The U.S. economy increasingly depends on international trade. Three hundred and sixty commercial sea and river ports in the U.S. move 2 billion tons of import and export cargo each year while 16.9 million cruise passengers also move through a port facility. It should come as no surprise that ports underpin roughly 32 percent of the U.S. economy and provide jobs for 13 million workers.ê Moving this trade through sea and river ports requires many trucks, trains, ships, cargo handling equipment, barges and marine workboats. Diesel fuel and engines are predominantly used to power these vehicles and equipment due to their fuel efficiency, power, performance and reliability.

Thirty-nine of the 360 commercial ports in the U.S. are located in areas of non-attainment for one or more criteria pollutant. Widely available clean diesel technologies are increasingly deployed across the large spectrum of vehicles, vessels and equipment and will play a vital role in improving air quality in regions surrounding America’s maritime gateways.

This whitepaper will provide an overview of diesel power used in America’s ports and address several key issues relating to the use of both new and existing diesel engines and equipment including the emissions performance of new technology clean diesel engines and capabilities to modernize and upgrade existing equipment.

**Sources of Port Emissions**

While every port is different in terms of the mix of cargo handled, most ports have a variety of diesel-powered equipment to move freight and provide key services to the port. These include heavy-duty trucks and other vehicles, ocean going vessels, barges, trains, tug boats and other yard equipment used to move freight. About one-in-ten of the nation’s ports are located in areas classified as non-attainment for one or more pollutants including particulate matter, or soot, and oxides of nitrogen, a smog forming compound.î

Though no two ports are exactly alike, generally speaking the largest emissions contribution comes from the ocean going vessels (OGV) that include container ships, oil and gas tankers, dry bulk carriers, and “roll-on roll-off” vessels that carry automobiles and project cargoes. Other sources of emissions include truck, rail and material handling equipment.
Particulate Matter Emissions in the Port Authority of NY-NJ (2010)

- Ocean-Going Vessels: 64%
- Cargo Handling: 18%
- Heavy-Duty Vehicles: 11%
- Railroad: 2%
- Harbor Craft: 5%

Particulate Matter Emissions in the Port of Los Angeles (2012)

- Ocean-Going Vessels: 51%
- Cargo Handling: 10%
- Heavy-Duty Vehicles: 8%
- Railroad: 16%
- Harbor Craft: 15%

Particulate Matter Emissions in the Ports of Tacoma, Seattle and Vancouver (2011)

- Ocean-Going Vessels: 64%
- Cargo Handling: 3%
- Heavy-Duty Vehicles: 4%
- Railroad: 4%
- Harbor Craft: 25%

Source: Port Authority of New York-New Jersey, Port Commerce Department, 2010 Multi-Facility Emissions Inventory, Port of Los Angeles Inventory of Air Emissions 2012, Puget Sound Maritime Air Emissions Inventory 2011
Port Activities and Air Quality
Strategies to reduce emissions from ports target three areas: reducing emissions from the trucks, trains, tugboats and cargo handling equipment servicing the port; controlling emissions from the OGVs serving the ports; and improving operational efficiencies at the port.

Significant emission reduction benefits may be achieved by the adoption of clean diesel technologies that power vehicles and equipment in port operations. Clean diesel refers to the system of cleaner fuels alongside modern engine design and exhaust aftertreatment technologies to fundamentally reduce emissions from these new engines. The new generation of clean diesel technology is now available in commercial trucks, material handling equipment, and starting in 2015, in the largest engines used in workboats and locomotives.

Strict emissions rules for heavy-duty trucks and vehicles established by the Environmental Protection Agency (EPA) in 2007 and further tightened in 2010 saw the widespread adoption of clean diesel technologies in the trucking fleet. These standards result in a reduction in emissions of particulate matter (PM) and oxides of nitrogen (NOx), by 98 percent relative to a truck manufactured before 1988. Similar emissions regulations were adopted for off-road equipment according to a phased-in schedule based on the size of the engine and apply to equipment used in port operations including harbor craft, locomotives and cargo handling equipment. Most of those standards have been adopted beginning January 2014 with only very large engines used in stationary power, locomotives and marine workboats set for January 1, 2015.

Clean Diesel Success Story – The Ports of Long Beach and Los Angeles
Thanks to the introduction of new clean diesel engines deployed in the many applications in ports, along with retrofit activities to install emission control technologies on older diesel engines, air quality in ports is rapidly improving. Nowhere is this more evident than in Southern California. The Port of Los Angeles estimates that between 2005 and 2012, PM fell by 77 percent, or 645 tons per year, while NOx fell by 56 percent or 9,100 tons per year. Other ports have also reported similarly impressive emission reductions. The overwhelming majority of these clean air achievements are attributable to the introduction of clean diesel technology in ports.

Technologies Used to Move Goods at Ports
Ocean Going Vessels
While every port is different in terms of the mix of cargo handled as well as the share of trucks, vessels, trains, tug boats and other yard equipment used to move freight, the largest emitter of emissions in ports are ocean going vessels (OGV). Given the fact that these large ships ply international waters, emissions from large ocean going vessels are regulated by a United Nation’s treaty. Those rules allowed the United States to establish an emissions control area along the East, West, and Gulf Coast and in the Caribbean and require the adoption of clean diesel fuel with lower sulfur content beginning in 2010 as well as rules governing stricter emissions requirements on engines to reduce emissions of oxides of nitrogen. By January 1, 2020,
the sulfur content of fuel used in ocean going vessel must not exceed .5 percent - a reduction from 3.5 percent allowed as of January 2, 2012. Meanwhile, new engines installed on vessels since 2011 must meet Tier 2 emissions standards and beginning in 2016 new engines must meet cleaner Tier 3 rules.  

**NOx Limit on New Engines in Large Ocean Going Vessels**

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g/Kw Hr

- 2000: 15 g/Kw Hr
- 2011: 10 g/Kw Hr
- 2016: 2 g/Kw Hr

80% Reduction
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Source: International Maritime Organization, Marpol Annex VI

Other initiatives are in place to reduce OGV emissions. Many military vessels and cruise ships are deployed with the capability of cold-ironing, the ability to use shore-side electrical grid power instead of operating diesel engines while at berth. These capabilities have been deployed in the ports of Los Angeles and Long Beach for use in larger container vessels. The state of California will also require cargo and cruise vessels to shut down a proportion of auxiliary diesel engines while at berth and use cold-iron capabilities. Many ports also offer incentives to vessel operators to reduce speed when approaching marine terminals so as to reduce emissions.

**Port Trucks**

One of the most visible applications of diesel technology at work in ports are the many trucks hauling containers and other cargo through marine terminals. The majority of these trucks are powered by diesel engines. EPA rules established in 2007 and further tightened in 2010 result in a dramatic reduction in many criteria pollutants including particulate matter and oxides of nitrogen from new diesel engines. Nationally, about one-in-three heavy-duty trucks on the road meet these clean truck standards and about 15 percent meet the tougher 2010 regulations. Roughly five percent of the older truck fleet is scrapped each year and is replaced with a new truck deployed with a clean diesel engine. Many cargo ports along the East, West and Gulf Coasts recognize the need to encourage the rapid turnover of trucks used to haul cargo through ports and have adopted
programs requiring or encouraging truck owners to use cleaner equipment in operation and a mix of state, federal and port authority funds are frequently available to truckers to purchase new or newer equipment. vi

**Progress to Near Zero Emissions in Heavy-Duty Trucks and Vehicles**

Source: U.S. EPA

**Southern California’s Ports Lead the Way in Clean Trucks**

A program implemented in 2008 in the ports of Los Angeles and Long Beach required all trucks entering and exiting the port to be deployed with an engine that meets or exceeds model year 2007 EPA emission standards by January 1, 2012. The fleet of clean harbor trucks in service in southern California are responsible for just under nine percent of all port emissions of particulate matter, down from 32 percent in 2007. Meanwhile, the truck fleet is responsible for about 18.5 percent of NOx emissions in 2012, down from almost 40 percent in 2007. Diesel particulate matter from harbor trucks fell almost 80 percent since 2007 and NOx emissions fell over 92 percent over the same period. vii

A mix of state and federal funding along with funding provided by port authorities has been available to help truck owners purchase newer equipment that meets cleaner emissions standards. For example, funding made available through the federal Diesel Emissions Reduction Act (DERA) between 2008 and 2010 provided roughly $64 million in matching funds for port related diesel emission reduction activities. Over one-third of port related funding, or $23 million was made available for the purchase of new trucks or retrofit kits to significantly reduce emissions form port trucks. vii As an example, the Port Authority of New York-New Jersey received $7 million in DERA assistance coupled with an additional $21 million in non-federal matching funds to help replace 636 older dray trucks with new equipment. Many states also provide similar funding programs as well as some port authorities that provide funds, no or low-interest loans and other efforts to provide equipment owners with resources to purchase new or newer equipment.
Railroads: Line Haul and Yard Switching Locomotives

Railroads are also responsible for moving cargo through ports. The most visible types of railroad equipment in use in ports are line-haul locomotives deployed with large engines typically between 3,000 and 4,000 horsepower and smaller switching engines. EPA regulations in place require the use of cleaner low sulfur diesel fuel, beginning in 2012, along with a phased-in set of emissions rules for new engines. Those final emissions regulations are set to be implemented in 2015 and will result in near zero emissions of particulate matter and oxides of nitrogen. Some railroads in southern California are experimenting with switching locomotives powered by natural gas.

In addition to new engine emissions standards, many seaports adopted strategies to encourage more efficient use of railroad equipment, such as idle reduction strategies, to reduce emissions. Seaports have also encouraged the adoption of innovative switching engines that reduce emissions.

### Emissions Rules for New Locomotive Engines

<table>
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<th>Tier</th>
<th>Emissions Standards</th>
<th>PM (g/bhp-hr)</th>
<th>NOx (g/bhp-hr)</th>
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<tr>
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**PM: 86% Reduction**

**NOx: 86% Reduction**

*Source: U.S. EPA*

### Innovative Clean Diesel Technology: Multi-Engine “GenSet” Switchers

Many ports around the country with large rail operations have incentivized the introduction of innovative technologies to reduce emissions from large switch engines. The technology deploys several smaller diesel powered engines with modern aftertreatment solutions in place of one large diesel engine. During conditions of light load, the switch locomotive may operate one engine at reduced power instead of operating one large engine at low power and thereby significantly reducing overall emissions. Two switcher locomotives were
repowered in the Port Authority of New York and New Jersey, funded in part through DERA grants. Over a five year period, these two switch engines are estimated to reduce NOx by 185 tons and 4.5 tons of PM while increasing fuel efficiency by 25 percent.\textsuperscript{viii}

**Cargo Handling Equipment**

Ports use a wide variety of specialized equipment to load, unload, shuttle, stack and sort various kinds of cargo. Much of this equipment is mobile, yet some of the equipment is stationary. While every port is different, cargo handling equipment typically accounts for 3-20 percent of the NOx and PM emissions.

In the Port of Los Angeles for example, about 65 percent of cargo handling equipment is powered by diesel engines. The remaining equipment is powered by natural gas, predominantly found in propane powered forklifts and yard tractors, and electricity that powers giant gantry cranes that load and unload cargo from ocean going vessels.\textsuperscript{ix}

A variety of regulations cover the emissions from diesel engines used in this equipment. EPA rules covering on-road engines include some trucks that are found performing cargo handling functions. Those rules, mentioned earlier, significantly reduce emissions to near zero levels beginning with model year 2007 engines. Other diesel-powered equipment, such as cranes and yard hostlers, is covered under special off-road emissions rules, Tier 4 rules, that also require newer engines to achieve significant near zero emissions of PM and NOx beginning with model year 2014.\textsuperscript{x}
Federal, state and local port authority funds are also available to retrofit older cargo handling equipment with technologies to significantly reduce emissions. Of the roughly $65 million awarded in federal diesel emissions grant funding between 2008 and 2010 for port activities, more that $16 million, or 25 percent, helped retrofit cargo handling equipment. As an example, the Puget Sound Clean Air Agency that encompasses the ports of Tacoma and Seattle, WA, received $850,000 in DERA assistance to retrofit 74 pieces of cargo handling equipment with diesel particulate filters and closed crankcase ventilation devices.

As a result of the introduction of new clean diesel engines and equipment, retrofit activities to improve the emissions from older equipment and electrifying some stationary engines, emissions from cargo handling equipment in many ports has fallen. The Port of Los Angeles estimates that cargo handling emissions of PM have fallen by about 60 percent and emissions of NOx fell by almost 50 percent between 2005 and 2012. The Ports of Seattle, Vancouver and Tacoma estimate that emissions of NOx from cargo handling equipment fell by almost 30 percent and emissions of PM fell by 40 percent between 2005 and 2011.
Harbor Craft

Seaports and river ports are home to many marine vessels and harbor craft that help larger vessels and cruise ships navigate narrow ship channels. Many large seaports are also home to active ferry terminals helping to transport commuters. Inland waterways and Great Lakes ports host a large population of barges and the workboats that propel these crafts. These ferries and workboats are almost exclusively powered by diesel engines. Many of these vessels will have one or more diesel engines for prime power and may also have another set of engines to provide auxiliary electrical power.

EPA regulations in place governing new off-road engines such as those found in cargo handling equipment and locomotives also apply to harbor craft. A phased-in approach was applied beginning in 2004 to implement these emissions standards and fuel requirements. Those rules will require Tier 4 standards to be met between 2014 and 2015, depending on the size of the engine, applied to new engines found on many tugboats, towboats, Great Lake freighters and stationary or auxiliary engines. According to the EPA, these Tier 4 rules will reduce PM by 90 percent and NOx by 80 percent.

Upgrading or replacing older marine engines is the largest category of engines receiving federal incentive funding. Of the roughly $65 million made available to upgrade or replace older engines in port service through the DERA program, almost half of funding, or $30 million, was awarded to projects that included engines on harbor craft and other vessels. As an example, the New York City Department of Transportation was awarded $2 million to help upgrade four older engines on a Staten Island Ferry while the Port of Houston was awarded $2.86 million to upgrade or replace 96 older marine engines. xi

Conclusion
America relies on its sea and river ports to deliver economic growth and provide jobs to more than 13 million workers. Clearly, America’s ports rely on diesel engines and fuel to make sure that products reach store shelves, and manufacturers receive inputs while U.S. exports reach markets overseas. While the economy is growing reliant on international trade, the equipment that moves this commerce is growing cleaner. New and newer diesel engines increasingly power the many trucks, trains, vessels and equipment that deliver commerce.

Additional Resources
• Diesel Technology Forum: www.dieselforum.org
• American Association of Port Authorities: www.aapa-ports.org
• U.S. Environmental Protection Agency, Office of Transportation and Air Quality: [http://www.epa.gov/otaq/](http://www.epa.gov/otaq/)
• Port of Los Angeles Emissions Inventory (2012): [http://www.portoflosangeles.org/pdf/2012_Air_Emissions_Inventory.pdf](http://www.portoflosangeles.org/pdf/2012_Air_Emissions_Inventory.pdf)
• Port Authority of New York-New Jersey, Port Commerce Department, 2010 Multi-Facility Emissions Inventory: [http://www.panynj.gov/about/port-initiatives.html](http://www.panynj.gov/about/port-initiatives.html)

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iii Port of Los Angeles Inventory of Air Emissions 2012
iv International Maritime Organization, Marpol Annex VI: [http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx](http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx)
v The American Association of Port Authorities maintains a complete listing of clean port truck programs: [http://www.aapa-ports.org/Issues/USGovRelDetail.cfm?itemnumber=17444](http://www.aapa-ports.org/Issues/USGovRelDetail.cfm?itemnumber=17444)
vi Port of Los Angeles Inventory of Air Emissions 2012
ix Port of Los Angeles Inventory of Air Emissions 2012
x Port of Los Angeles Inventory of Air Emissions 2012; Puget Sound Maritime Air Emissions Inventory 2011;