

San Pedro Bay Ports **Clean Air Action Plan**  
**Technology Advancement Program**



*Moving towards zero emissions*

## Table of Contents

<b>Executive Summary</b> .....	1
<b>1.0 Introduction</b> .....	5
1.1 Background & Program Objectives.....	5
1.2 Implementation Process.....	7
1.3 Advisory Committee.....	8
<b>2.0 Key Projects in 2007</b> .....	10
2.1 Ocean Going Vessels.....	11
2.1.1 APL Singapore Slide Valve & Water-In-Fuel Emulsion Demonstration.....	11
2.2 Harbor Craft.....	13
2.2.1 Foss Maritime Diesel Electric Hybrid Tugboat.....	13
2.3 Cargo Handling Equipment.....	15
2.3.1 LNG Yard Tractor Demonstration & Commercialization Project...	15
2.3.2 Hybrid Yard Tractor.....	18
2.3.3 VYCON REGEN Rubber-Tired Gantry Flywheel System.....	19
2.4 Container Drayage Trucks.....	21
2.4.1 Balqon Electric Class 8 Tractor.....	21
2.4.2 Westport ISX LNG Engine Development.....	22
2.5 Locomotives	
2.5.1 Pacific Harbor Line Locomotive Diesel Particulate Filter.....	24
<b>3.0 Project Expenditures &amp; Budget Status</b> .....	25
3.1 Financial Report.....	25
3.2 Summary of Expenditures by Project.....	26

## Table of Contents - continued

<b>4.0</b>	<b>Funding Priorities for 2008.....</b>	<b>27</b>
4.1	Summary of Technical & Programmatic Priorities for 2008.....	27
4.2	Identified Technology Pursuits.....	27

<b>Appendices.....</b>	<b>29</b>
------------------------	-----------

Appendix A:	Technology Advancement Program Advisory Committee Membership & Port Staff Contacts.....	30
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Appendix B:	Summary Reports for Completed Projects.....	31
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### Figures

Figure 2.1-1:	Specifications of the APL Container Ship Singapore.....	11
Figure 2.3-1:	PM Emissions Attributable to CHE.....	15
Figure 2.3-2:	NO <sub>x</sub> Emissions Attributable to CHE.....	15
Figure 2.3-3:	Typical Load Profile for RTG Crane with and without REGEN.....	19

### Tables

Table 1:	TAP Funding by Fiscal Year & Participating Agency.....	3
Table 2:	Technology Advancement Program Balance Sheet .....	3
Table 3-1:	TAP Funding by Fiscal Year & Participating Agency.....	25
Table 3-2:	Technology Advancement Program Balance Sheet .....	25
Table 3-3:	Summary of TAP Investments by Project.....	26

## Acronyms & Abbreviations

AC	Advisory Committee
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
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
NO <sub>x</sub>	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 <sub>10</sub>	Particulate matter less than 10 micrometers in diameter
PM <sub>2.5</sub>	Particulate matter less than 2.5 micrometers in diameter
RFI	Request for Information
RFP	Request for Proposals
RL	Railroad Locomotives
SCR	Selective Catalytic Reduction
SO <sub>x</sub>	Sulfur Oxides
SPBP	San Pedro Bay Ports
TAC	Toxic Air Contaminant
TAP	SPBP CAAP Technology Advancement Program
VSR	Vessel Speed Reduction

## EXECUTIVE SUMMARY

### 2007 Annual Report

The San Pedro Bay Ports (SPBP) comprise a huge regional and national economic engine. The Los Angeles Customs District accounts for approximately \$300 billion in annual trade. More than 40% of all containerized trade in the nation flows through the San Pedro Bay Ports. Economic forecasts suggest that the demand for containerized cargo moving through the San Pedro Bay region will more than double by the year 2020.

The economic benefits of the Ports are felt throughout the nation; however, the environmental impacts of trade are more locally concentrated. The Ports recognize that their ability to accommodate the projected growth in trade will depend upon their ability to address adverse environmental impacts and, in particular, the air quality impacts that result from such trade. The Clean Air Action Plan (CAAP) is designed to develop mitigation measures and incentive programs necessary to reduce air emissions and health risks while allowing port development to continue. The Clean Air Action Plan (CAAP) identifies and describes the measures the Ports of Los Angeles and Long Beach will take toward reducing air pollutant emissions related to port operations. The five-year CAAP highlights the objectives, emission reduction goals, and budgetary needs for fiscal years 2006/2007 through 2010/2011.

As an element of the CAAP, the Ports' conceived, developed, and are now implementing the Technology Advancement Program (TAP). 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"*.

The Technology Advancement Program 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. This document is the first Technology Advancement Program Annual Report under the San Pedro Bay Ports Clean Air Action Plan.



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

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

This first 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.

A TAP Advisory Committee has been established consisting of agency partners that include the Port of Long Beach, Port of Los Angeles, South Coast Air Quality Management District, the California Air Resources Board, and US Environmental Protection Agency Region 9. The Ports established the Advisory Committee by invitation during the first quarter of 2007.

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 Advisory Committee 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.

As the first complete year of Technology Advancement Program implementation, 2007 proved to be a very productive year for the San Pedro Bay Ports, with technology demonstration projects initiated in prior years completed, new projects initiated, and technologies identified for pursuit in 2008.

This first Technology Advancement Program Annual Report includes a summary of the eight (8) projects implemented under the TAP to date. These include:

<b>Source Category</b>	<b>TAP Project</b>
▪ Ocean Going Vessels	APL Singapore Slide Valve & Water-In-Fuel Emulsion
▪ Harbor Craft	Foss Maritime Diesel Electric Hybrid Tugboat
▪ Cargo Handling Equipment	LNG Yard Tractor Demonstration Hybrid Yard Tractor Development & Demonstration VYCON REGEN Rubber-Tired Gantry Flywheel System
▪ Container Drayage Trucks	Balqon Electric Class 8 Tractor Westport ISX LNG Engine Development
▪ Locomotives	Pacific Harbor Line Locomotive Diesel Particulate Filter

Each of the projects listed above is discussed in the following Sections of this Report.

The Technology Advancement Program is funded by both Ports at an annual level of \$1,500,000 from each Port for a period of five years. Additional funding is contributed by participating agencies, including but not limited to the South Coast AQMD, California Air Resources Board, and the US Environmental Protection Agency. In 2007, additional agency funding was provided by the 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 Technology Advancement Program are shown below Table 1. Note that 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 2007-'08 and beyond is likely to be greater than the minimum values shown.

**Table 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	<b>\$7,500,000</b>
POLB	\$1,500,000	\$1,500,000	\$1,500,000	\$1,500,000	\$1,500,000	<b>\$7,500,000</b>
AQMD	\$271,500	\$1,557,125	TBD	TBD	TBD	<b>≥ \$1,828,625</b>
CARB	\$783,628	TBD	TBD	TBD	TBD	<b>≥ \$783,628</b>
EPA	\$375,000	TBD	TBD	TBD	TBD	<b>≥ \$375,000</b>
CEC	\$0	\$500,000	TBD	TBD	TBD	<b>≥ \$500,000</b>
Other	\$889,920*					<b>≥ \$889,920</b>
<b>Totals</b>	<b>\$5,320,048</b>	<b>\$5,057,125</b>	<b>\$3,000,000</b>	<b>\$3,000,000</b>	<b>\$3,000,000</b>	<b>\$19,377,173</b>

\* Additional POLA funding from residual funds from the "NO<sub>x</sub> and PM Emission Reduction Credit Program"

Total revenue for the Technology Advancement Program equates to \$5,320,048 for fiscal year 2006/'07 and a minimum of \$5,057,125 for fiscal year 2007/'08. Table 2, below, provides an accounting by fiscal year for the Technology Advancement Program:

**Table 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
<b>FY2006-'07 Balance Forward</b>	<b>\$282,965</b>	<b>\$869,465</b>	<b>\$0</b>
FY 2007-'08 Appropriations	\$1,500,000	\$1,500,000	\$2,057,125
FY2007-'08 Encumbrances	\$250,000	\$250,000	\$2,057,125
<b>Current Balance Available for FY 2007-'08</b>	<b>\$1,532,965</b>	<b>\$2,119,465</b>	<b>\$0</b>
<b>Total FY2007-'08 Balance Available</b>	<b>\$3,652,430</b>		

Total investment in the Technology Advancement Program for fiscal years' 2006-'07 and 2007-'08 equates to \$10,377,173. Of this amount, \$6,724,743 has been encumbered for specific projects. The current balance for FY 2007-'08, as of February 2008, is \$3,652,430.

## TECHNOLOGY ADVANCEMENT PROGRAM

### 1.0 Introduction

The San Pedro Bay Ports (SPBP) comprise a huge regional and national economic engine. The Los Angeles Customs District accounts for approximately \$300 billion in annual trade. More than 40% of all containerized trade in the nation flows through the San Pedro Bay Ports. Economic forecasts suggest that the demand for containerized cargo moving through the San Pedro Bay region will more than double by the year 2020.

The economic benefits of the Ports are felt throughout the nation; however, the environmental impacts of trade are more locally concentrated. Both Ports have adopted and are implementing a wide range of new environmental initiatives. These efforts include better documentation of environmental impacts and more detailed evaluation of effective mitigation measures. 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 are also aware of the views of port users and operators that inconsistent or conflicting environmental measures could have unintended and even counterproductive effects. The Ports recognize that their ability to accommodate the projected growth in trade will depend upon their ability to address adverse environmental impacts and, in particular, the air quality impacts that result from such trade. The Clean Air Action Plan is designed to develop mitigation measures and incentive programs necessary to reduce air emissions and health risks while allowing port development to continue. The Ports have several upcoming 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 Clean Air Action Plan to satisfy the twin goals of clean air and economic growth. The Ports also anticipate several new major leases and lease amendments in the next five years. In short, the Ports intend to serve as a catalyst for rapid change, recognizing the rights of all involved in, and affected by, Port operations.

This document is the first Technology Advancement Program (TAP) Annual Report under the San Pedro Bay Ports Clean Air Action Plan. The Clean Air Action Plan (CAAP) identifies and describes the measures the Ports of Los Angeles and Long Beach will take toward reducing air pollutant emissions related to port operations. The five-year CAAP highlights the objectives, emission reduction goals, and budgetary needs for fiscal years 2006/2007 through 2010/2011. At the end of the five-year period, virtually all required measures necessary to meet the air quality improvement goals set forth in the CAAP will be in place. Staff from both Ports regularly evaluate progress towards meeting CAAP goals, review status of existing control measures, evaluate new measures, and, on an annual basis jointly develop a revised CAAP.

### 1.1 Technology Advancement Program Objectives

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”*.

The Technology Advancement Program 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.

As the Technology Advancement Program is a component of the CAAP, it is anticipated that the Program will undergo a review and update each year during the annual CAAP update process in order to ensure that the Program is supporting 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, & Testing
3. "Green-Container" Transport Systems
4. Emissions Inventory Improvements

This first 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.

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

As new technologies are identified, those that appear feasible and commercially viable will be evaluated by the Ports and participating regulatory agencies as to their likely successful use on the port-related emissions sources listed above. In some cases, port tenants or carriers are moving forward with technology demonstrations without financial support from the ports or supporting agencies. In these cases, the ports will seek to stay informed on the progress and performance of these projects, and will work with the technology developers to pursue CARB verification, where appropriate, in order to increase awareness of these technologies and to ensure that there is agency consensus as to the emission reduction efficiency of the technology.

### **Specific Control Measure Requirements**

Several measures included in the Clean Air Action Plan 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 Clean Air Action Plan 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<sub>x</sub>, and SO<sub>x</sub> reductions associated with the measure;

- SPBP-OGV2: Demonstration and testing of 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 Oceangoing 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 emissions reduction technologies for harbor craft, focusing on the transfer of successful control strategies for 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 LNG locomotives;
- SPBP-RL2: Demonstration, emissions source testing, and evaluation of emissions reduction technologies for long-haul locomotives including DOCs, DPFs, SCRs, and other emerging technologies that could be utilized by these locomotives.

### **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 Clean Air Action Plan. 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 Clean Air Action Plan update.

### **1.2 Implementation Process**

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

- Port Generated Projects;
- Solicited Proposals;
- Unsolicited Proposals.

#### **Port Generated Projects**

In cases where 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. In these instances, the Ports may seek grant funding from other stakeholders to assist with project implementation.

### **Solicited Proposals**

The Ports develop joint Requests for Proposals (RFPs) for Technology Advancement projects. This formal process is used to solicit proposals for a specific technology or for technologies that are applicable to a specific source category. Using a competitive selection process, the technologies that have the greatest potential to achieve TAP goals are selected. This process is managed in a manner similar to the Research and Development component of the Port of Los Angeles' Air Quality Mitigation Incentive Program, whereby projects are evaluated using a defined scoring system.

### **Unsolicited Proposals**

The Ports often receive solicitations to fund various technology advancement projects, either from agencies or tenants working with technology providers, or from technology providers directly. Information received by either Port is entered into the shared Technology Advancement Program database. Port staff will then perform an initial screening of the proposal, using the following criteria:

- Technology Application – *Is the technology applicable to the port industry? Is the application feasible?*
- CARB Verification – *Is the technology developer currently seeking, or are they willing to seek, CARB verification?*
- Matching Funds – *Is the project supported by in-kind or direct capital matching funds?*
- Emission Reductions – *Are the emission reductions consistent with the CAAP goals? Does the technology reduce some emissions will 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?*

Based upon the Port staffs' preliminary screening, if a technology is not recommended for further evaluation, the information on the technology is filed. If the technology does pass initial screening, additional information and/or a formal proposal may be requested.

## **1.3 Advisory Committee**

A Technology Advancement Program Advisory Committee has been established consisting of agency partners that include the Port of Long Beach, Port of Los Angeles, South Coast Air Quality Management District, the California Air Resources Board, and US Environmental Protection Agency Region 9. The Ports established the Advisory Committee by invitation during the first quarter of 2007; a list of current Advisory Committee members is included in Appendix A of this Annual Report.

The Advisory Committee, as the name suggests, serves in an advisory capacity to the Ports for screening, evaluating, and recommending projects that merit further development or demonstration. 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 Advisory Committee members also receive regular updates on the Technology Advancement projects being conducted in the Ports.

The Advisory Committee 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.

## 2.0 Key Projects in 2007

As the first complete year of Technology Advancement Program implementation, 2007 proved to be a very productive year for the San Pedro Bay Ports, with technology demonstration projects initiated in prior years completed, new projects initiated, and technologies identified for pursuit in 2008.

This first Technology Advancement Program Annual Report includes a summary of the eight (8) projects implemented under the TAP to date. These include:

<b>Source Category</b>	<b>TAP Project</b>
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▪ Container Drayage Trucks	Balqon Electric Class 8 Tractor Westport ISX LNG Engine Development
▪ Locomotives	Pacific Harbor Line Locomotive Diesel Particulate Filter

Each of the projects listed above is summarized in the following Sections of this Report.

## 2.1 Ocean Going Vessels

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

Under the Technology Advancement Program, the San Pedro Bay Ports are participating in a three-year demonstration of emission reduction technologies aboard the container ship APL Singapore (formerly known as American President Line) 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.

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



Figure 2.1-1: Specifications of the APL Container Ship Singapore

### Emission Control Technologies

Two emission control technologies and included in the demonstration and were installed on vessel's main engine:

- 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 is provided by Sea to Sky Pollution Solutions. A fuel homogenizer was installed in the APL Singapore's engine room to produce the emulsification. The unit injects water into the bunker fuel used by the vessel's main engine and continually agitates the mixture to keep oil and water from separating. Introducing water into the combustion cylinder reduces the maximum peak combustion temperature and the formation of oxides of nitrogen (NO<sub>x</sub>). The in-cylinder evaporation of the water also improves the atomization of the fuel causing it to burn more completely. The WiFE system is connected to the ship's main engine and is expected to yield approximately

1% reduction in NO<sub>x</sub> for every 1% concentration of water in the emulsion<sup>1</sup>. Varying concentrations of water will be tested to determine the emulsion level that best reduces emissions; NO<sub>x</sub> reductions greater than 25% are expected from this control technology, with additional reductions in particulate matter, carbon monoxide (CO), and sulfur oxides (SO<sub>x</sub>) expected;

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

### Project Partners

Eight partners have 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
- California Air Resources Board
- 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

Additional stakeholders in this project include the technology implementers, APL, MAN B&W Diesel, Sea to Sky Pollution Solutions, and the Maritime Administration.

Emission testing is an essential element of this project and will determine the actual air pollution reduction benefits resulting from the control technologies undergoing demonstration. Emission testing is being conducted by the University of California Riverside College of Engineering/Center for Environmental Research and Technology (CE-CERT) in cooperation with the engine manufacturer MAN B&W Diesel. The San Pedro Bay Ports, the Bay Area, 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 of Los Angeles and Long Beach have each contributed \$22,500 in TAP funding towards emissions testing.

The installation of the emulsification equipment was completed in early 2007 and emission testing is currently being conducted.

### Project Status

In fall 2007, the vessel retrofit was completed and emission testing was conducted during a 15-day transpacific voyage from Kaohsiung Taiwan to the San Pedro harbor. Emissions testing was conducted in parallel by University of California-Riverside and MAN B&W. Data analysis and publication of the emissions test report are expected to be finalized in early 2008. A second evaluation is scheduled for late Spring 2008.

<sup>1</sup> This linear relationship is approximate, but most pronounced at water concentration percentages above 12 percent.

## 2.2 Harbor Craft

### 2.2.1 Foss Maritime Diesel Electric Hybrid Tugboat

Foss Maritime is participating in the Technology Advancement Program to develop a hybrid-electric tugboat based on their original Dolphin class tugboat design. Tugboats are an excellent fit for hybrid technologies; they typically experience high idling times and the majority of their operations in low power modes. Tugs also experience extremely high power requirements, but only for short durations.

The Dolphin tug is a compact platform of 78ft x 34ft x 15ft generating 5,080 horsepower and over 60 tons of bollard pull. The hybrid tug will use this existing platform and, from the outside, appear exactly like a conventional tug.



The Quanta DES system, an existing hybrid technology modified for use in the tug, is a flexible design that can be adapted to a variety of power and duty cycle requirements. The hybrid technology that will be incorporated into the propulsion system of the new tug minimizes fuel consumption by using a power management system to supply required power using the most efficient combination of batteries, generators, and main engines. Key design features of the hybrid electric propulsion system include two Cummins 1,800 hp QSK50 Tier 2 main engines replacing the conventional tug's two Caterpillar 2,540 hp engines. Supplementing the Cummins engine is a 1,200 hp motor generator and one megawatt (1,340 hp) of battery power. The two 125 kilowatt (168 hp) generator sets in the conventional design will be replaced by two 250 kW (335 hp) generator sets. The two 205 FP Rolls Royce Azimuthing Stern Drives from the conventional tug design are retained in the hybrid configuration. The combination of lower rated main engines plus availability of supplemental power give the hybrid tug the full horsepower and bollard pull of a conventional Dolphin class tug.

The hybrid system will have four distinct modes of operation, as outlined below:

1. Minimal Emissions (0-5% load)
  - When boat 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, 1 or 2 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, which will reduce emissions during idle or low speed/low load operation but the tug will be able to access full power on demand.

### **Environmental Benefits**

The hybrid electric tugboat is designed to reduce both oxides of nitrogen (NO<sub>x</sub>) and particulate matter (PM) by approximately 44% when compared with the Dolphin tugs currently operating in the San Pedro Harbor. Fuel consumption is expected to be reduced by approximately 20 to 30%, yielding additional reductions in carbon dioxide (CO<sub>2</sub>) and sulfur oxide (SO<sub>x</sub>) emissions.

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. Once completed, the hybrid electric tug prototype will operate in the San Pedro Bay for a minimum of five years.

### **Project Partners**

Foss Maritime is working closely with their project partners to implement the Diesel/Electric Tugboat project. These partners include Port of Long Beach, Port of Los Angeles, California Air Resources Board, and the South Coast Air Quality Management District.

### **Project Status**

Negotiations of a four-party agreement between Foss, Port of Long Beach, Port of Los Angeles, and the South Coast AQMD are nearing completion, with final contract execution anticipated in the first quarter of 2008. The hybrid electric tug will be the 10<sup>th</sup> in the series of Dolphin class tugboats. The hybrid tug is currently under construction and is scheduled for completion in the fourth quarter of 2008.



## 2.3 Cargo Handling Equipment

### 2.3.1 LNG Yard Tractor Demonstration and Commercialization Project

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 San Pedro Bay Ports. According to emission inventories compiled by the Ports of Long Beach and Los Angeles, yard tractors emit approximately 61% of the particulate matter and 60% of the nitrogen oxides (NO<sub>x</sub>) 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 on terminal source of PM and NO<sub>x</sub> emissions at the Ports.

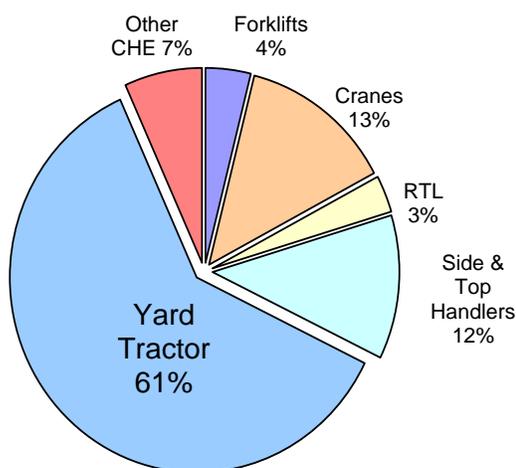


Figure 2.3-1  
PM Emissions Attributable to CHE

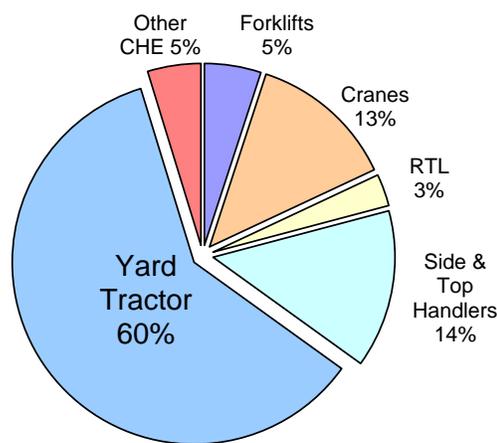


Figure 2.3-2  
NO<sub>x</sub> Emissions Attributable to CHE

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;
- Evaluation the emissions of LNG yard tractors as compared to conventional diesel-fueled hostlers used at the Ports;
- Assess the business case for LNG yard tractors at ports and similar applications such as rail yards and distribution centers.

### Project Phases

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.

### Project Partners

The project team consisted of the Port of Long Beach, US EPA, 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. Funding for the project included \$350,000 from the Port of Long Beach TAP and \$75,000 from US EPA Region 9.



### Project Partners

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<sub>x</sub> standard of 1.8 g/bhp-hr.

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 - 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 were collected on the baseline yard tractor group in parallel with the LNG tractors under similar operating conditions.

### Demonstration Program 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.

### Environmental Benefits

The emissions testing segment of the project yielded the following results, as shown in Table 2.3-1:

Table 2.3-1: Yard Tractor Weighted Emissions Factors (g/whp-hr)

Engine Model - Year	Emissions Certification	Weighted Emissions Factors (g/whp-hr)				
		THC	CO	NO <sub>x</sub>	PM	CO <sub>2</sub>
C8.3L – 2001	Tier 1 off-road	0.29	0.63	11.06	0.26	1013
C8.3L – 2003	Tier 2 off-road	0.16	0.24	6.28	0.13	815
ISB 5.9L – 2005	2004+ on-road	0.05	0.51	2.94	0.10	791
CG 8.3L – 2005 LNG	2004+ on-road	2.92	0.09	3.57	0.00	658

As shown in Table, the 2005 on-road diesel engine-equipped tractor and the 2005 LNG tractor produced the lowest NO<sub>x</sub> and PM emissions, respectively. NO<sub>x</sub> emissions from the LNG yard tractor were approximately 21% higher than NO<sub>x</sub> emissions from the on-road diesel engine equipped with a diesel oxidation catalyst and closed crankcase ventilation system.

### Potential for Replication at the Ports

The successful demonstration of LNG in a marine terminal environment, especially as it pertains to driver acceptance of the LNG yard tractors, indicates the potential for acceptance in the off-road vehicle marketplace. At least one Original Equipment Manufacturer (OEM) yard tractor chassis manufacturer now offers 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 currently the lowest emitting heavy-duty engine certified by the Air Resources Board.

### 2.3.2 Hybrid Yard Tractor

As a follow on to the demonstration of alternative fuel technology in yard tractors operating at the San Pedro Bay Ports, the Technology Advancement Program is investigating the feasibility and commercial viability of using advanced technology drive systems in cargo handling equipment. The Ports' TAP Program, in partnership with the US EPA's West Coast Collaborative, are collaborating to develop and test hybrid technology yard tractors for use at container terminals.

Three hybrid yard tractors will be integrated with hybrid drive systems and operate for a six-month period at Long Beach Container Terminal at the Port of Long Beach. The hybrid vehicles will use either a *hybrid-electric* system to combine the cleanest available diesel or alternative fuel engine technology with an electric motor, or a *hybrid-hydraulic* system that would combine the cleanest available diesel or alternative fuel engine technology with components that use hydraulic fluid to store energy.

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.



#### Environmental Benefits

The hybrid drive system is expected to deliver a 93% reduction in smog-forming nitrogen oxides and diesel particulate matter compared to typical 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 cuts in emissions from idling reductions during the six-month test are approximately 19 tons of NO<sub>x</sub> and 200 pounds of particulate matter.

#### Project Funding

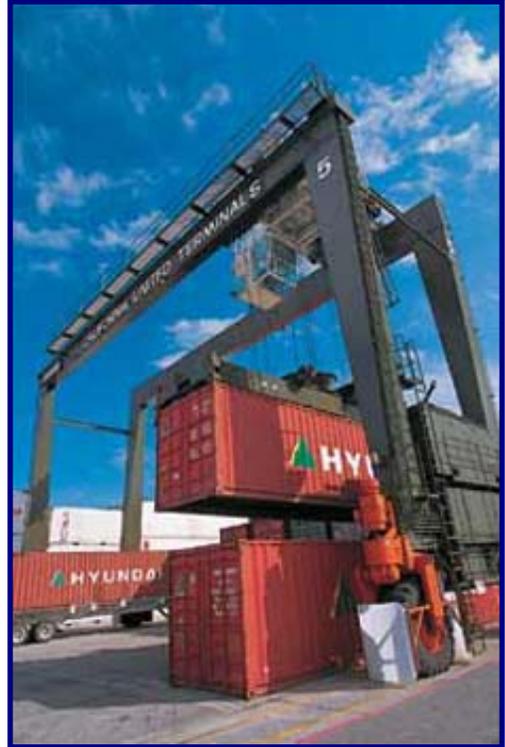
The two-year demonstration project is valued at \$1.2 million. Under the TAP, the Ports of Long Beach and Los Angeles will contribute \$300,000 each and the US EPA will contribute \$300,000 through its West Coast Collaborative. In-kind support from Long Beach Container Terminal, the hybrid equipment supplier, and port staff costs are estimated at \$300,000. CALSTART, a non-profit company that focuses on advancing cleaner technologies, is providing project management assistance and coordinating the emissions testing component of the program as well as assessing the potential for hybrid yard tractor commercialization.

#### Project Status

A Request for Proposals (RFP) soliciting manufacturers of hybrid drive systems was released in early February 2008. Following vendor selection, the hybrid drive systems will undergo final design and integration. Delivery of fully integrated hybrid yard tractors to Long Beach Container Terminal is expected during the first quarter of 2009.

### 2.3.3 VYCON Rubber-Tired Gantry Crane REGEN Flywheel System

Rubber Tired Gantry (RTG) cranes are mobile cargo handling equipment used by marine terminal operators for container movement. This equipment can load/unload containers, which may weigh up to 30 tons, at a rate of one container per minute. Each crane is powered by an onboard diesel generator set. Variable-speed alternating current (AC) hoist motors receive power from an inverter that provides the required voltage and frequency for the lift and lowering functions. These AC motors demand short-duration peak power from the generator for each lift cycle. Then, when lowering the containers, the AC motors are used as brakes, actually becoming generators that create free regenerated energy, which could be put to use if that energy could be stored. Up until now, this regenerated energy from the lowering cycle has been directed to onboard resistor banks, where the excess energy is converted to heat. The high cycle rate characteristics of RTG cranes have previously limited technology from harnessing this free energy for productive use.



#### Technology Overview

The VYCON REGEN flywheel system, whose name is derived from an AC motor's regenerative braking capabilities, is an energy storage device designed to capture, store, and discharge energy on demand. The technology consists of a highly reliable permanent magnet motor/generator, active magnetic bearings, and integrated control systems. VYCON's REGEN system is able to charge each time the AC motors regenerate power, and then store that energy to be used when the power demand requires the diesel generator set to burn the most fuel and produce the most emissions. With the instantaneous response of the REGEN system during every hoist cycle, the RTG efficiency is increased.

#### Project Partners

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

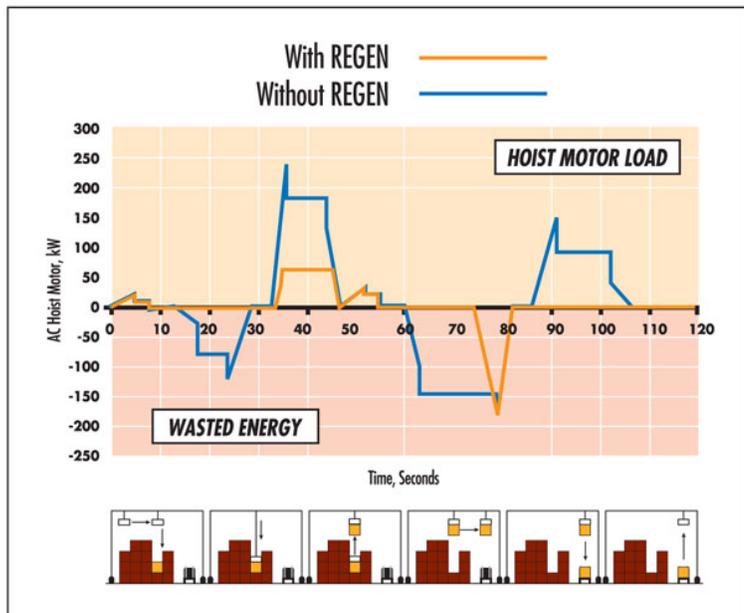


Figure 2.3-3: Typical Load Profile for RTG Crane With and Without REGEN

The REGEN System can be retrofitted to in-use cranes or installed during RTG manufacture as part of a new crane.

### **Project Funding**

The Ports' Technology Advancement Program supported the emissions testing of the VYCON REGEN system as it was undergoing the CARB verification procedure. Each Port committed \$11,500 for a total TAP funding contribution of \$23,000. Additional project partners include ITS, Evergreen, the California Air Resources Board, and the South Coast AQMD.

### **Project Results & Environmental Benefits**

VYCON received Level 1 verification from the California Air Resources Board in October 2007 for the REGEN system. REGEN is now verified to reduce diesel particulate matter emissions by a minimum of 25% and is estimated to reduce NO<sub>x</sub> emissions by 30 percent. Emissions of carbon dioxide (CO<sub>2</sub>) are also reduced by approximately 30 percent based on the reduction in diesel fuel consumption estimated at approximately 35 percent.

## 2.4 Container Drayage Trucks

### 2.4.1 Balqon Electric Class 8 Tractor

The Port of Los Angeles is demonstrating the use of a low-speed class 8 electric tow tractor for transporting containers between the Port and near-dock rail facilities or other short, captive hauls. The project, funded by the Port of Los Angeles and the South Coast Air Quality Management District, will investigate the feasibility of replacing diesel-powered class 8 tractors with zero-emission, electrically powered trucks.



Balqon Corporation was selected to develop and demonstrate the zero-emission class 8 tow tractor. The Balqon Model T324 is an all-electric terminal tractor with a payload capacity of 60,000 lbs and an estimated range of 40 miles on a single charge. The vehicle is equipped with a fast charge capability that allows the vehicle to be fully recharged in 30 to 45 minutes.

#### Environmental Benefits

The Balqon T324 is a zero emission electric vehicle using electric motors for motive power and batteries for energy storage. Tailpipe emissions for this low-speed electric tow tractor are zero.

#### Project Partners

The development and first unit procurement cost of the low-speed electric tow tractor was \$527,000. The Port of Los Angeles provided \$263,500 in TAP funding, matched with \$263,500 provided by the South Coast AQMD.

#### Project Status

The electric truck is designed and fully built. Balqon is currently in the process of fine-tuning the truck's operation and is scheduled to conduct a road test in the first quarter of 2008.

## 2.4.2 Westport ISX LNG Engine Development

Westport Innovations Inc. (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<sub>x</sub> 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 San Pedro Bay Ports.



### Technology Overview

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. 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<sub>x</sub> 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<sub>x</sub> (2010 standard) compliant truck by late 2008 for deployment in early- to mid-2009.

### Project Partners

Project stakeholders include the Ports of Long Beach and Los Angeles, South Coast AQMD, California Energy Commission, Clean Energy, Kenworth Truck Company, and Westport.

### Project Funding

The total project cost for development and certification of the "0.2 gram" ISX HPDI 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.

### **Environmental Benefits**

The "0.2-gram" LNG engine will accelerate NO<sub>x</sub> emission reductions by making trucks meeting the final 2010 standard available in 2009. Westport estimates emission reductions of at least 0.45 tons of NO<sub>x</sub> 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 on a life cycle basis.

## 2.5 Locomotives

### 2.5.1 Pacific Harbor Line (PHL) Locomotive Diesel Particulate Filter

This project will demonstrate the effectiveness and durability of diesel particulate filters (DPF) 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.



Pacific Harbor Line will 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. For this TAP project, a Tier 2-compliant PHL switch locomotive will be retrofitted with a MobiClean™ Active Regeneration Diesel Particulate Filter. This technology application is expected to reduce particulate matter by approximately 90 percent. Should the DPF prove to be a technically viable and commercially feasible technology, this project could be replicated both regionally and nationally resulting in significant reductions in toxic air contaminant emissions.

#### Project Partners

The principal funding partners for the PHL DPF demonstration project are the South Coast AQMD, Miratech Corporation, Pacific Harbor Line, and the Ports of Long Beach and Los Angeles.

#### Project Funding

The total project cost is \$466,070. 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 to the project using funding from the Clean Air Action Plan TAP Program.

#### Environmental Benefits

The MobiClean™ Active Regeneration DPF system is expected to reduce switch locomotive particulate matter emissions by 90%, or 0.14 tons per year per locomotive. This technology, once proven successful, can be retrofitted on the remaining 15 new Tier 2 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 on the test switch locomotive is scheduled to be complete by July 2008.

### 3.0 2007 Project Expenditures & Budget Status

The Technology Advancement Program is funded by both Ports as an element of the Clean Air Action Plan at an annual level of \$1,500,000 from each Port for a period of five years. Additional funding is contributed by participating agencies, including but not limited to the South Coast AQMD, California Air Resources Board, and US Environmental Protection Agency. In addition, during 2007, the California Energy Commission (CEC) was a co-funding partner on one of the Technology Advancement Program projects. Project co-funding is also contributed in the majority of cases by the project proponent as either cash or in-kind funding contribution.

The annual minimum funding levels for the Technology Advancement Program are shown in Table 3-1, below. Note that 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 2007-'08 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	<b>\$7,500,000</b>
POLB	\$1,500,000	\$1,500,000	\$1,500,000	\$1,500,000	\$1,500,000	<b>\$7,500,000</b>
AQMD	\$271,500	\$1,557,125	TBD	TBD	TBD	<b>≥ \$1,828,625</b>
CARB	\$783,628	TBD	TBD	TBD	TBD	<b>≥ \$783,628</b>
EPA	\$375,000	TBD	TBD	TBD	TBD	<b>≥ \$375,000</b>
CEC	\$0	\$500,000	TBD	TBD	TBD	<b>≥ \$500,000</b>
Other	\$889,920*					<b>≥ \$889,920</b>
<b>Totals</b>	<b>\$5,320,048</b>	<b>\$5,057,125</b>	<b>\$3,000,000</b>	<b>\$3,000,000</b>	<b>\$3,000,000</b>	<b>\$19,377,173</b>

\* Additional POLA funding from residual funds from the "NO<sub>x</sub> and PM Emission Reduction Credit Program"

### 3.1 Financial Report

As shown in Table 3.1, above, total revenue for the Technology Advancement Program equates to \$5,320,048 for fiscal year 2006/'07 and a minimum of \$5,057,125 for fiscal year 2007/'08. Table 3-2, below, provides an accounting by fiscal year for the Technology Advancement Program:

**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
FY2006-'07 Balance Forward	\$282,965	\$869,465	\$0
FY 2007-'08 Appropriations	\$1,500,000	\$1,500,000	\$2,057,125
FY2007-'08 Encumbrances	\$250,000	\$250,000	\$2,057,125
Current Balance Available for FY 2007-'08	\$1,532,965	\$2,119,465	\$0
Total FY2007-'08 Balance Available	\$3,652,430		

Total investment in the Technology Advancement Program for fiscal years' 2006-'07 and 2007-'08 equates to \$10,377,173. Of this amount, \$6,724,743 has been encumbered for specific projects. The current balance for FY 2007-'08 is \$3,652,430. 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 Expenditures by Project

Table 3-3, below, summarizes Technology Advancement Program funding commitments by project and funding entity:

**Table 3-3: Summary of Agency Investments by Project**

PROJECT CATEGORY	Technology Advancement Program Funding Contribution						Total Agency Investment
	POLB	POLA	AQMD	CARB	US EPA	CEC	
<b>Ocean Going Vessels</b>							
APL Singapore Slide Valve/Wife	\$22,500	\$22,500		\$783,628			\$828,628
<b>Harbor Craft</b>							
Foss Maritime Hybrid Tugboat	\$500,000	\$889,920*					\$1,389,920
<b>Cargo Handling Equipment</b>							
LNG Yard Tractor	\$350,000				\$75,000		\$425,000
Diesel Hybrid Yard Tractor	\$300,000	\$300,000			\$300,000		\$900,000
Vycon RTG REGEN Flywheel	\$11,500	\$11,500	\$8,000				\$31,000
<b>Container Drayage Trucks</b>							
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
<b>Locomotives</b>							
PHL Locomotive DPF	\$33,035	\$33,035	\$307,125				\$373,195
<b>Total Investments to Date</b>	<b>\$1,467,035</b>	<b>\$1,770,455</b>	<b>\$1,828,625</b>	<b>\$783,628</b>	<b>\$375,000</b>	<b>\$500,000</b>	<b>\$6,724,743</b>

\*POLA funding from residual funds from the "NO<sub>x</sub> and PM Emission Reduction Credit Program"

## 4.0 Funding Priorities for 2008

The Technology Advancement Program continually seeks to support the identification, demonstration, and, ultimately, CARB verification of lower emitting technologies applicable to the source categories and focus areas identified in the Clean Air Action Plan. The CAAP serves as the “blueprint” that defines the strategies necessary to reduce air emissions and health risks while allowing port development to continue. Therefore, it is fully expected that TAP funding priorities for 2008 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 District.

### 4.1 Summary of Technical & Programmatic Priorities for 2008

While the Technology Advancement Program will continue to seek emission reductions from all source categories identified in the CAAP, the initial programmatic and technical TAP priorities for 2008 are as follows:

2008 Programmatic Priorities:

- **Expand Outreach** to Port tenants, industry groups, and equipment operators regarding the TAP opportunity as well as other grant funding opportunities available, including but not limited to those offered by the South Coast AQMD and Port of Los Angeles Air Quality Mitigation Improvement Program;
- **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 Clean Air Action Plan;
- **Streamline** TAP implementation and identify strategies to improve the efficiency of reviewing candidate technologies and processing proposals;
- **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.

2008 Technical Priorities:

- **Identify and Demonstrate** technologies that target emission reductions from on-road trucks;
- **Identify and Demonstrate** technologies that target emission reductions from ocean going vessels.

### 4.2 Identified Technology Pursuits

#### On-Road Truck Emission Reductions

The San Pedro Bay Ports handle approximately two-thirds of the total container traffic coming into U.S. west coast ports and approximately 43% of all US imported goods. 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 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.

Over the past three years, Port container throughput has increased by one-third, from 11.84 million TEU in 2003 to 15.76 million TEU in 2006. Over this period, even with rapid expansion of on-dock rail usage, the amount of cargo handled by trucks has increased from less than 10 million TEU in 2003 to nearly 12 million TEU in 2006. This trend is expected to continue, with total Port throughput projected to reach 35 million TEU by 2020 and 42 million TEU by 2030.

Based on the various sizes of containers being transported, the ratio of TEU to actual truckloads of cargo is approximately 1.8 to 1. Therefore, the roughly 12 million TEU handled by trucks in 2006 represented about 6.66 million truckloads of cargo. This cargo is handled by an estimated population of 41,000 trucks, of which approximately 16,800 shuttle to and from the Ports on a regular basis.

To mitigate emissions from drayage trucks, both Ports have recently adopted tariffs that gradually limit access to all but the cleanest vehicles. The tariff will cut air pollution from drayage trucks by nearly 80 percent within five years.

The tariff is based on a progressive ban of the oldest trucks, implemented in accordance with the following schedule:

- October 1, 2008: All pre-1989 trucks will be banned from Port service;
- 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<sub>2.5</sub> 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 Tariff. In addition, new technologies are sought to reduce greenhouse gas (GHG) emissions from drayage operation; this requires lower carbon content fuels or improvements in truck engine and drive train efficiencies.

In the first quarter of 2008, the Ports anticipate the release of two (2) solicitations related to improving the efficiency and reducing the emissions associated with container drayage under the TAP:

- A Request for Proposals (RFP) for the development and demonstration of a Hybrid Terminal Tractor; and
- An RFP for the development and demonstration of a Hybrid Drayage Truck (Class 8 on-road tractor).

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

### **Ocean Going Vessel Emission Reductions**

The projected increase in container traffic cited in the previous Section directly reflects the anticipated increase in container ships calling on the San Pedro Bay Ports. The Ports have taken unprecedented actions to reduce the environmental impact of ocean going vessels on the neighboring communities, implementing a voluntary vessel speed reduction (VSR) measure and expanding the availability of container terminal shore power and vessel cold-ironing under the Port of Los Angeles' alternative maritime power (AMP) program and the Port of Long Beach "green" leases and voluntary MOU with BP. As documented herein, TAP has supported the demonstration and emissions testing of on-demand water-in-fuel emulsion technology and slide valves, one of the first projects funded under TAP.

For 2008, TAP is targeting the demonstration of technologies and OGV emission reduction strategies that directly support the OGV specific control measures identified in the CAAP, including advancing CAAP measure OGV5. This may potentially include the demonstration and emissions testing of the Alternative Maritime Emissions Control System (AMECS), targeting "at-berth" emissions reductions from OGV auxiliary engines (SPBP-OGV2). Proof-of-concept demonstrations were conducted at a bulk material terminal at the Port of Long Beach in late 2007; demonstration and testing of the AMECS' emission control system is slated for early to mid-2008.

## APPENDIX A

### TECHNOLOGY ADVANCEMENT PROGRAM ADVISORY COMMITTEE MEMBERSHIP



Dr. Matt Miyasato, South Coast AQMD

Peggy Taricco, California Air Resources Board

Roxanne Johnson, US EPA Region 9

### TECHNOLOGY ADVANCEMENT PROGRAM STAFF

#### Port of Long Beach

925 Harbor Plaza  
Long Beach, CA 90802

#### POLB Technology Advancement Program Staff

- Heather Tomley, Senior Environmental Specialist
- Thomas Jelenic, Senior Environmental Specialist
- Allyson Teramoto, Environmental Specialist

#### Port of Los Angeles

425 S. Palos Verdes Street  
San Pedro, CA 90731

#### POLA Technology Advancement Program Staff

- Teresa Scognamillo, Environmental Mitigation Coordinator
- Kevin Maggay, Environmental Specialist
- Tim DeMoss, Environmental Specialist

#### Additional Administrative & Technical Support Staff

- Lauren Dunlap, Starcrest Consulting Group
- Bruce Anderson, Starcrest Consulting Group
- Ray Gorski, Starcrest Consulting Group
- Alycia Gilde, Starcrest Consulting Group

## Appendix B

### Summary Reports for Completed Projects

Two Technology Advancement Program projects have been completed to date:

- Liquefied Natural Gas Yard Tractor Demonstration and Commercialization Project;
- VYCON REGEN<sup>®</sup> System for Rubber-Tired Gantry Cranes

Summaries of the Final Reports submitted for these projects are included herein. Additional information is available on the joint Ports' Clean Air Action Plan website ([www.cleanairactionplan.com](http://www.cleanairactionplan.com)).

# Vycon REGEN<sup>®</sup> System for Rubber-Tired Gantry Cranes

## 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<sup>®</sup> system supports the goal of clean air and a healthier environment through the reduction of air pollution from port cargo handling equipment. Under 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 rubber tire gantry (RTG) crane at each terminal.

## Technology Description

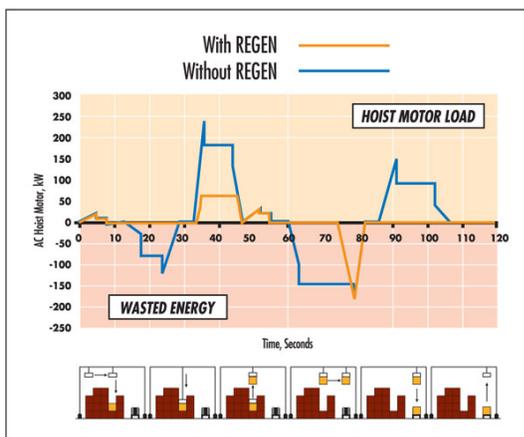
Two marine terminals, ITS in the Port of Long Beach and Evergreen in the Port of Los Angeles, installed VYCON's REGEN system onto one of the terminals' rubber tire gantry (RTG) cranes. VYCON's REGEN system is an energy storage system that is also capable of supplying the stored energy on demand. Basically, the REGEN system charges 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. VYCON recently achieved Level 1 verification from the California Air Resources Board.

## Typical Load Profile vs. Load Profile with REGEN



## 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 PM emissions by a minimum of 25 percent and is estimated to reduce 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, UPS and wind power applications.

# Liquefied Natural Gas (LNG) Yard Tractor

## 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 San Pedro Bay Ports. According to emission inventories compiled by the Ports of Long Beach and Los Angeles, yard tractors emit approximately 64% of the particulate matter and 59% of the nitrogen oxides (NO<sub>x</sub>) 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 particulate matter and nitrogen oxides (NO<sub>x</sub>) 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;
- Evaluation the emissions of LNG yard tractors as compared to conventional diesel-fueled hostlers used at the Ports;
- 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 was 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, 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<sub>x</sub> 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 - 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 draft final report, dated August 11, 2007 has been received.

### 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<sub>x</sub> and PM emissions were produced by the 2005 on-road diesel engine-equipped tractor and the 2005 LNG tractor, respectively. NO<sub>x</sub> emissions from the LNG yard tractor were approximately 21% higher than NO<sub>x</sub> 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 approximately \$1M. 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 a marine terminal environment, especially as it pertains to driver acceptance of the LNG yard tractors, indicates the potential for acceptance in the off-road vehicle marketplace. At least one Original Equipment Manufacturer (OEM) yard tractor chassis manufacturer now offers 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 Air Resources Board.