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The Good Haul

Innovations That Improve Freight Transportation *and* Protect the Environment

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Innovations That Improve Freight Transportation *and* Improve the Environment

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Cover photos (clockwise from top right): Nippon Yusen K.K. and Nippon Oil Corporation's solar power-assisted vessel, the MV Auriga Leader, courtesy NYK Line; truck stop electrification, courtesy Jennifer Witherspoon; Norfolk Southern's battery-powered switching locomotive, courtesy of Norfolk Southern Corporation.

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Executive summary

Solar powered ships. High-tech GPS truck tolling systems. Advanced diesel-electric engines. These are just a few of the technologies that the freight sector is using to reduce the pollution that comes from moving goods.

Trade is the lifeblood of the global economy, but it comes at a high price for the environment and local communities. Moving freight creates traffic congestion, greenhouse gas emissions, toxic air pollution and noise in local communities. Without thoughtful infrastructure and operations improvements, projected increases in trade threaten to make these problems worse and place greater strains on the nation's aging infrastructure. By 2020, 90.1 million tons of freight per day are expected to move throughout the United States, a 70% increase from 2002.[1]

Generally, freight transportation—how to keep it functioning well and how to reduce its environmental and community impacts—has received little policy attention domestically or internationally. This has begun to change as trade becomes more international, infrastructure ages, and environmental damages worsen.

This report addresses the three principle freight modes: trucking, rail and ships. It focuses on real-world, innovative solutions that reduce pollution and increase freight transportation efficiency. While most of these solutions are in place somewhere in the world, they have not been widely adopted in the United States.

We focus on a handful of exemplary projects; there are many more that hold promise, such as on-dock rail initiatives and various technologies still in research stages. We discuss ten categories of innovative projects that are working right now to improve freight transport while reducing its environmental impacts:

- Port and corridor cleanup plans
- Shoreside power
- Ship cleanup
- Coastal shipping
- Rail yard and port cargo handling equipment
- Diesel engine emissions reductions and incentives
- Truck tolling
- Truck stop electrification
- Logistics
- On-the-horizon technologies for rail, port and maritime

Each case study is evaluated based on environmental benefits, co-benefits and economic benefits. We also touch on funding sources. For the purpose of this report, we define co-benefits as any health, quality of life or time-saving benefit that goes beyond emissions reductions or cost savings.

Widespread adoption of the solutions outlined in this report would help create a modern freight system that is cleaner and more efficient, supports a strong economy and creates stable jobs.

Introduction

The U.S. freight sector faces a serious challenge in the coming years. By 2020, 90.1 million tons of freight per day are expected to move throughout the United States, a 70% increase from 2002.[1] Goods now travel faster, farther and for less cost per unit than a decade ago. In addition to using a wider web of global trade, many businesses have adopted the strategy of "Just in Time" shipping, keeping inventory at a minimum, saving valuable warehouse space and increasing investment returns. This strategy places greater demand on energy-intensive transportation to meet tight delivery schedules.[2] One result has been a decrease in vehicle load size, meaning more vehicle trips and greater system congestion and emissions.[3]

Expected trade increases will place greater strains on our highway, rail and waterway systems and test their safety. The domestic trucking sector loses an estimated $8 billion per year as a result of clogged roads, and projected increases will likely worsen congestion and increase the risk of accidents. The average U.S. bridge is 43 years old; 47% of locks are functionally obsolete; and major investments are necessary to keep aging roads safe for both people and goods.[4] On top of concerns about the system's safety and capacity, the freight sector must address its environmental and societal impacts.

The environmental and social costs of freight

Transportation accounts for a third of global energy consumption, and freight movement represents nearly a quarter of the transportation sector, or approximately 8% of total global carbon dioxide emissions.[5] The freight sector's greenhouse gas emissions have increased 58% since 1990. This increase is double that of passenger travel (27%), which has significantly more environmental regulations aimed at improving vehicle efficiency, lowering emissions and mandating cleaner fuels.[6]

Freight is also a major source of health-threatening air pollutants, including diesel soot, sulfur and the major components of ground-level ozone or smog. These pollutants are linked to premature death, asthma, lung cancer, low birth weight and cardiovascular illness. The U.S. Environmental Protection Agency (EPA) classifies pollution from diesel engines—the most common engines used in freight—as a toxic air contaminant responsible for 20,000 premature deaths annually.[7]

In California—where the Ports of Los Angeles and Long Beach handle more than 45% of U.S. ship-borne freight—the California Air Resources Board estimates that the health costs from freight-related air pollution in 2005 amounted to more than $19.5 billion. Freight-related pollution was responsible for about 2,400 premature deaths, 2,000 respiratory-related hospital admissions, 62,000 asthma and lower respiratory cases, 360,000 lost work days, and 1.1 million lost school days. The agency estimated that every dollar spent on reducing freight-related pollution would produce long-term health and productivity benefits between $3 and $8.[8]

Pollutants from freight movement affect neighborhoods along busy corridors and near ports.[9] These neighborhoods are often made up of low-income residents. Noise and vibrations from trucks and equipment keep residents up at night, affecting sleep patterns and school performance.[10] Levels of cancer and other health problems are also higher in these communities.

The West Oakland community abuts the Port of Oakland, the fourth largest port in the United States.[11] West Oakland residents inhale three times as much diesel particulate matter as residents of the entire San Francisco Bay Area, and it is estimated that 71% of cancer risk from diesel particulate matter originates from port-related activities.[12] The community's life expectancy is ten years lower than residents of other Oakland communities. In Southern California, where operations from the Ports of Los Angeles and Long Beach, as well as truck traffic along I-710, disproportionately affect low-income residents, a study revealed that women had a 128% and 91% higher risk of premature delivery (prior to 30 weeks) due to exposure from nitrogen oxides and particulate matter, respectively.[13] These are only some of the health consequences that these communities must bear.

Trucks, trains and ships: inside freight modes

Each of the major freight modes—trucks, trains and ships—has advantages and disadvantages. Trucking is the most flexible, and more than 80% of U.S. cities and towns are served exclusively by trucks. In 2006, trucks moved 61% of all freight in the U.S. by weight.[14] They are often indispensable for the "last mile" of a product's journey from factory to storefront. However, trucks are also the most fuel-intensive freight mode, emitting tons of greenhouse gases and unhealthful pollutants.

Rail freight is three times more fuel efficient than trucking and is a flexible and efficient way to move bulk commodities long distances since containers can easily move from ship to rail to truck.[15] Although rail is considerably more fuel efficient, increases in tonnage typically require additional diesel fuel, which reduces the magnitude of the environmental benefits. Moreover, older rail locomotives and a great deal of rail yard equipment are highly polluting. Rail yard sites create noise and pollution in surrounding neighborhoods.

The increase in international trade over the past decades has placed a high premium on ocean-going vessels. Every year ships make more than 10,000 visits to U.S. ports, and West Coast ports are expected to experience a 138% increase in container traffic by 2035.[16] Maritime shipping is efficient in terms of goods moved per mile. However, ships use heavily polluting bunker fuel. Also, the sector has few regulations, partly because the majority of ships serving U.S. ports are foreign flagged. Such ships are governed primarily by an international regulatory system, leaving the United States with limited ability to independently regulate the sector's emissions.

Each mode of moving freight requires infrastructure, facilities and related ground equipment that add to greenhouse gas emissions, unhealthful pollution and congestion. Most of this equipment uses highly polluting fuels—either bunker fuel or high sulfur diesel fuel—and the turnover to new and cleaner engines is slow. The concentration of freight at various facilities also contributes to congestion, especially in metropolitan areas. By delaying shipments and slowing mobility overall, congestion affects not just the environment, but also the local economy.

Port of Long Beach

West Coast ports are expected to see a 138% increase in container traffic by 2035, worsening congestion.

What's in this report: case studies of best practices

Several players within the freight movement sector have taken steps to reduce greenhouse gases and other pollutants. This report aims to showcase these leaders, highlighting innovative programs that are environmentally, economically and socially effective but not yet universally adopted.

This report addresses the three principle freight modes: trucking, rail and maritime. Air freight will not be addressed as 60% of air cargo travels in the belly of passenger planes, and policies and regulations vary in this area. Within and overlapping these modes are intermodal components, such as port and corridor facilities, cargo handling equipment and supply chain innovations that improve door-to-door logistics.

The United States needs national programs and policies to make our freight system more effective now and in the future. This report provides examples of real-world freight transportation innovations that can help the economy, create and support good jobs, and reduce environmental impacts.

U.S. freight regulations

Generally, freight transportation—how to keep it functioning well and how to reduce its environmental and community impacts—has received little policy attention domestically or internationally. That has begun to change as trade has become more international, as older infrastructure has reached the end of its functioning life, and as environmental impacts have increased.

Federal transportation laws

In response to the 1990 Clean Air Act amendments, Congress adopted the Intermodal Surface Transportation Efficiency Act (ISTEA) in 1991, which contained the Congestion Mitigation and

Six common criteria pollutants

EPA sets standards for six "criteria" pollutants that are known to affect local air quality and public health.[17]

1. **Carbon monoxide (CO):** A gas created when the carbon in fuel is not completely burned. Health impacts include cardiovascular, nervous and respiratory system problems.
2. **Nitrogen oxides (NO_x):** Nitrogen oxides are a group of reactive gasses. While EPA's National Ambient Air Quality Standard is designed to protect against exposure to the entire group of nitrogen oxides, EPA sets standards for nitrogen dioxide (NO_2). Nitrogen oxides come from combustion. Inhalation can lead to asthma and respiratory illness, and they combine with other pollutants to create ozone and particulate matter.
3. **Lead:** Lead emissions come from industrial sources, and to a lesser extent from motor vehicles. Exposure can harm the kidneys and the nervous, immune, reproductive, developmental and cardiovascular systems.
4. **Sulfur dioxide (SO_2):** This highly reactive gas comes from power plants, industrial facilities and diesel fuel used in locomotives, ships and non-road engines. Short-term exposure can cause serious respiratory problems.
5. **Particulate matter (PM):** Made up of dust, soil, metals, acids and organic compounds, these particles are found near dusty areas, in forest fire smoke, and in diesel fuel exhaust. $PM_{2.5}$ is less than 2.5 micrometers (an average human hair is 70 micrometers), whereas PM_{10} is between 2.5 and 10 micrometers. Both lead to heart and lung problems. $PM_{2.5}$ from diesel soot is especially toxic.
6. **Ozone (O_3):** Ozone is created when nitrogen oxides (NO_x) react with volatile organic compounds from engine combustion. At ground level, ozone combines with sunlight to create smog, which impacts visibility and can cause respiratory diseases.

Greenhouse gases

These pollutants trap the sun's heat within the Earth's atmosphere. The increased burning of fossil fuels since the Industrial Revolution has exacerbated the natural carbon cycle and led to a warming of the Earth's climate. Climate change will lead to new rainfall patterns, an increase in catastrophic weather events, sea level rise, and a range of impacts on wildlife, plants and humans.[18] The most important manmade greenhouse gases include:

- **Carbon dioxide (CO_2):** This gas is emitted through the burning of fossil fuels and naturally through the carbon cycle.
- **Methane:** This gas is more potent than carbon dioxide and is emitted from a variety of sources, including agricultural practices and the transport of coal, natural gas and oil.
- **Nitrous oxide:** This gas is created from agriculture sources, sewage treatment and fossil fuel combustion. Nitrous oxide is also produced naturally.
- **Fluorinated gases:** These gases are produced through industrial processes, including semiconductor processing and electrical transmission. Usually emitted in small amounts, these gases are very potent and are called High Global Warming Potential gases based on their impact on the atmosphere.

Air Quality (CMAQ) Improvement Program. CMAQ provided $6 billion for surface transportation and other projects to improve air quality and reduce congestion. CMAQ was reauthorized in 2005 under the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU). SAFETEA-LU's CMAQ program authorized more than $8.6 billion from 2005 to 2009 for local and state agencies to invest in projects that reduce air pollution from transportation-related sources.[19]

Though CMAQ is a start, SAFETEA-LU has few freight movement provisions and lacks comprehensive freight movement language. Efforts at regulating greenhouse gas emissions and air pollution from freight transportation vary from state to state. State and national programs that have successfully reduced pollution remain only voluntary.

Federal regulations

Several promising steps have been taken to clean up locomotive, marine and heavy-duty truck engines and fuel. In December 2000, EPA announced its plan to mandate ultra-low sulfur diesel (ULSD) fuel. ULSD reduces sulfur compounds that contribute to acid rain, and allows pollution control devices to function effectively, reducing nitrogen oxides and diesel particulate matter. EPA required ULSD to have a sulfur content of 15 parts per million by weight (ppmw) for on-road vehicles by mid-2006, down from the former 500 ppmw maximum standard. In 2007, EPA also began a slow phase-in of ULSD for non-road vehicles.

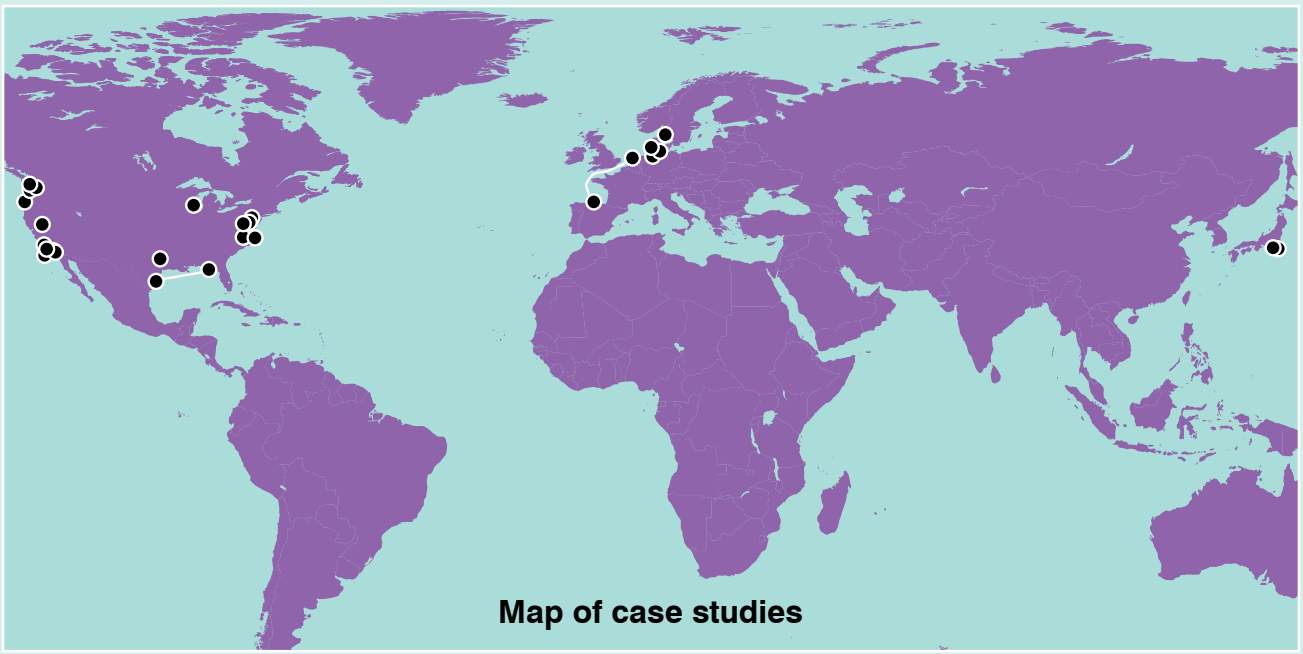
In addition to the ULSD requirements, EPA enacted heavy-duty highway engine regulations in 2001, which were phased in from 2007 to 2010. The rules place stricter regulations on particulate matter, nitrogen oxides and non-methane hydrocarbons and are intended to reduce emissions by 95%.[20,21]

In March 2008, EPA adopted strong emissions limits for locomotive and marine engines. The regulation follows three strategies: it sets more stringent emissions standards for remanufactured locomotive and marine engines; creates standards, phased-in starting in 2009, for newly rebuilt locomotive and marine engines; and sets standards for new marine and locomotives diesel engines beginning in 2014 and 2015, respectively. The new engine standards are based on advanced engine technology that requires ULSD fuel, which will be available nationwide by 2012 for off-road engines.[22]

California regulations

California was an early champion of ULSD standards for diesel fuel, limiting the sulfur content to 500 ppmw beginning in 1993. The standards were amended in 2003 to align with EPA on-road diesel fuel requirements of 15 ppmw. Unlike the federal requirement, the California requirement applied to both on-road and off-road engines, starting in mid-2006.[23]

California has also pioneered regulations for bunker fuel from ocean-going vessels, requiring the use of low sulfur marine distillates within 24 nautical miles (28 miles) of the coastline in main and auxiliary engines. The regulation, applying to both international and domestic vessels, was enacted in July 2008, and will be phased in between 2009 and 2012. By 2012, the rule will reduce sulfur dioxide by 95% and nitrogen oxides by 6%.[24] The International Maritime Organization (IMO), the United Nations agency concerned with the prevention of marine pollution from ships, also adopted more stringent sulfur regulations, and the United States and Canada are set to vote on expanded Sulfur Emissions Control Areas (two currently exist in the Baltic Sea and the North Sea) in March 2010.[25,26] Like EPA's and California's ULSD regulations, these are promising steps but there is room for further reductions and voluntary actions.



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CHAPTER 1

Port and corridor cleanup plans

In coastal U.S. cities, ports are often the single largest polluter, generating diesel emissions from tugboats, ferries, cargo handling equipment, trucks and locomotives.[1] Each cargo ship alone emits several thousand times more sulfur and particulate emissions than legally allowed for on-road vehicles.[2]

The ten busiest U.S. ports have taken steps to reduce diesel emissions.[3] However, only some have created comprehensive cleanup plans to address a wider range of environmental impacts, including air quality, greenhouse gas emissions and noise. The Ports of Los Angeles and Long Beach were the first to adopt a comprehensive plan to curb criteria pollution in all sectors of port operations. The Port of Seattle has begun to address greenhouse gas emissions, which have only recently become a concern of the maritime industry.

Rail yards also face daunting congestion and pollution problems, especially for adjacent communities. Traditionally, planning for rail yards has focused on reducing congestion by constructing additional rail lines and transfer facilities. Future growth projections indicate that a new strategy will be required: expansion may provide only a temporary fix for congestion and pollution problems. Rail yards and intermodal facilities, which transfer goods between trucks and rail, also need comprehensive cleanup plans similar to those adopted for ports. The Chicago Region Environmental and Transportation Efficiency Program presents a good first step.

Interstate highway corridors with heavy truck traffic also could use comprehensive cleanup plans; however, we were unable to locate any examples of such a plan. (See Truck Stop Electrification for examples of programs aimed at reducing idling at truck stops).

PORT AND CORRIDOR CLEANUP PLANS CASE STUDY #1

Chicago Region Environmental and Transportation Efficiency (CREATE) Program

One-quarter of the nation's rail freight volume travels through Chicago. The region's three rail corridors handle approximately $350 billion worth of freight each year. The traffic handled by these corridors accounts for about $10 billion, or 29%, of the revenues earned by U.S. Class I freight railroads.

Freight traffic within Chicago is forecast to increase 23% from 2002 to 2015 and 89% from 2002 to 2035. To meet the increasing demand, address environmental issues and reduce congestion, the U.S. Department of Transportation, the State of Illinois, the City of Chicago, Amtrak, the nation's freight railroads and the local commuter rail, Metra, partnered to develop the Chicago Region Environmental and Transportation Efficiency (CREATE) Program in 2003.[4] Federal funding was authorized in 2005 and appropriated in 2007. As of September 2009, more than 30 projects had yet to go through the planning and development stage, putting final completion of CREATE several years down the road.

CREATE focuses on Chicago's four major rail corridors: three freight rail corridors and one passenger rail corridor. The program is comprised of 71 projects, including 25 new roadway

overpasses and underpasses; six new rail overpasses and underpasses to separate passenger and freight train tracks; viaduct improvements; grade crossing safety enhancements; and upgrades to tracks, switches and signal systems. Although CREATE is not specifically a cleanup plan, the project contains elements that will lead to a less-polluting freight system, and has the specific goals of reducing rail and motorist congestion, improving air quality and enhancing public safety and economic development.[5] CREATE demonstrates that, when planned right, freight infrastructure improvements can go hand-in-hand with protecting the environment.

Environmental benefits

- Projected annual pollution reductions from locomotives after CREATE projects are completed: 1,453 tons of nitrogen oxides, 225 tons of carbon monoxide, 80 tons of volatile organic compounds and 51 tons of particulate matter.

CREATE Program

Streamlined train and road systems will reduce congestion in Chicago, which handles one-quarter of the nation's rail volume.

- Decreasing highway congestion will reduce emissions from vehicular traffic. Projected annual pollution reductions from vehicles: six tons of nitrogen oxides, 213 tons of carbon monoxide and 24 tons of volatile organic compounds.
- The cleaner air will be equivalent to seven smog-free days every summer.[6]

Co-benefits

- Railroad operations improvements are predicted to reduce diesel fuel consumption by 7 to 18 million gallons.[7]
- CREATE is expected to make roads safer and mitigate property damage. Safety benefits are estimated at $94 million. Safety benefits from the 25 crossings alone are estimated at $32 million through 2042.[8]
- New overpasses and underpasses at railroad crossings will save drivers approximately 3,000 hours per day, and motorist delays at grade crossings will be reduced by 27%.[9]
- Traffic rerouting will free up available land, which will be converted to parkland and residential and commercial developments.

Economic benefits

- The air quality improvements will translate to $1.12 billion in reduced health care and loss of life costs over a 40-year planning horizon (2003–2042).[10]
- The construction-related benefits will include an estimated annual average of 2,700 full-time jobs and more than $365 million in output. During the peak year of construction, the CREATE Program will employ nearly 4,000 workers and generate economic activity valued at more than $525 million.
- The value of the time that will be saved by current and additional rail commuters between 2003 and 2042 is estimated to be $190 million, in 2003 dollars.[11]
- The reductions in driver delay because of improvements at rail crossings, train reroutings and more fluid train movement between 2003 and 2042 is estimated to be $202 million, in 2003 dollars.[12]
- Improvements to Metra, the local commuter rail line, will reduce vehicle miles traveled by an estimated 34 million miles per year, avoiding $77 million in highway construction. Additional time savings will be realized as current Metra riders switch travel patterns and drive shorter distances.[13]

Funding

Private and public contributions fund the CREATE Program. The six railroad partners and Metra each provided $232 million, an amount equal to their expected economic benefits. Federal, state and local funds will fill the remaining need; this includes a $100 million authorization from the federal SAFETEA-LU bill. Additional federal funds will be needed to complete the planned projects, and program proponents will be requesting $700 million in the next federal transportation bill.[14]

PORT AND CORRIDOR CLEANUP PLANS CASE STUDY #2

The Ports of Los Angeles and Long Beach

In 2006, the Ports of Los Angeles (POLA) and Long Beach (POLB) adopted the most assertive port cleanup plan in the nation, the Clean Air Action Plan (CAAP). The goal is to reduce health

Port of Los Angeles

The ports of Los Angeles and Long Beach handle 45% of the nation's containerized goods. Cleaning up these ports will improve local air quality and reduce greenhouse gas emissions.

risks from port-related air pollution and attain federal ozone and particulate matter standards while expanding throughput. The CAAP establishes uniform air quality standards and uses a variety of mechanisms, including lease requirements, tariffs and incentives, to reduce nitrogen oxides, sulfur dioxide and diesel particulate matter emissions.

The two ports together handle 45% of the nation's containerized goods, generating $28 billion in state and local revenue and 3.3 million jobs nationwide annually.[15] Port operations also contribute over 25% of all criteria pollutants to the Los Angeles region.[16] The South Coast Air Quality District's Multiple Air Toxics Exposure Study concluded that diesel particulate emissions contributed to 71% of cancer risk for residents of the Los Angeles Metropolitan Area.[17]

While legal hurdles, most notably a lawsuit against the Clean Trucks Program by the American Trucking Association, have delayed some aspects of the CAAP timeline, others are continuing as planned.[18] The plan targets all port-related emissions sources: ships, trucks, trains, cargo handling equipment and harbor craft, with specific plans and benchmarks:

- All 16,800 "dirty" diesel trucks will be retrofitted or retired by 2011 through the Clean Trucks Program.
- All major container and cruise ship terminals will be equipped with shoreside power within five to ten years. Ships are required to reduce their speed within 24 nautical miles of the ports and switch to 2,000 ppm sulfur marine fuel in the auxiliary engines. Ships are also requested to use low sulfur fuels at berth when not using shore power.
- All cargo handling equipment will be replaced or retrofitted by 2011 to meet the most stringent EPA emissions standards.
- All switching locomotives will meet the most stringent EPA emissions standards, use cleaner diesel and employ automatic anti-idling devices within the first five years of the plan.
- A "Technology Advancement Program" identifies and evaluates emerging technologies. It is a collaboration between the ports, the California Air Resource Board, the South Coast Air Quality Management District, U.S. EPA and tenants.

Environmental benefits

- By 2011 the plan aims to eliminate 47% of diesel particulate matter (1,200 tons per year); 45% of nitrogen oxides (12,000 tons per year); and 52% of sulfur dioxide emissions (8,900 tons per year).
- While greenhouse gases are not specifically addressed in the CAAP, none of the emissions reductions measures will increase greenhouse gases and some will reduce them. As of October 2009, the Clean Trucks Program had already taken 2,000 of the most polluting trucks off the road, reducing truck-related emissions by 80%.[19]

Co-benefits

- The CAAP was translated into six languages, and is available at local libraries and on the Internet. The ports also conducted several outreach meetings, improving their relationship with local communities.
- Diesel engine replacements and retrofits will reduce noise and noxious odors.[20]
- Additional security and screening measures are included in the CAAP.[21]

Economic benefits

- Revenues from the CAAP, such as the Cargo Fee, are applied toward traffic flow improvements, helping increase throughput and save time.[22]
- The CAAP will provide additional jobs. At the Port of Los Angeles alone, the CAAP has provided 3,239 jobs in the following areas:
  - The Technology Advancement Program's demonstration and evaluation projects have created 37 one-year-equivalent jobs.
  - Diesel retrofits and replacements have provided 52 one-year-equivalent jobs.
  - Shoreside power, or Alternative Marine Power, has provided 645 one-year-equivalent jobs through 2014.
  - Construction on projects funded via the CAAP have supported 2,505 one-year-equivalent jobs through 2012.[23]

Funding

The Port of Los Angeles has committed $177.5 million, the Port of Long Beach $240.4 million, the South Coast Air Quality Management District $47 million, and bond/impact fee funding an additional $1.6 billion. The Carl Moyer Memorial Air Quality Standards Attainment Program, a state-administered diesel cleanup grant program, has supplied money for cleaning up port vehicles. The average grant is $20,000–$25,000 per engine. EPA's CleanPorts USA and SmartWay Transport Partnerships supply grants between $75,000 and $150,000 for air pollution control programs. The EPA/West Coast Collaborative is another source of funding, as are the Department of Energy's Clean Cities Program and the Department of Transportation's Congestion Mitigation and Air Quality Improvement Program.[24]

PORT AND CORRIDOR CLEANUP PLANS CASE STUDY #3

The Port of Seattle

The Port of Seattle is the eighth largest seaport in the United States, handling almost two million containers in 2006. Although Seattle, unlike Los Angles and Long Beach, is in attainment of federal air quality standards, its first ever inventory of maritime-related emissions, the Puget Sound Maritime Air Emissions Inventory (EI) of 2005, found that maritime sources account for 33% of

Courtesy of Port of Seattle

The Port of Seattle's Seaport Air Quality Program works to clean up all port-related activities and equipment.

sulfur dioxide emissions in the region, 28% of diesel particulate matter and 11% of nitrogen oxide emissions. Because the port is in attainment of federal standards, Seattle's Seaport Air Quality Program is voluntary. In addition to criteria pollutants, the plan also focuses on greenhouse gases.[25]

Seattle's action has spurred a regional clean air plan. In 2008, the ports of Seattle, Tacoma and Vancouver agreed to voluntarily adopt the Northwest Ports Clean Air Strategy. The three primary objectives are to reduce maritime and port-related air quality impacts on human health, the environment and the economy; reduce contributions to climate change through associated co-benefits; and ensure that the Georgia Basin–Puget Sound airshed continues to meet air quality standards and objectives.[26]

Plans at the Port of Seattle address the following areas:

- Cargo handling equipment: Working with EPA, the Washington Department of Ecology and the Puget Sound Clean Air Agency, the port has retrofitted and replaced cargo handling equipment at privately operated container terminals. As of 2009, all eligible cargo handling equipment has been retrofitted with cleaner engines.
- Marine terminals: Prior to EPA's ULSD regulations, terminal operators voluntarily switched to ULSD and biodiesel blends for non-road equipment, adopted anti-idling practices and opted for cleaner on-road engines for new equipment.[27]
- At-Berth Clean Vessels Incentive Program (ABC Fuels): This program provides a $1,500-per-call incentive to vessels that use 0.5% (or lower) sulfur fuel in auxiliary engines while at berth, which is 80% cleaner than the heavy fuel oil typically used. Since the program's inception in January 2009, eight shipping lines representing more than 35% of all vessel calls made in 2008 (265 out of 755) have signed up to participate in ABC Fuels.[28]
- Clean Truck Plan: Partnering with the Puget Sound Clean Air Agency, the Port's Clean Truck Plan is fee-free, allowing truck drivers to turn their old trucks in for scrap. Truckers receive $5,000 or the Kelley Blue Book value, whichever is greater. All trucks must meet federal 1994 $PM_{2.5}$ standards by 2010; 80% of trucks must meet federal 2007 standard by 2015; and 100% must meet the 2007 standard by 2017.[29]
- Shore power for cruise terminals (see Shoreside Power).

Environmental benefits

The plan aims to reduce criteria pollutants and greenhouse gases. The port has not set percentage reductions for specific pollutants, but has set fuel goals (see above) to achieve greenhouse gas and criteria pollutant reductions.[30] The port expects to have an updated emissions inventory by 2011.

Co-benefits

- Radio frequency identifications (RFIDs) for containers and drawbridge opening alerts reduce congestion and increase throughput.
- The cleanup plan involved more than 60 meetings with representatives from industry, labor, environment, government and local community groups, fostering stronger relationships.

Economic benefits

- The fee-free Clean Truck Plan provides an incentive for drayage truck drivers to replace their old, polluting trucks. (See details in Funding section.)
- The Port's Customer Support Package provides one year of support to Marine Terminal Operators through direct and deferred cost reductions in exchange for compliance with the clean truck program and cargo handling equipment standards.[31]

Funding

For the fee-free trucking program, the port will contribute $2.3 million to the Puget Sound Clean Air Agency (PSCAA) for air emission reduction programs. The PSCAA will administer the funds and offer programs for drivers including buy-back and scrapping of pre-1994 trucks. The Port also received $35,000 in 2005 from EPA for its Diesel Emissions Reduction Project, along with $70,000 in matching funds from additional sponsors.[32] The emissions inventory project was funded through $100,000 in EPA grants and $310,000 in matching grants from other groups. The Cargo Handling Equipment Replacement and Retrofit Program received $850,000 through EPA grants and $318,000 from the PSCAA and the ports of Seattle and Tacoma.[33]

CHAPTER 2

Shoreside power

Shoreside power, or "cold-ironing," provides an alternative source of energy so that ships can turn off their heavily polluting diesel auxiliary engines and use electric power while at berth. Shoreside power is one of the most promising pollution control strategies for port operations.[1] Ships can maintain communications, pumps, lighting, ventilation and additional onboard equipment without the exhaust gases, soot, particulates and noise that accompany auxiliary engine use. While the benefits of shoreside vary from port to port, at the Port of Long Beach, for example, one day of shoreside power removes the equivalent of 33,000 cars from the road for a day, eliminating nitrogen oxides, particulate matter, hydrocarbons and carbon dioxide emissions.[2]

Shoreside power is not a new technology; however, its widespread adoption is hampered by voltage differences between ports and ships and low voltage connections that require several heavy cables as opposed to a standard, high voltage 400V cable. Efforts have been made to standardize these voltage differences. A recent Publically Available Specification by the International Organization of Standards and the International Electrotechnical Commission outlines technical data for ports and shipping companies, facilitating the widespread adoption of shoreside power.[3] An additional constraint on shoreside power is that its environmental effectiveness is dependent on the local electricity source.[4]

The Port of Gothenburg, Sweden, BP's liquid bulk terminal in Long Beach and the Port of Seattle's Terminal 30 for cruise ships all have overcome technical and local constraints to provide shoreside power, improving the quality of life for workers and port communities.[5]

SHORESIDE POWER CASE STUDY #1

The World's first shoreside power for RORO vessels, Gothenburg, Sweden

The Port of Gothenburg worked with Stora Enso, a global paper company, to create the first electrical connection for roll-on/roll-off (RORO) vessels in 2000. Unlike lift-on/lift-off (LOLO) vessels, which require a crane to unload, RORO vessels have cargo (cars, trucks or trailers) that can be wheeled on and off the vessel.

Gothenburg offers two quays at the RORO terminal with onshore power, and six Stora Enso vessels regularly use these electrical connections.[6] The shoreside electricity is provided by a 6–20 kV high voltage cable, and an on-board transformer reduces the voltage to 400 V. In the RORO terminals, 30% of all calls use shore power. The average harbor stay for a RORO is approximately 5,000 kWh—the equivalent of three months of electricity use by a detached house. The shore-connected electricity in the RORO terminal in Gothenburg is generated from two local wind turbines.

Gothenburg has produced a guide for ports to implement shoreside power through the World Ports Climate Initiative (WPCI) and has created a web site to disseminate information which will be launched in spring 2010.[7]

Port of Gothenburg

The Port of Gothenburg's shoreside power eliminates 882 tons of carbon dioxide annually.

Environmental benefits

- Shoreside power for ROROs eliminates 882 tons of carbon dioxide annually.[8]
- In total, RORO shoreside power eliminates 94–97% of criteria pollutants. Annually, shoreside power eliminates 80 tons of nitrogen oxides, 60 tons of sulfur dioxide and 2 tons of particulate matter at the port.[9]

Co-benefits

Shoreside power eliminates all noise, noxious fumes and vibrations from the auxiliary engine, creates a better and safer environment for workers, and improves the quality of life for neighboring communities.[10]

Economic benefits

Shoreside power via two local wind turbines saved 598 megawatt hours of electricity in 2006 alone.

Funding

A creative cooperation was developed between the owners of the six Stora Enso ships, Cobelfret and Wagenborg Shipping, and the supplier of the electrical equipment, ABB. The Swedish Environmental Agency provided a 2.4 million euro grant ($3.4 million).[11] The total cost for installation and maintenance varied between 60,000 and 500,000 euros per quay. The Port of Gothenburg supplied approximately 250,000 euros for each quay.[12]

SHORESIDE POWER CASE STUDY #2

The Port of Long Beach tanker berth

In 2007, the California Air Resources Board issued a regulation that requires all container, refrigerated cargo and passenger ocean-going vessels to use shoreside power at the ports of Los Angeles, Long Beach, Oakland, San Francisco, San Diego and Hueneme. This regulation begins in 2010, with a goal of 80% shoreside power by 2020.[13] In response, BP has retrofitted

two tankers and Long Beach's Pier T for shoreside power, supplying 8 megawatts of power at 6,600 volts to the *Alaskan Navigator* and the *Alaskan Frontier*, two oil tankers with regular routes between Valdez and Long Beach.

The Port of Long Beach currently has three terminals with shoreside power in addition to BP's Pier T: International Transportation Service's Terminal G, SSA Terminals/Matson Navigation's Pier C and Mitsubishi Cement Corporation's Terminal F.[14] The Port of Long Beach has plans for nine container berths with shoreside power, and has mandated shore power for all frequent callers by 2014.[15]

One challenge is the energy source for shoreside power. Unlike Gothenburg, the Port of Long Beach is supplied mostly through coal-fired power plants. While the port anticipates that the city's power source will become more environmentally friendly in years to come, this is an important consideration.

Port of Long Beach

BP's shoreside power partnership with the Port of Long Beach reduces noise and auxiliary engine vibration, creating a cleaner work environment.

Environmental benefits

- It is estimated that the oil tanker berth will remove 30 tons of air pollution annually, the equivalent of taking 187,000 cars off the road.
- The project is expected to reduce emissions by at least 2.2 tons of nitrogen oxides and 0.8 tons of diesel particulate matter each year.[16]

Co-benefits

Shoreside power eliminates all noise, noxious fumes and vibrations from the auxiliary engine, creates a better and safer environment for workers and improves the quality of life for neighboring communities.[17]

Economic benefits

- The project will save 10,000 gallons of diesel fuel per day.[18]
- Approximately 145 new jobs were created.[19]

Funding

The project cost $23.7 million and was completed in three years. The port contributed $17.5 million and $6.2 million came from BP America.[20]

SHORESIDE POWER CASE STUDY #3

Port of Seattle Terminal 30 Cruise Facility, Seattle, WA

The ports of Seattle and Juneau, Alaska, are the only two ports in the United States to offer shoreside power to cruise ships, and the Port of Seattle is the only port that allows two ships

Princess Cruises

In Seattle, electricity plugs right into the ship's power unit, saving fuel and reducing emissions.

to simultaneously plug into the city grid.[21,22] The first shoreside power was built for Princess Cruises in 2004, and a second facility was built for Holland America in 2006. Seven Princess Cruise vessels and three Holland America vessels have been retrofitted to connect with the local electrical network via four 3.5-inch flexible electrical cables. Seattle's shoreside power uses hydroelectric grid power from the local utility, Seattle City Light, and is stepped down from 27 kV to 11kV by a dual voltage transformer.

Environmental benefits

- The ships were able to cut their emissions by 29% annually, leading to a reduction of 7.7 tons of particulate matter and 203.5 tons of sulfur dioxide emissions.[23]
- In 2005 alone, Princess Cruises reduced its carbon dioxide emissions at the Port of Seattle Terminal 30 Cruise Facility by 2,735 tons.[24]

Co-benefits

Shoreside power eliminates all noise, noxious fumes and vibrations from the auxiliary engine, creates a better and safer environment for workers and improves the quality of life for neighboring communities.[25]

Economic benefits

- Ships reduced their fuel consumption by 28.5 tons of turbine engine fuel per ship call, for a total of 1,540 tons throughout the entire summer cruise season.
- Shoreside power is at a lower cost per kilowatt hour.

Funding

The total cost was $3.2 million, with $1.7 million from Princess Cruises and $1.5 million from Holland America. Vessel modifications cost $500,000 for Princess Cruises and $1.1 million for Holland America. EPA provided $50,000 through Clean Ports USA grants and the Puget Sound Clean Air Agency provided $25,000 in grants.[26]

CHAPTER 3

Ship cleanup

Ocean-going vessels (OGVs) are massive (the *Eugen Maersk*, the world's largest freighter, is four football fields long), have hand-built, often one-of-a-kind engines, and operate for decades, transporting freight around the globe. Their massive size is accompanied by a massive pollution burden. OGVs burn residual fuel, the literal dregs of the barrel after petroleum is refined. Criteria pollutants from OGVs seriously affect port and coastal regions, contributing to poor air quality.

According to the International Maritime Organization, the governing body for maritime shipping, the industry emits 1.12 billion tons of carbon dioxide annually, contributing 3.5% to global carbon emissions. This number is expected to rise by 30% in 2020.

OGVs are an environmental challenge because the maritime industry has only modest controls on criteria pollutant emissions, and the majority of ships are foreign-flagged, limiting the reach of U.S. regulations. As a result, cost savings are a key incentive for environmental improvements. While no shipping company or port has fully addressed every aspect of OGV retrofits, there are numerous technological innovations and financial incentives that encourage environmentally friendly and economically efficient shipping.

It is important for environmental improvement that shipping companies adopt these new technologies across their fleets and not in a piecemeal fashion. It is also important that these technologies continue to be adopted, even if fuel prices decline.

SHIP CLEANUP CASE STUDY #1

SkySails

This Hamburg-based company equips OGVs with large towing kites. The kites augment the ship's propulsion system to reduce fuel consumption. They currently supply SkySails for cargo vessels with a sail area of 160 to 300 square meters and an effective load between 8 and 16 tons. The pilot tests were run on Wessels' *Michael A.* and the Beluga Group's *Beluga SkySails*, which was chartered for its first voyage by the shipping company DHL.[1] A computer on board the ship adjusts the kite based on wind direction to achieve maximum propulsion. SkySails plans to build 640 square-meter towing kites by 2012.

Environmental benefits

- Under good wind conditions, which SkySails found to be present on most major shipping routes, the system reduces carbon dioxide, sulfur dioxide and nitrogen oxide emissions by 10–35% annually.
- Tests on the *Michael A.* saw maximum emissions reductions of 57%.

Co-benefits

- The kites generate 5 to 25 times more propulsion power per square meter sail than conventional sail propulsion.[2]

SkySails towing kites reduce emissions by 10–35% and can fold into a space the size of a telephone booth when not in use.

- The *Michael A.* requires 11 tons of thrust for full cruising speed; the kite was able to increase the ship's speed by an additional 1.6 knots.[3]
- No additional crew is needed, and the sail can fold into a space the size of a telephone booth so no container space is substituted.[4]
- The kite can be used as emergency propulsion in case of a main engine breakdown.

Economic benefits

- The SkySails system comes with SkyProfit, a savings measurement system which gauges fuel savings throughout the entire ship's voyage.
- In pilot tests on the *Beluga SkySails,* using a 160 square-meter kite, bunker fuel savings were between 10 and 15%, or more than $1,000 per day.[5]
- The price of SkySails ranges between 450,000 to 2.5 million euros, with annual maintenance costs between 5 and 10%. The kite's payback is between three and five years.

SHIP CLEANUP CASE STUDY #2

Solar-power-assisted vessel

Nippon Yusen K.K. and oil distributor Nippon Oil Corporation have created the world's first partially solar-powered ship, the 60,000-ton car carrier the *MV Auriga Leader.* The ship's 328 solar panels will generate 40 kilowatts of electricity and are designed to cut vessel emissions and fuel consumption. While ships have been outfitted with panels before, this is by far the most extensive and advanced use of solar power. The ship arrived in Long Beach in July 2009, and while the *Auriga Leader* is still technically in the testing phase, after two years of further service, NYK plans to create a line of practical-use solar-power-assisted vessels based on the *Auriga Leader.*[6]

Courtesy NYK line

NYK's vessel is covered with 328 solar panels, which will save 18 tons of fuel oil per year

Environmental benefits

- The solar panels will cut carbon dioxide emissions by 40 tons per year.
- The panels provide 1% of the ship's electric power on average, helping not only on the voyage but also at berth.[7]

Co-benefits

- The power aids the ship's steering and thrust.
- The panels provide protection for the ship, reducing salt water damage, wind pressure and vibrations.[8]

Economic benefits

The solar panels will save up to 6.5% of the fuel oil needed to power the vessel's diesel generator, or approximately 18 tons per year.[9]

SHIP CLEANUP CASE STUDY #3

Slow steaming

Maersk, the world's biggest shipping company, has used a process called "slow steaming" to slow down its ships. Normally ships travel at around 26 knots, but after a 110-vessel study in 2007, Maersk found that two-stroke engines can run on loads as low as 10%, reducing speeds from 26 to 10 knots, cutting fuel costs as much as $5,000 per hour. Maersk has been using slow steaming on 100 of its vessels since 2007.[10]

One significant issue with slow steaming, however, is the route a ship takes. In the current economic climate, many shippers have opted against distance-cutting canals, like the Suez, which charges a $600,000 toll. Instead, a ship will travel an added 5,500 miles, sailing around the Cape of Good Hope. While slow steaming is environmentally and economically efficient, when used as a discount mechanism for a much longer route, the benefits are less effective.[11]

Environmental benefits

Slow speeds at 10% engine load eliminate 10,000 tons of carbon dioxide per year.[12]

Economic benefits

Fuel consumption drops to 100–150 tons a day, from 350 tons, reducing fuel consumption by 10–30%.

Photo provided by Maersk Line

Maersk has been experimenting with slower speeds since 2007, reducing emissions between 10 and 30%.

CHAPTER 4

Coastal shipping

Coastal shipping, short sea shipping and America's Marine Highway are all terms that describe waterborne freight that is transported without crossing a major ocean or leaving a continent. According to the U.S. Maritime Administration (MARAD), coastal shipping reduces the infrastructure constraints of clogged highways, which in turn curtails the need for expensive bridge retrofits, road expansion and additional highway safety funding.[1]

The European Union's (EU) Marco Polo Program funds coastal shipping through its Motorways of the Sea grant program. The entire intermodal program, which includes rail, aims to remove the equivalent of 700,000 trucks per year between Paris and Berlin, or 74.4 billion tons of freight per mile, which in turn will reduce congestion and emissions, while improving throughput and reliability.[2]

In the United States, coastal shipping is not very popular. Though the mode has been around for some time, only 2% of U.S. freight moves via domestic water.[3] Shipping routes between the Pacific Northwest and Alaska, as well as routes along the Eastern seaboard, have long been used to transport goods; however, coastal shipping is generally secondary to trucking, which is seen as more flexible and without as many legal and financial constraints. There are also environmental concerns, including fuel type and the potential need to expand port operations to accommodate coastal shipping.[4] The two U.S. cases highlighted here, SeaBridge Freight and the 64 Express, are exceptions, and have demonstrated considerable benefits, including reduced congestion along high-traffic truck corridors.

Funding from the National Defense Authorization Act for Fiscal Year 2010 (HR 2647) provides language for short sea shipping infrastructure and freight transportation needs within the United States, though money has yet to be allocated.[5]

COASTAL SHIPPING CASE STUDY #1

RORO Past France

Motorways of the Sea is a specific category within the EU's Marco Polo Program that funds short sea shipping. It is estimated that the Marco Polo Program could lead to environmental, social and economic benefits for Europe worth nearly one billion euros.[6] For every euro of Marco Polo support, 9.5 euros of external costs are saved. Currently the EU moves 40% of its domestic freight by water compared to 2% in the United States. Begun in 2007, the Motorways of the Sea RORO Past France program provides regular RORO service, as well as LOLO service (defined on page 14), via five weekly roundtrips between Zeebrugge, Belgium and Bilbao, Spain. The ferry service has a maximum capacity of 198 semitrailers and 600 twenty-foot equivalent units (TEUs). TEUs are used to define a standard, intermodal container, as containers are 20 feet in length.

Environmental benefits

Studies on the actual emissions reductions have not been completed at this time.

Co-benefits

- The service is expected to move 7.89 million tons per mile, avoiding 1,242 miles of highway between Zeebrugge and Bilbao.
- RORO s are safer for valuable or hazardous goods, as they avoid overnights in unguarded parking lots and can easily handle oversized cargo.
- The RORO network allows for much faster connections to nearby ports in Sweden, Finland, Russia and the United Kingdom.[7]

Wikimedia Commons

RORO s avoid congested highways and can transport bulky and hazardous goods safely.

Economic benefits

Reported savings of up to 20% are due to efficient planning of driver hours and the ability of companies to grow their business without purchasing additional trucks.[8]

Funding

The RORO network is funded under Marco Polo II, which provides 450 million euros for 2007–2013, or two euros per every 500 metric ton-kilometer (885.67 ton-mile) shifted from road to an alternative mode.[9] This particular program received 6.8 million euros from the Marco Polo Motorways of the Sea Program. Other partners include the transportation groups Spliethoff's Bevrachtingskantoor B.V. (Netherlands), Transfennica Iberia (Spain), Transfennica Belgium (Belgium) and Oy Transfennica AB (Finland).

COASTAL SHIPPING CASE STUDY #2

The 64 Express, Virginia

In 2008, the James River Barge Line started the "64 Express" a nighttime tug/barge container service between the ports of Richmond and Hampton Roads. The tugs used for this operation burn ultra-low sulfur diesel (ULSD) in IMO-compliant Tier 2 engines, and are operated by the Norfolk Tug Company—an innovative, environmentally conscious newcomer to the tug and barge business.

The coastal highway helps moderate congestion in Hampton Roads and along the Interstate 64 corridor, which can be a bottleneck for international cargo shipments. The service moves approximately eighty 40-foot containers each week, and the group plans to grow the service to twice or three times weekly in the future.

Environmental benefits

At this time, greenhouse gas and criteria pollutant reductions have not been determined. However, it appears that the 64 Express does reduce emissions and congestion. The service runs at night, and without sunlight the components in diesel emissions produce less ground-level ozone.

Courtesy 64 Express

The 64 Express maiden voyage on December 1, 2008.

Economic benefits

- Compared to trucking, every container moved by barge eliminates around 25 gallons of fuel emissions.[10]
- Once the service begins three-days-a-week operation, fuel savings will be much higher.

Funding

The 64 Express is supported through a grant from the Richmond metropolitan planning organization. This grant is administered and assisted by the Virginia Port Authority.[11]

COASTAL SHIPPING CASE STUDY #3

SeaBridge Freight

SeaBridge Freight provides an intermodal container shipping service between Port Manatee, Florida and Brownsville, Texas, which facilitates access between markets in Texas, Mexico and the Eastern United States. SeaBridge helps companies reduce their supply chain costs, while cutting fuel consumption, reducing emissions, and eliminating an average of 1,386 miles of congested highways via this trans-Gulf Marine Highway. SeaBridge was the first marine transport provider to earn EPA's SmartWay status.[12]

Courtesy SeaBridge Freight

The total cost per pound via SeaBridge is 29% less than the trucking alternative.

Environmental benefits

- At a capacity of 600 TEUs, on one voyage a single vessel eliminates more than 375 tons of carbon monoxide, hydrocarbons and nitrogen oxide emissions, or 27,000 tons annually.
- In comparison to trucking, SeaBridge eliminates approximately 10.2 tons of carbon monoxide, hydrocarbons and nitrogen oxides emissions monthly.[13]

Co-benefits

Reduced congestion is one of SeaBridge's additional benefits. One unit removes 400,000 truck highway miles per trip or 29 million truck highway miles per year.[14]

Economic benefits

- SeaBridge Freight saves more than 70,000 gallons of diesel fuel per voyage, or more than 4 million gallons of diesel fuel per year.
- The total cost per pound via SeaBridge is 29% less than the trucking alternative.[15]
- In comparison to rail, SeaBridge offers a reduction of over 50% of fuel on a per ton-mile basis.[16]

Funding

SeaBridge is funded through private equity dollars, and the operators hope to deploy a second barge sometime in 2010.[17]

CHAPTER 5

Rail yard and port cargo handling equipment

Along with shoreside power, retrofitting or replacing diesel-powered cargo handling equipment with electricity- or natural gas-powered equipment is considered one of the top pollution control strategies for ports and corridors. Diesel pollution from cargo handling equipment is a serious concern for ports, rail yards, airports and local communities because off-road diesel engine and fuel standards are looser than those for on-road.[1] On-terminal locomotives—often called road or yard switchers—drayage trucks and other pieces of equipment generally carry cargo short distances, sit idle for long periods, and frequently stop and start, leading to high fuel costs and air quality problems for local communities. The engines are noisy, extremely polluting and older due to their relatively infrequent use. Hybridization and electrification of equipment and trucks, as seen at several ports, is a promising solution, though the cost of retrofits and replacements is often a serious hurdle.

RAIL YARD AND PORT CARGO HANDLING EQUIPMENT CASE STUDY #1

Port of Virginia's Green Goat and RP Series

In October 2008, the Virginia Port Authority's (VPA) Norfolk International Terminal began using the Green Goat, a battery-dominant hybrid yard switcher with diesel engines, designed by

Courtesy Jack Denton, Virginia Port Authority

Debuting in 2008, the Green Goat has produced fuel savings between 40 and 60%.

RJCorman/Railpower Hybrid Technologies Corporation. The VPA purchased one Green Goat and two other ultra-low-emission rail switchers to replace heavily polluting diesel locomotives from the 1970s.[2]

Environmental benefits

The Green Goat is predicted to reduce nitrogen oxide and particulate matter emissions between 80 and 90%.

Co-benefits

- The smaller generator reduces noise, and the generator is positioned lower on the locomotive, improving driver visibility.
- The Green Goat is maintenance-free in the first year, and later maintenance is easier because of lighter, smaller and more uniform parts.
- The heavy weight of the batteries improves traction.[3]

Economic benefits

The Green Goat has produced fuel savings between 40 and 60% or $58,000 per year.[4]

Funding

The Green Goat and two ultra-low-emission rail switchers cost the VPA $3.6 million and will be leased from RJ Corman/Railpower Hybrid Technologies Corporation and Norfolk Southern Corporation for three years, after which the VPA will buy them. EPA provided $750,000; the VPA provided $2 million; and the operating company, Virginia International Terminals, provided $850,000.[5]

RAIL YARD AND PORT CARGO HANDLING EQUIPMENT CASE STUDY #2

BNSF Cranes in Seattle

BNSF installed four, wide-span, electric, rail-mounted gantry cranes, manufactured by Konecranes of Finland, at the Seattle International Gateway (SIG) intermodal facility. Their wide footprint allows them to span three tracks, stack containers and load and unload both trucks and railcars. The cranes regenerate power, allowing them to repower every time they lower a container. They are the first of this type operating in North America.

Environmental benefits

- The cranes produce zero onsite emissions.
- The previous rubber-tired gantry cranes produced 3.66 tons of nitrogen oxides per year per unit of equipment. The new cranes produce 0.06 tons per year of nitrogen oxides.
- The new cranes produce no diesel particulate matter.[6]

Co-benefits

- The cranes have doubled capacity at SIG, while retaining the same physical footprint.
- The cranes have significantly reduced noise.
- The crane's wide stance is more convenient for truckers, reducing unnecessary truck trips and idling.

Courtesy BNSF

This Finnish-made electric crane produces zero onsite emissions and increases throughput by 30%.

Economic benefits

BNSF has increased throughput at SIG by 30% because of the cranes.[7]

Funding

BNSF invested a total of $50 million in SIG. The cranes themselves are $3 million each.

RAIL YARD AND PORT CARGO HANDLING EQUIPMENT CASE STUDY #3

Foss Maritime hybrid tugboat, the Green Dolphin

In response to the Port of Los Angeles and Long Beach's Clean Air Action Plan, Foss Maritime in partnership with Aspin, Kemp and Associates and their affiliate XeroPoint, have developed the Green Dolphin tugboat, which will meet EPA's Tier 2 emissions requirements. Tugboats require brief spurts of high power, making them ideal candidates for hybridization as they tend to run on full power only 7% of the time and sit idle 50% of the time.[8] The tug *Carolyn Dorothy* debuted in February 2009 at the Port of Long Beach, and will increase energy efficiency while reducing greenhouse gases and criteria pollutants.[9]

Environmental benefits

- Foss officials predict that the Green Dolphin will reduce particulate matter and nitrogen oxides by 44% compared to existing tugs.[10]
- The tug will also reduce sulfur dioxide and carbon dioxide, though how much is uncertain since this data is currently being modeled.[11]

Co-benefits

Foss worked with tug operators to develop the simplest operation system possible.

Economic benefits

- Operators have reduced lube oil usage and have reduced fuel costs between 20 and 30%.[12]
- There are reduced maintenance costs because the engine is shut down the majority of the time.

Port of Long Beach

Tugboats require only brief spurts of power, making them ideal for hybridization.

- Foss Maritime produced a discounted cash-flow analysis that revealed a net present value of close to $1 million based on fuel savings and reduced maintenance costs over the life of the tug.[13]

Funding

Foss has agreed to homeport the tug at the Port of Long Beach in exchange for $850,000 from the Port of Los Angeles and the South Coast Air Quality Management District and $500,000 from the Port of Long Beach for research and development. The tug cost $8 million to build.[14] Foss is also part of EPA's SmartWay Transport Partnership.

U.S. EPA's SmartWay

U.S. EPA launched the SmartWay program in 2004. The SmartWay brand identifies products and services that reduce transportation-related emissions and greenhouse gases. SmartWay Transport specifically addresses freight transport, with different partnership requirements for truck stops, drayage trucks, shippers, freight and rail carriers, and logistics companies. SmartWay Transport's goals are to reduce fuel consumption, operating costs, carbon dioxide emissions, and air pollution and toxics. Some of the ways to become a SmartWay-certified partner include:

- Installing aerodynamic devices on the truck and trailer
- Improving pickup and delivery strategies
- Purchasing a SmartWay certified truck or trailer
- Installing idle reduction technologies on-board and at truck stops
- Using an alternative fuel
- Implementing training programs

SmartWay Transport's estimated savings are between 3.3 and 6.6 billion gallons of diesel fuel per year, which represents as much as 150 million barrels of oil and nearly $10 billion in operating costs.[15]

CHAPTER 6

Diesel engine emissions reductions and incentives

Diesel engines are durable and have a long life span. As a result, natural fleet turnover is slow, and it can take decades for a diesel engine to be retired and replaced by a cleaner, more efficient engine. Diesel truck engines from model year 2010 are the cleanest available; hybrid electric vehicles emit even less pollution and use dramatically less fuel. However, it will take a considerable amount of time before the nationwide fleet is composed of these new engine technologies.

Trading in an old engine for a newer, cleaner engine is just one way to reduce emissions. Another option is to clean up existing equipment by installing a device on the engine system that captures pollution before it is released into the atmosphere. A third option is to rebuild an existing engine to bring its emissions performance up to like-new standards.

While these three options are less expensive and often more cost-effective than buying an entirely new truck tractor, locomotive or piece of equipment, they still come at a significant cost. Some federal, state and local agencies offer innovative funding programs to help fleet owners finance and buy cleanup equipment and, in some cases, an entirely new truck or engine. Some states and regions also have regulations to speed up the natural turnover of dirty diesel engines and equipment by targeting in-use equipment and setting deadlines for meeting cleaner standards.

What is a rebuild, repower and retrofit?

Unlike passenger vehicles, which generally are replaced after years of use, several options exist to extend the life of diesel equipment used for freight transport. Since diesel equipment and vehicles come with a hefty price tag, these options are more cost-effective and result in a more efficient engine, with reduced emissions as well as fewer repair and maintenance costs.

Aside from totally replacing equipment, three common ways to improve diesel equipment are known as rebuild, repower and retrofit:

- **Rebuild:** Engine rebuilds after three or four years of use can return emissions performance to original or better levels. This involves using remanufactured and/or rebuilt engine parts, cleaning and refurbishing them, and then reassembling them to make a working engine.
- **Repower:** An engine repower replaces an older engine with a new or newer one. Newer engines can dramatically reduce emissions and are often more fuel efficient.
- **Retrofit:** Installing an emissions control device, such as a diesel particulate filter (DPF), oxidation catalyst, exhaust gas recirculation (EGR) device, selective catalytic reduction device (SCR) and/or lean nitrogen oxide catalyst (LNCs), can reduce one or a combination of pollutants.

Incentive programs

Several federal, state and local programs provide assistance to fund diesel cleanup projects. These types of funding programs are necessary to speed up engine turnover, clean the air and protect public health. Examples of these programs include the National Clean Diesel Emissions Reduction Program (DERA), California's Carl Moyer Program and Boston's CleanAir Vehicles Program.

National Clean Diesel Emissions Reduction Program (DERA): DERA was created under the Energy and Policy Act of 2005 and awards grants for emissions reduction projects. DERA is comprised of both a national program and a state component. The national component is divided into three sub-programs:

- National Clean Diesel Funding Assistance Program Regional Grant Competitions, distributed regionally, largely for the cleanup of public fleets.
- The SmartWay Clean Diesel Finance Program.
- The Clean Diesel Emerging Technologies Program.[1]

These projects include installing emissions control devices or idle-reduction technologies, upgrading or repowering engines, using cleaner fuels, replacing equipment, or creating and implementing innovative financing programs to support diesel emissions reduction projects. In the Houston-Galveston area, SmartWay funding through DERA created the Houston Clean Truck Program, a revolving loan fund to help drayage truck operators purchase and operate cleaner trucks. The program provides a "bridge" between the state's Texas Emissions Reduction Plan loans and the cost of a retrofit or replacement. The loans range from $5,000 to $100,000 and are targeted at more than 3,000 truck operators at local area ports.[2]

The Carl Moyer Memorial Air Quality Standards Attainment Program (Carl Moyer Program): California's Carl Moyer Program was created in 1998 when the state budget allocated $25 million to fund a lower-emission heavy-duty engine incentive program. Legislation enacted shortly thereafter established the statutory framework for the program. Eligible projects include retrofit devices or cleaner engines for on-road, off-road, marine, locomotive and stationary agricultural pumps. The program's focus is to achieve reductions of criteria and toxic pollutants, with the goals of helping the state meet its Clean Air Act commitments and improve public health. The program also reduces greenhouse gases by funding hybrid and electric vehicles and equipment. The California Air Resources Board administers the Moyer Program and is responsible for updating its guidelines.

Clearie Advanced Emission Controls, LLC

Providing incentives for add-on technologies, like this retrofitted exhaust pipe, helps existing engines run cleaner.

The program is currently funded at a level of about $140 million a year through 2015. Demand for Carl Moyer funds annually exceeds their availability.

Boston's CleanAir Vehicles Program: The City of Boston offers grants to pay for half the cost of any verified diesel retrofit device, while the vehicle owner pays the other half. The vehicle must be a pre-2007 on- or off-road diesel vehicle. The grant amount is up to $10,000 per business, with the option of retrofitting multiple vehicles. Eligible applicants are Boston-based businesses or others with a significant presence in Boston. Businesses applying for off-road retrofits must commit to use only ultra-low sulfur diesel fuel (ULSD).[3] EPA regulations already require ULSD for on-road vehicles.

The program began in 2008 and was extended for an additional year, as funding was still available. Commission staff has found that aggressive marketing and advertising for the CleanAir program is critical for garnering interest. Yet, the lack of in-use regulations, with the exception of equipment used on government projects, means there is little incentive for businesses to voluntarily clean up their vehicles.[4]

Environmental benefits

- **DERA:** In fiscal year 2008, $49.2 million was allocated to clean up more than 14,000 pieces of diesel-powered equipment and vehicles. EPA estimates that by 2031 DERA-funded projects will have reduced 46,000 tons of nitrogen oxides and 2,200 tons of particulate matter. The health benefits from the projects will range from $580 million to $1.4 billion (in 2006 dollars) for the lifetime of the projects.[5] The 2008 projects alone will avoid 35,600 tons of carbon dioxide emissions per year.
- **Carl Moyer:** In its first seven years, the Carl Moyer Program provided $170 million to clean up approximately 7,500 engines.[6] This has resulted in reductions of about 24 tons per day of nitrogen oxides and one ton per day of diesel particulate matter.
- **Boston's CleanAir Vehicle Program:** As of November 2009, three companies have signed up to retrofit a total of 18 trucks with diesel oxidation catalysts. Each vehicle will reduce its particulate emissions by 20%, carbon monoxide by 40% and hydrocarbons by 50%.[7]

Co-benefits

All three programs have improved air quality and public health. For Carl Moyer, a 2006 status report estimated that the program's air quality improvements avoided 17,000 lost work days, 2,800 asthma attacks and 100 premature deaths between the years of 2001–2005.[8]

Economic benefits

- **DERA:** It is estimated that the 2008 projects will save 3.2 million gallons of fuel per year; at $2.50 per gallon, this represents $8 million in annual savings.[9]
- **Carl Moyer:** The societal improvements correspond to program benefits of five times the initial cost.

Funding

- **DERA:** Funding for DERA comes from EPA appropriations. Congress appropriated $49.2 million in fiscal year 2008. For fiscal year 2009, funding was boosted to $60 million, and the American Reinvestment and Recovery Act (ARRA) provided DERA with an additional $300 million.[10] The national program will receive 70% of its funding from the ARRA.
- **Carl Moyer:** Annual budget appropriations funded the program's first four years. In 2004, the state legislature expanded the program to provide continuous funding from Smog

Check fee increases, new tire fees and vehicle registration surcharge fees, totaling $141 million annually.

- **Boston Program:** The funding for the program comes from Boston city funds. The state of Massachusetts' Air Pollution Control Commission received $100,000 for the program.[11]

DIESEL EMISSIONS REDUCTIONS AND INCENTIVES CASE STUDY #2

Diesel-electric hybrid trucks

Hybrid gasoline-electric passenger cars have become a popular alternative to conventional vehicles, offering improved emissions and better fuel economy than most cars. Hybrid diesel-electric engine technology has become more established in the past few years, and has begun to penetrate various size classes in the diesel truck market.

A diesel-electric hybrid truck is powered by a diesel engine and an electric motor. The diesel engine generates electricity for the electric motor. Hybrid electric engines generate electricity on-board and do not need to be recharged before use. Diesel fuel powers an internal combustion engine that is usually smaller and more efficient than a conventional engine. The internal combustion engine works in concert with the electric motor. The electric motor derives its power from an alternator or generator that is coupled with an energy storage device, such as a set of batteries.

Since much of the electricity is generated through regenerative breaking, diesel-electric technology is used most commonly in medium- and heavy-duty vehicles in urban, stop-and-go settings, such as local delivery trucks and transit buses. There is less usage in long-haul trucking.

Companies such as FedEx, Wal-Mart, Coca-Cola Enterprises, Inc. and Ryder have purchased diesel-hybrid electric trucks; and vehicle manufacturers such as Honda, Volvo and Navistar have begun or are expanding the manufacture of hybrid electrics to other vehicle types and sizes. While the technology is well-established and continues to improve, market penetration for diesel hybrids has been slow. Many of the companies that purchase diesel hybrids do so as part of a "green initiative" or as an experimental or pilot project.

One of the largest impediments to widespread adoption of hybrids is their cost. A new typical medium/heavy-duty delivery truck costs more than $60,000; a hybrid electric costs more than

EDF Photo Library

EDF's partnership with FedEx has helped purchase low emission, hybrid electric delivery trucks.

$110,000.[12] However, there are several state and federal funding opportunities, as well as tax credits, to aid with the purchase of the vehicles. Additional funding and incentive measures are necessary to expand the commercial market for diesel-electric hybrid trucks to further capitalize on their fuel savings and emissions reductions.

Environmental Benefits

Compared to a 1999 baseline vehicle, hybrid trucks have the following benefits:

- Greenhouse gas emissions reductions of 30–50%.[13]
- Diesel particulate matter reductions of 96%.[14]
- Nitrogen oxide pollution reductions of 65%.[15]

Co-benefits

Air quality and public health benefits for workers and neighboring communities, as well as reduced noise and vibration from traditional diesel engines.

Economic benefits

Increased fuel efficiency of 30–57%.[16]

DIESEL EMISSIONS REDUCTIONS AND INCENTIVES CASE STUDY #3

In-use diesel regulations in California and Tokyo

A significant challenge for diesel regulation is addressing in-use diesel engines and vehicles. While many governments have regulations for new engines and vehicles, cleaning up existing vehicles is challenging. The state of California has adopted a far-reaching Diesel Risk Reduction Program, and several Asian cities, including Tokyo, have begun their own initiatives to reduce diesel pollution in advance of national legislation. These plans offer sound environmental and health benefits.

Getty Images

In-use diesel regulations require the cleanup of existing engines and accelerate the turnover of dirty trucks to newer models, as can be seen in California and Tokyo.

CALIFORNIA'S DIESEL RISK REDUCTION PLAN

California is the only state to have a comprehensive plan to reduce emissions from diesel vehicles and engines currently in use. The California Air Resources Board (CARB) identified diesel particulate matter as a toxic air contaminant in August 1998, which led to the development of the "Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles," or the Diesel Risk Reduction Plan (DRRP), in September 2000. One of the main strategies to reduce diesel particulate matter is to retrofit existing engines.

The DRRP's In-Use Diesel Retrofit plan contains three elements: (1) identification of engines and vehicles that are capable of being retrofitted; (2) verification and demonstration of the capabilities of retrofit devices; and (3) installation of retrofits on specific engines. Starting in 2000, CARB began to develop regulations to reduce emissions from existing equipment, and it has adopted 13 out of 14 of these in-use regulations, including regulations to cover trucks, off-road equipment and transport refrigeration units.[17]

Environmental benefits

The goal of the DRRP is to reduce diesel particulate emissions and the associated health risk by 75% in 2010 and 85% by 2020.

Co-benefits

Each in-use regulation has undergone its own benefits assessment, and an aggregation of total benefits has not been done. CARB's 2008 In-Use Diesel Truck and Bus regulation, for example, is estimated to prevent 9,400 premature deaths statewide by 2025.[18] It is also estimated that the rule will prevent 3,000 respiratory and cardiovascular hospital admissions; 150,000 cases of asthma-related and other lower respiratory symptoms; 12,000 cases of acute bronchitis; 5,500,000 minor restricted activity days; and 950,000 work loss days.[19]

Economic benefits

Every year, direct diesel particulate exposure costs the state $16 billion as a result of premature death and $3.5 billion in hospitalizations, treatment and lost workdays.[20] While a total aggregation of savings has not been done, the In-Use Diesel Truck and Bus Regulation, for example, would save the state between $48 billion and $69 billion in avoided deaths and healthcare costs by 2025.[21]

Funding

California has several incentive programs, as well as a low-interest loan program. The state also takes advantage of federal grant programs to help pay for the early cleanup of diesel engines. Grant funds are generally not used to pay for regulation compliance.

TOKYO'S IN-USE DIESEL RULES

In 2000, the Tokyo Metropolitan Government (TMG) began a "Say No to Diesel Vehicles" campaign, which included an "Environmental Preservation Ordinance" to regulate nitrogen oxides and particulate matter from diesel engines. As of June 2002, in addition to Tokyo, three prefectures—Saitama, Chiba and Kanagawa—and three cities—Yokohama, Chiba City and Kawasaki—established similar programs.

Vehicles not in compliance by 2003 were prohibited from the metropolitan area. Owners could either replace older vehicles with newer models or retrofit older vehicles with approved control devices. Vehicle owners could also export their trucks, and unfortunately, other nations, such as New Zealand, have had to bear the brunt of these exports.[22]

Environmental benefits

There has been 100% compliance with the regulations since 2005.[23] At the start of the program, approximately 202,000 vehicles were subject to the new controls. By December 2004,

149,000 vehicles had been replaced or disposed, and 46,000 had been fitted with particulate matter–reducing devices.[24]

Co-benefits

Improved air quality and health benefits for citizens.

Economic benefits

Subsidies are provided for the fitting of particulate matter–capturing devices, and the purchase of CNG-powered vehicles and private buses. Financial intermediary services are also provided for the purchase of low-polluting vehicles for businesses and individual citizens.

The Tokyo Metropolitan Government also subsidized the price difference between low sulfur and ordinary sulfur diesel fuel in 2001 and 2002. The Petroleum Association of Japan agreed to shift all diesel fuel to low sulfur by 2003.[25]

CHAPTER 7

Truck tolling

Congestion from freight movement is a significant transportation problem, slowing regional passenger traffic and harming local businesses and quality of life. Additionally, congestion reduces driving speeds, which increases greenhouse gases and criteria pollutant emissions and lowers average fuel economy.[1] A truck traveling at five miles per hour produces 318% more particulate matter than at 55 miles per hour, and 22 pounds of carbon dioxide for every hour it idles. Pollutants include organic gases, carbon monoxide, sulfur oxide, nitrogen oxides and particulate matter.

Truck tolling offers several solutions to protect the environment, reduce fuel consumption and increase the efficiency of freight movement. Tolling can be used to alleviate congestion by encouraging off-peak travel times. Tolling tons of emissions, in addition to miles, can create industry changes, motivating truck companies to use cleaner fuel and vehicles as well as smarter supply chain management.

TRUCK TOLLING CASE STUDY #1

PierPASS, California

Container traffic at the ports of Los Angeles and Long Beach creates congestion on local freeways, roads and in queues outside marine terminal gates, as containers from ships are

Carrie Denning

PierPASS encouragess truck drivers to transport cargo at night, preventing heavy congestion for Los Angeles commuters.

loaded onto trucks, which drive inland to distribution centers. This truck traffic, along with increased truck idling, emits greenhouse gases and worsens local air quality. In 2005, the West Coast Marine Terminal Operators Association created PierPASS, a nonprofit organization to develop industry-led solutions. PierPASS' flagship program is OffPeak, which provides a financial incentive to move cargo outside of peak daytime traffic hours and a funding mechanism for five new shifts per week (Monday through Thursday nights and Saturday).

Under OffPeak, during peak hours, which last from 3 a.m. to 6 p.m., the marine terminals charge a Traffic Mitigation Fee of $50/TEU (usually $100 for a 40-foot container). During off-peak hours, the fee is not assessed for cargo movement in or out of the ports.[2]

Revenues from the fee are used to pay the costs of keeping the marine container terminals open longer hours and are allocated to each terminal operator according to their volume of throughput. More efficient terminals receive a higher share of the fee to operate at night. The program both encourages cargo owners to shift the movement of their cargo to off-peak hours and promotes more efficient operations in the container terminals. Funds are not used for engine retrofits or truck replacements. The program has successfully redistributed 40% of truck traffic to off-peak hours, which in turn reduces highway congestion and diesel emissions and improves the throughput and reliability of freight transportation. Unfortunately, the program has also increased nighttime truck traffic and noise in local communities.

Environmental benefits

- It is unclear if OffPeak has reduced emissions, as a study of emissions has not yet been conducted.
- Reports have indicated that the OffPeak program has shifted truck traffic from day to night hours, reducing midday congestion, which in turn reduces emissions from idling vehicles.[3]

Co-benefits

- Traffic delays have been reduced. OffPeak handles approximately 40% of all container moves.[4] Approximately 11.46 million trips were diverted as of December 2008.
- A survey of drayage truck drivers in May 2006 reported perceived congestion reduction on I-710 and around terminals at a ratio of ten to one.[5]
- Studies have indicated reduced congestion for Los Angeles motorists after the implementation of OffPeak.[6]

Economic benefits

- Congestion can delay shipments for almost eight days at the ports; OffPeak improves companies' distribution.[7]
- OffPeak makes more efficient use of port assets by keeping terminals open.

Funding

The Traffic Mitigation Fee provides funding for terminal operators to keep operations running at night.

TRUCK TOLLING CASE STUDY #2

Germany's Toll Collect

While payment for road usage has existed in Europe since the eleventh century, Germany's recent truck tolling initiative, Toll Collect, uses advanced technologies to benefit the environment, the German economy and truck drivers.[8] In January 2005, Germany launched a distance-based toll for all trucks over 12 tons on the country's 12,538 kilometer (7,791 mile) network to relieve

congestion, shift freight movement to waterways and railways, and generate revenue for transportation projects. It created the first satellite-based GPS, mobile toll collection system, tolling heavy-duty trucks based on mileage, location and time of day, while taking into account the number of axels and the emissions class. Ninety percent of users have an on-board unit that provides the truck's location, and charges the truck accordingly, eliminating the need for toll stations.[9]

©Toll Collect

Germany's satellite-based GPS tolls truck drivers based on mileage, location, time of day, axels and emission category.

Toll increases in 2009 doubled the range between the lowest and highest tolls according to emission category, furthering the shift toward cleaner Euro V engines. The new charge for Euro V or EEV engines is 14 eurocents per kilometer, while heavily polluting Euro II engines, or worse, are tolled 28 eurocents per kilometer.[10] Revenues from tolling are redistributed to other transportation sectors, including rail and water. Toll Collect recommends that toll rates encourage the installation of particle filters in the future.[11]

Germany's emissions tolling model has been replicated in other countries, including Austria and the Czech Republic.

Environmental benefits

- The number of "dirty" trucks, Euro II engines or worse, fell from 50% to 20% of total trucks on the road. Euro V engines, with the most modern exhaust systems, increased from <1% in 2005 to almost 51% in 2008.[12]
- The mobile toll collection system eliminates the need for toll booths, reducing idling.

Co-benefits

- Toll Collect has reduced highway congestion, as the number of empty truck trips has fallen by 20%, and the number of containers carried by train has risen 7%.[13]
- Toll revenues provide additional funding to infrastructure projects, improving highway safety.

Economic benefits

- Since 2007, Toll Collect has seen revenues of 3.4 billion euros with a violation rate under 2%.[14]
- Toll Collect distributes revenues throughout Germany's transportation sector. The road sector receives 50% of revenues; 38% goes to rail; and the remaining 12% is used for waterway improvements.[15]
- A portion of the toll (0.45 eurocents) provides incentives to German truck companies to convert their fleets through low-interest loans and direct investment grants of up to 50% of additional costs of 4,250 euros per vehicle.[16]

Funding

The system, a public-private partnership, places the government in charge of regulations, contracting and enforcement and the private sector in charge of operations.

CHAPTER 8

Truck stop electrification

Federally mandated safety rest periods for truck drivers often lead to idling to maintain heating, air-conditioning and other cab comforts. The average sleeper cab tractor idles for 1,500 to 3,000 hours per year, consuming an average of one gallon of diesel per hour.[1] With each gallon of conventional diesel emitting 22 pounds of carbon dioxide, EPA estimates that long-duration idling generates more than 11 million tons of carbon dioxide annually.[2]

Truck stop electrification eliminates this idling and fuel consumption by allowing truck drivers to connect to an electric power system. Truck stop electrification provides truckers with the same creature comforts and work needs, but keeps the surrounding air and cab free of toxic pollution and greenhouse gases.

More than 200 sites have been electrified nationwide.[3] The following case studies highlight projects that involve a more integrated approach, multi-stakeholder partnerships, or other characteristics that support truck stop electrification and encourage strategic planning for future electrification projects.

For truck stop electrification to become more widely available, however, initial start-up funding to establish the network is critical. Once established, the system can pay for itself.

TRUCK STOP ELECTRIFICATION CASE STUDY #1

Truck stop electrification on Oregon's Interstate 5

In 2004, Oregon's Governor Ted Kulongoski announced a pilot project to electrify 600 out of the roughly 2,000 truck parking spaces along Oregon's Interstate 5 corridor.

Oregon's truck stop electrification project is part of a larger, regional effort to reduce greenhouse gases and diesel pollution. In 2003, the governors of Washington, California and Oregon began investigating ways to reduce greenhouse gas emissions and initiated the Global Warming Initiative. The West Coast Diesel Emissions Reduction Collaborative grew out of the Initiative and also includes federal, private sector and nonprofit interests.[4]

The Oregon government designated a team to identify strategies to reduce truck stop idling and strategically chose certain sites for electrification. As truck stop electrification facilities (TSEs) are installed throughout Oregon and results are documented, the Collaborative aims to install more TSEs throughout state and along the West Coast.[5]

Shorepower and IdleAire have been the two main providers of TSE technology. As this report went to press, IdleAire closed its operations. Prior to this, IdleAire had upgraded two sites with 118 parking spaces total, and Shorepower, which is still in operation, has electrified, or will soon electrify, five sites and 252 parking spaces. In total, 370 spaces will be electrified. While a considerable achievement, this falls short of the original goal of electrifying 600 truck parking spaces, though there may be additional TSE sites on the horizon.

Cascade Sierra Solutions, a nonprofit organization that uses innovative financing mechanisms to fund diesel cleanup projects, has recently received federal funding to partner with

Courtesy Jennifer Witherspoon

Electrifying truck stops allows drivers to maintain cab comfort and help the environment.

Shorepower and expand truck stop electrification to 50 sites and 1,300 parking spaces throughout the United States. The exact locations have yet to be determined.

Environmental benefits

- Over the past year at the IdleAire sites, there have been reductions of 12.47 tons of carbon monoxide, 2,310 tons of carbon dioxide, 29.99 tons of nitrogen oxides, 1.54 tons of volatile organic compounds and 0.81 tons of diesel particulate matter.[6]
- Emissions data for the Shorepower locations are not yet available.
- Full build-out of the program is estimated to reduce 33,000 tons of carbon dioxide per year, and more than 900 tons of carbon monoxide, nitrogen oxides, hydrocarbons and particulate matter emissions per year.[7]

Co-benefits

- Truck stop electrification makes it easy for truckers to comply with idling regulations that have been adopted in various states.
- Electrification reduces noise and benefits the health of truck drivers.
- For truck stop owners, electrification provides an opportunity to offer another service to customers. The response from truck stop owners has been overwhelmingly positive.

Economic benefits

- Over the past year at the IdleAire sites, truckers have saved 201,934 gallons of fuel.[8]
- Full build-out of the project is estimated to save 3.1 million gallons of diesel fuel.[9]
- The truck stop electrification business has many opportunities for long- and short-term job creation and retention. Sites must be built and maintained. Additionally, TSE companies have administrative, helpline, sales, marketing and technical support

staff. Shorepower, for example, hires several subcontractors for building and maintaining the sites. Their planned 50 upcoming sites are expected to create or retrain 962 employees.[10]

- The project will result in a net savings of $1.8 million per year in reduced fuel costs (based on September 2004 data) and reduced wear-and-tear.[11]
- The air quality benefits will translate to public health and environmental benefits of at least $6.6 million per year.[12]

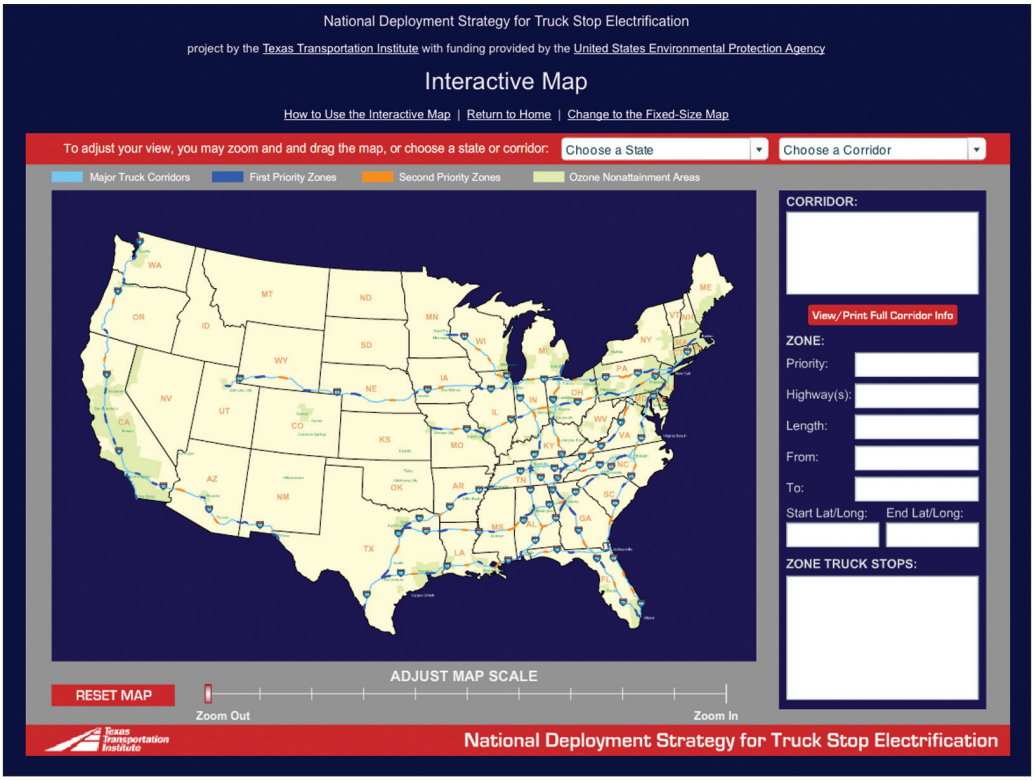
Funding

The funding for this project has been a coordinated effort among several different groups. EPA contributed $200,000 to Oregon State University for research on optimal locations for truck stop electrification. The Climate Trust, a nonprofit organization specializing in offsets and consulting services, has committed more than $2 million. The Oregon Business Energy Tax Credit Program, administered through the Oregon Department of Energy, agreed to provide $2.3 million in credits, and the State Low Interest Energy Loan Program, also administered by the Oregon Department of Energy, provided loans for $1.4 million. IdleAire and Shorepower provided a matching contribution of $1.6 million.[13]

TRUCK STOP ELECTRIFICATION CASE STUDY #2

National deployment strategy for truck stop electrification and interactive map

Funding availability and political support have generally been strong drivers of truck stop electrification projects. However, the resulting locations may not represent optimal TSE sites.



http://tse.tamu.edu/map.htm

Texas Transportation Institute's map not only identifies electrified sites but also shows a future, integrated national strategy for truck stop electrification.

A team of researchers and modelers at the Texas Transportation Institute identified and prioritized a total of 15 major truck corridors along the U.S. interstate system. They prioritized potential locations for TSE technology using criteria such as corridor length, major activity centers, truck volume, truck growth rates, nonattainment areas, existing TSE sites, number of truck stops, average temperatures and major intersections. As part of the EPA-funded project, the team produced the report, "National Deployment Strategy for Truck Stop Electrification," and developed a user-friendly interactive map that is free to the public and allows access to the data on each of the 15 identified truck corridors and priority TSE zones.[14]

The electrification study was coupled with actual deployment of three TSE sites, two in Ohio and one in Indiana. This provided a real-life case study to examine the before and after impacts of TSE usage, emissions and other factors.

Environmental benefits

The three sites along the TSE corridor—two in Ohio and one in Indiana—saw reductions in fuel consumption, pollutants and greenhouse gases ranging from 5 to 44% for the three stops. This wide range is a result of temperature differences, as milder temperatures do not necessitate the need for heating or cooling of the truck cab. Over a one-year period, each truck stop on average reduced fuel consumption by 61,000 gallons. This led to reductions of 11 tons of nitrogen oxides and 767 tons of carbon dioxide emissions.[15]

Co-benefits

Several states, jurisdictions and others have contacted the Texas Transportation Institute, making the study a critical component for future truck stop electrification deployment.

Funding

EPA provided the Texas Transportation Institute with a $3 million grant for the project.[16]

CHAPTER 9

Logistics

Inefficiencies in freight operations contribute to congestion at freight transportation hubs and lead to idling engines and wasted fuel from trucks and trains carrying half-full or empty containers. A typical long-haul truck drives empty for more than 14,000 miles each year, consuming 2,400 gallons of diesel and emitting more than 26.4 tons of carbon dioxide.[1] Smarter supply chain management and logistics can make companies more efficient by optimizing total tons-per-mile performance. These initiatives help reduce total trips, which reduces greenhouse gas emissions, improves air quality and relieves congestion.

Companies can employ a broad suite of strategies to streamline their supply chain and reduce emissions, including route optimization, employee and driver training programs, and contract specifications. Companies are finding that adopting new technologies and employing simpler measures to improve performance benefits the environment, reduces fuel costs and improves customer service. Smarter logistics benefit the environment and the company's bottom line.

Some companies have incorporated several of the logistics concepts described below into comprehensive programs as part of strategies to reduce carbon footprints and meet internal company greenhouse gas and fuel consumption reduction goals.

LOGISTICS CASE STUDY #1

Technological solutions and route optimization

Several devices and other options are available to reduce idling, improve aerodynamics and determine the best route to deliver goods. Some companies have designed vehicles that combine several of these technologies to maximize the benefits. Each technology has varying emissions and greenhouse gas benefits, depending on how much the vehicle is used and the accompanying weather and road conditions.

The following summarizes the technological solutions available to reduce emissions and make the transport of goods more efficient:

- **Idle reduction:** With varying weather conditions and driver comfort needs, simply turning off a vehicle to eliminate idling is often not an option. Instead of running the engine for hours, trucks can be equipped with an auxiliary power unit (APU), a small engine mounted externally on the cab that provides power. There are also automatic engine idle systems that drivers can program to start and stop the truck engine.[2]
- **Vehicle aerodynamics:** Aerodynamic drag from wind resistance decreases fuel efficiency, especially for vehicles that travel long distances. Higher speeds and longer distances mean greater losses. Roof fairings, cab extenders, side fairings and other devices can be installed to streamline the profile of the tractor. For the trailer, reducing the gap between the trailer and the cab, as well as installing side skirts, are options that improve aerodynamics.[3]

Courtesy S. Rodger, ATDynamics

Advanced vehicle aerodynamics, like rear fairings and side skirts, as well as other technological solutions improve fuel economy and save money."

- **Tire options:** Improperly inflated tires increase rolling resistance and waste fuel. Automatic tire inflation systems monitor and continually adjust the level of pressurized air in the tires, even while the truck is on the road.[4] Another option to decrease rolling resistance is to use single wide-based tires. A single wide-base tire and wheels are lighter than the typical two standard tires and wheels.[5]
- **Route optimization:** Computerized routing, scheduling software and global positioning systems (GPS) allow drivers to determine the most efficient routes, minimize the chances of getting lost, keep track of pickup and delivery schedules, and find out about adverse weather or traffic conditions. These technologies reduce unnecessary idling at loading docks and in traffic, and often reduce the distance driven, all of which result in fuel savings.[6]
- **Advanced vehicles:** Several companies are using vehicles that incorporate GPS and routing technology software, alternative fuels and other fuel saving technologies on an experimental basis. Many of these projects have yet to be deployed on a fleet-wide level.[7]

Environmental benefits

- **Idle reduction:** APU systems and the amount of emissions they produce vary. Battery-electric APUs are the cleanest, followed by diesel-electric hybrid APUs.[8] Diesel-powered APUs are the dirtiest, though their emissions can be reduced if installed on a 2007 or newer vehicle, and the APU is either retrofitted with a particulate matter control device or the APU exhaust is rerouted through the truck's particulate trap retrofit system.[9] The systems also prevent additional wear-and-tear on the engine, reducing vehicle maintenance costs.[10]
- **Vehicle aerodynamics:** Compared to a classic profile tractor, a streamlined profile tractor with aerodynamic devices can improve fuel economy by up to 15%, saving up to 2,430 gallons of fuel annually and eliminating more than 5.5 tons of greenhouse gas emissions.[11]
- **Tire options:** Automatic tire inflation systems can improve fuel economy by 1% and reduce greenhouse gas emissions by 1.1 tons annually. Properly inflated tires also have a longer

life, which reduces overall tire expenditures and improves vehicle safety. Single wide-base tires can reduce more than 4.4 tons of greenhouse gas emissions a year and result in fuel savings of 2% to 5%.[12]

- **Route optimization:** Route optimization technologies vary widely, so it is difficult to determine precise emissions benefits. However, a simple 5% idling reduction through improved routing and loading practices could save 100 gallons of fuel and reduce greenhouse gases by 1.1 tons per year.[13] Ryder Trucking, for example, offers RydeSmart, a GPS fleet location, tracking and vehicle performance management system. The system allows Ryder to refine route design, detect engine inefficiencies and measure driver performance and vehicle efficiency by monitoring speed, hard breaking and idling. RydeSmart uses Teletrac software and PanaStream's instructional service. This collaboration has reduced fuel consumption between 10% and 15% per truck per day.[14]

- **Advanced vehicles:** These vehicles often use advanced engines, such as electric or hybrid-electric, and alternative fuels such as biodiesel as part of their overall strategy to reduce emissions and fuel costs. The fuel used largely determines the emissions benefits, with the additional GPS system, aerodynamic devices and other technologies only adding to the emissions benefits. For example, DHL, the global freight and mail carrier, recently began the SmartTruck project, which uses dynamic route planning and live traffic data. So far, SmartTruck has achieved the hoped-for 6% reduction in fuel consumption and carbon dioxide emissions. DHL also has incorporated hybrid diesel-electric vehicles into its fleet. The company expects to use up to 20% less fuel and produce 20% fewer carbon dioxide emissions.[15]

LOGISTICS CASE STUDY #2

Eco-driving

The emissions benefits of driving a new or well-maintained used truck are often negated by driving style or by a driver not knowing how to properly operate on-board technology. Training programs that teach drivers how to maximize fuel economy and use advanced technology systems are an important part of improving logistics and reducing emissions. Changes in personal driving habits and behaviors can be challenging to achieve, but company policies, combined with on-the-ground educational programs, can help with the transition, often for a low cost.

- **Training programs:** Driving techniques to maximize fuel efficiency include reducing speed, minimizing or eliminating hard braking and reducing air-conditioning use. Volvo Trucks North America, for example, launched their Fuelwatch Initiative beginning in 2009. One of the major components of the initiative is to provide Volvo customers with Performance Guides on how to best operate their vehicles. These guides help customers keep up with scheduled maintenance. Each of

Wikimedia Commons

Driving behavior can be an impediment to fuel reductions; small changes to driver habits can make a big difference for a small cost.

Volvo's five sales regions have driver trainers, who work with fleets on the best ways to increase fuel economy.[16]

- **Company policies:** Improved company practices include initiatives that limit idling, have loading specifications, require routine vehicle and tire maintenance, and allow for flexible loading and receiving schedules. One company that has actively changed its policies to improve fuel economy is EA Logistics. EA Logistics is a Bensenville, Illinois–based domestic and international freight forwarder with services that include trucking, air freight, ocean freight and warehousing. EA Logistics also has five of its own vehicles. Some of the measures include enforcing an anti-idling policy both at their own loading dock and for all of their drivers. They also train drivers on eco-driving, tire pressure monitoring and methods to consolidate loads and reduce packaging. EA Logistics also requires that drivers drive at or under 60 mph.[17]

Environmental benefits

Some estimates suggest that driver training and monitoring programs can improve fuel economy by at least 5% per year and eliminate 8.82 tons of carbon dioxide emissions annually.[18]

LOGISTICS CASE STUDY #3

Contract specifications

Many freight transport companies subcontract their vehicles or work with a variety of vendors to deliver goods. Contract specifications that encourage or require external parties to employ the practices listed in Case Studies 1 and 2 in this chapter represent a huge opportunity not only to reduce emissions, but to educate others on how to improve a company's fuel economy and bottom line. Companies that already employ certain fuel-saving practices can be given a competitive advantage over those that do not, further encouraging companies to find ways to become more environmentally friendly.

- EA Logistics is one company that actively works with vendors to adopt responsible practices in their operations. For example, EA Logistics worked with one of its shippers to

Technologies alone won't reduce emissions; partnerships are crucial.

reduce the air in their packaging, allowing more cargo to fit on the truck trailer. Since hauling full loads saves fuel and increases company profit, EA Logistics has integrated maximization of load capacity into its business model.[19]

- Subcontracting is a major part of DHL's operations profile. DHL has begun negotiations with its subcontractors to improve efficiencies and reduce emissions, at the lowest costs, wherever feasible.[20]
- Ryder Truck's RydeSmart service is written into all of its new contracts, and the company is working with existing customers to amend their contracts to include RydeSmart.[21]

Environmental benefits

All of these initiatives do have sound environmental benefits; however, they vary greatly by company, contract specification and fleet characteristics, making it difficult to estimate overall emissions and fuel benefits at this time.

CHAPTER 10

On-the-horizon technologies for rail, port and maritime

Many promising freight-sector improvement projects are still early in the research, development and deployment stage. The Norfolk Southern battery-powered locomotive and General Atomics' Electromagnetic Cargo Conveyor (ECCO) projects described here are just two of several. Others include Coastal Connect's compressed natural gas ROROs, Science Applications International Corporation's jet fuel from algae and Solar Sailor and COSCO's solar-powered sail container ships.[1]

These projects offer sound environmental and economic benefits, as well as co-benefits, which contribute to cleaner freight movement. Policies and incentives that promote and fund cleaner freight will only spur more of these innovative, outside-of-the-box endeavors.

ON-THE-HORIZON TECHNOLOGIES CASE STUDY #1

Norfolk Southern battery-powered locomotive

In September 2009, Norfolk Southern unveiled NS 999, a prototype 1,500-horsepower switching locomotive powered with rechargeable batteries. This prototype locomotive was developed by Norfolk Southern, as a partnership between the U.S. Department of Energy, the Federal Railroad Administration and Pennsylvania State University.[2]

NS 999 is an electric locomotive used for railroad switching applications. It uses a lead-acid energy storage system comprised of 1,080 12-volt batteries instead of a diesel engine. The plug-in locomotive also incorporates regenerate, dynamic braking energy, which continually replenishes the energy storage system. The locomotive is equipped with a battery management system, which monitors and controls battery life to ensure safety.[3] When fully charged, NS 999 is able to operate for three shifts before it needs to be recharged.

Courtesy of Norfolk Southern Corporation

Testing of this zero-emissions battery-powered locomotive has yielded promising results.

Environmental benefits

NS 999 has zero emissions.

Co-benefits

This locomotive has reduced health impacts for those operating in or near the locomotive. The locomotive is also quieter.

Economic benefits

Manufacturing costs are comparable to diesel-powered locomotives.

Funding

Total costs are unknown at this time. Federal funding has provided $1.3 million.

Next steps

As the prototype is still being tested at the Norfolk Southern site in Pennsylvania, performance results are forthcoming. These tests will indicate how best to scale up manufacturing and use of this technology. And while NS 999 is a yard locomotive, there are plans to make a more powerful road locomotive for long distance shipping.[4]

ON-THE-HORIZON TECHNOLOGIES CASE STUDY #2

Electromagnetic Cargo Conveyor (ECCO)

Container traffic from the ports of Los Angeles and Long Beach travels inland via local Los Angeles highways, seriously affecting congestion and regional air quality. General Atomics and California State University Long Beach have jointly proposed a solution to this endless stream of traffic: An electromagnetic cargo conveyor (ECCO), which would transport containers from the ports to inland distribution centers, without clogging highways or emitting harmful pollutants and greenhouse gases.[5]

The ECCO system has been successfully tested at General Atomics' 400-foot test track in San Diego, California. The system relies on electro-dynamic levitation, developed ten years ago by Lawrence Livermore Laboratories. Containers "float" above the conveyor, without wheels, distributing their weight through large area magnets. The proposed corridor would produce zero emissions, take truck traffic off the road, and greatly improve velocity and throughput.[6]

Consensus on the technology has not been achieved, and there are competing systems, such as the Texas Transportation Institute's Freight Shuttle.[7] Scientists and advocates of the ECCO technology suggest a blue-ribbon panel to determine the best technology. This consensus will shore up additional grant funding and improve the feasibility of the proposed corridor.[8]

General Atomics

The electromagnetic cargo conveyor, an alternative to rail and truck, is tested in San Diego.

Environmental benefits

- General Atomics estimates that current emissions from trucks on the corridor amount to 78 tons per year of particulate matter and 1,572 tons per year of nitrogen oxides.[9]
- While the type of power plant greatly determines the environmental benefits of an electromagnetic system, the emissions are substantially lower than truck traffic.[10]

Co-benefits

- The ECCO corridor would reduce truck congestion on local highways between the ports and inland distribution centers.
- Reduced truck traffic would result in health benefits and less truck noise.[11]

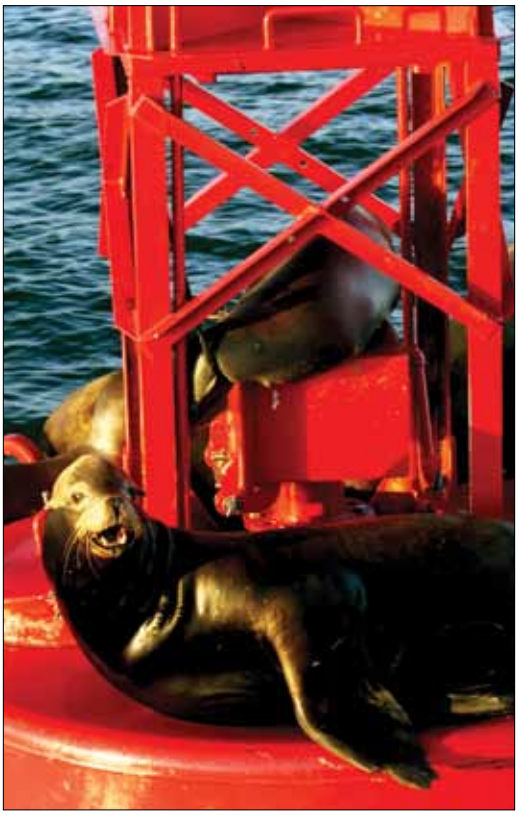
Economic benefits

- A corridor would improve the speed and quantity of container distribution.
- With estimated increases in trade at the ports of Los Angeles and Long Beach, a corridor that ensures faster delivery would improve throughput at the ports.[12]

Conclusion

The case studies highlighted in this report represent a small portion of projects around the world that are making the freight sector cleaner and more efficient. They prove that workable alternatives exist. These projects often involve multiple stakeholders and economic interests joining to implement creative initiatives that go beyond what is mandated to reduce greenhouse gases and criteria pollutants.

Trade is the lifeblood of the global economy, and freight movement is the backbone of the system. In the coming decades, global trade is predicted to increase. We need a system that accommodates increased trade without burdening the environment and public health. The current U.S. and global freight network needs to be modernized, and it needs to be done in ways that are smart, efficient, and clean.



Port of Long Beach

We need policies that can support a growing freight system without harming our environment and health.

Examples like those cited in this study should not remain innovations; they should become universal practices. Federal and state transportation funding programs—including the federal transportation bill—provide opportunities to make this happen. To green freight movement, spur innovation and develop a freight system for the future, these programs should prioritize spending in a way that:

- Identifies important freight corridors and hubs;
- Ensures planning for cleaning up freight transportation's emissions and other environmental impacts in those hubs and corridors;
- Implements those plans and reduces freight transportation's environmental impacts even as the sector grows; and
- Continues to advance innovation and cleaner technologies and practices, including the funding of demonstration projects.

This report highlights freight movement reforms that do not jeopardize—and in some cases even improve—a company's financial performance. With the right policies, innovations like those reported here can be adopted on a broader basis to benefit the environment and the economy.

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