4.2 Identified Technology Pursuits

Zero and Near-Zero Emission On and Off Road Trucks

The ports handle approximately two-thirds of the total container traffic coming into U.S. west coast ports. While the ports have increased their reliance on "on-dock rail" in recent years, i.e., loading containers directly onto long-haul trains on port property, approximately 75-80% of port throughput is still "drayed" – loaded onto trucks that carry containers via local roads and highways to various destinations – typically warehouses, distribution centers, or intermodal rail yards throughout the southern California region. A small number of containers are loaded directly onto long-haul trucks that are bound for destinations outside the region, but this currently represents only about 1% of total port throughput. Therefore, the vast majority of containers coming into the Los Angeles and Long Beach ports require some form of short-haul trucking to get to their final destination.

To mitigate emissions from drayage trucks, both ports adopted tariffs that gradually limit access to all but the cleanest vehicles. The tariff is based on a progressive ban of the oldest trucks. As of October 1, 2008, all pre-1989 trucks were banned from port drayage service. The next truck tariff milestones will be implemented as follows:

- January 1, 2010: 1989-1993 trucks will be banned along with non-retrofitted 1994-2003 trucks;
- January 1, 2012: All trucks that do not meet the 2007 federal standard will be banned.

These increasingly stringent standards will significantly reduce current levels of drayage truck pollution, especially emissions of nitrogen oxides, which are ozone and $PM_{2.5}$ precursor emissions, as well as diesel particulate matter, which is a toxic air contaminant.

The TAP plays an important role in the ports' overall drayage truck pollution reduction strategy. Given the projected increase in container traffic beyond 2012, the identification, demonstration, and certification/verification of technologies that lower truck emissions *below* 2007 standards are essential to maintain the emission levels achieved through the port tariffs. In addition, new technologies are sought to reduce greenhouse gas emissions from drayage operation; this requires lower carbon content fuels or improvements in truck engine and drive train efficiencies.

The Port of Long Beach also intends to pursue ultra-low emission advanced technology drayage trucks, but will conduct any demonstration project under the auspices of the TAP, as opposed to the POLB Clean Trucks Program.

In addition, TAP will continue to accept unsolicited proposals related to on-and off-road truck emission reductions, as well as unsolicited proposals pertaining to all CAAP source categories and focus areas.

Ocean Going Vessel Emission Reductions

The ports have taken unprecedented actions to reduce the environmental impact of ocean going vessels on the neighboring communities. Efforts to date include:

- Implementing a voluntary vessel speed reduction (VSR) measure
- Expanding the availability of container terminal shore power and vessel cold-ironing under the Port of Los Angeles' alternative maritime power (AMP) program;
- Demonstrating innovative and highly effective alternative emission control technologies such as the AMECS "at-berth" OGV auxiliary engine emission control system (SPBP-OGV2).
- The demonstration and testing of on-demand water-in-fuel emulsion technology and slide valves retrofit on the APL Singapore, one of the first projects funded under TAP.

For 2009, TAP will initiate SPBP-OGV5: Development of "Clean Ocean Going Vessel" guidelines with respect to air quality for both existing vessels and new builds.

APPENDIX A
TECHNOLOGY ADVANCEMENT PROGRAM ADVISORY COMMITTEE MEMBERSHIP

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Appendix B

SUMMARY REPORTS FOR COMPLETED PROJECTS

Four Technology Advancement Program projects have been completed to date:

1. VYCON REGEN® System for Rubber-Tired Gantry Cranes Testing & Verification
2. Liquefied Natural Gas Yard Tractor Demonstration
3. Advanced Maritime Emission Control System (AMECS) Demonstration & Testing

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

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

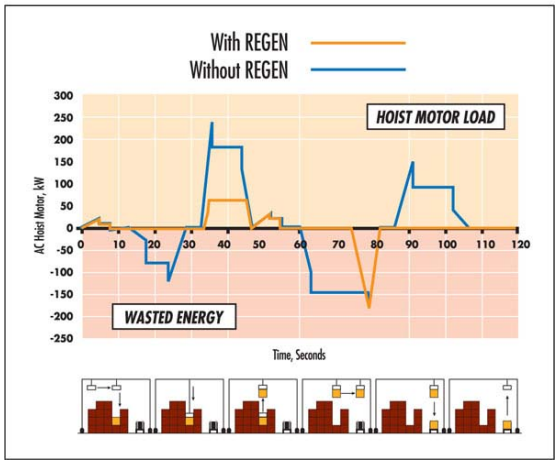
Background

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.

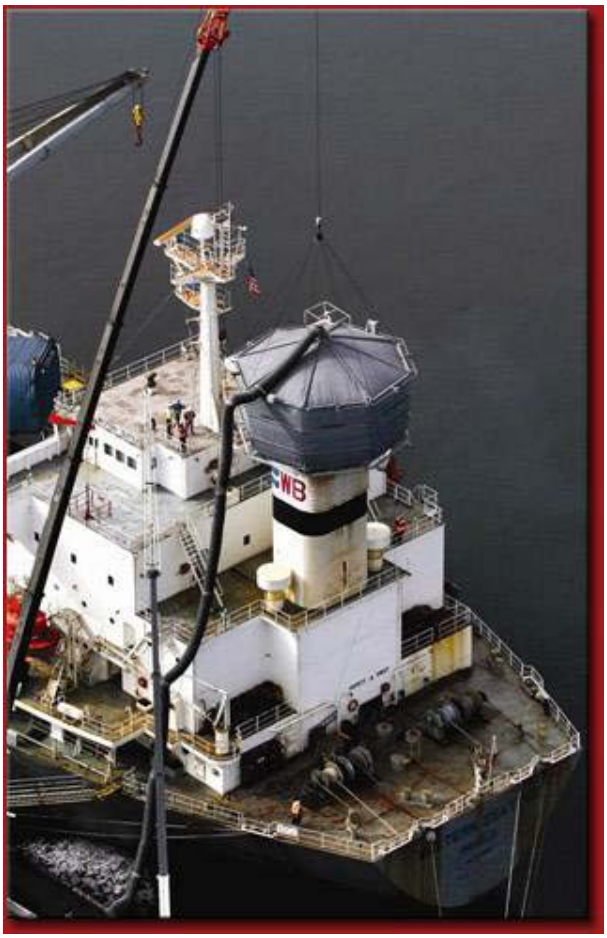
Commercialization and Applications

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.

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.