IAPH Tool Box for Greenhouse Gasses

Introduction

Welcome to the International Association of Ports and Harbors (IAPH) Air quality and Greenhouse Gas Tool Box. The purpose of this Tool Box is to provide ports, both members and non members of the IAPH, quick access to the tools needed to start the planning process for addressing port-related air quality and climate change related issues.

Balancing port operations and development with environmental considerations can be challenging, especially with issues like air quality and climate change that are complex and evolving. This Tool Box provides information on air and climate issues and their relationship to port and maritime activities. Based on actual port experiences, it describes strategies to reduce emissions and guidance on how to develop a Clean Air Program and a Climate Protection Plan. Strategies such as repowering older engines, applying effective technologies for efficiency and emission control, and using alternative and cleaner fuels in maritime operations will dramatically reduce air pollution and greenhouse gas emissions. Undertaking such bold strategies will improve local air quality, safeguard public health, and protect ports and the planet from the effects of climate change.

Every port in every country has different needs and capabilities. The resources in this toolbox are intended to help initiate, inspire, and inform your internal discussions about what course of action is right for you. You are invited to explore this Tool Box and join other ports around the world in seeking solutions to these challenging problems.

About The Toolbox

In prior years, this Tool Box has dealt primarily with the reduction of air emissions associated with local health impacts; however, with the increased concern for the effects of global climate change, the Tool Box has been expanded to include additional tools focusing on greenhouse gas (GHG) mitigation.

In April 2008, the IAPH requested its Port Environment Committee, in consultation with regional Port Organizations, to provide a mechanism for assisting the ports in mitigating climate change. Through this request, in July 2008 a group of 55 ports from all over the world adopted the C40 World Ports Climate Declaration to work together to reduce the

threat of global climate change. This group is now known as the World Ports Climate Initiative (WPCI).

The mission of the WPCI is to:

- raise awareness in the port and maritime community of need for action
- initiate studies, strategies and actions to reduce GHG emissions and improve air quality
- provide a platform for the maritime port sector for the exchange of information thereon
- make available information on the effects of climate change on the maritime port environment and measures for its mitigation

In support of this mission, the WPCI has developed a website and formed subgroups focusing on "Themes" that will provide guidance to ports looking to monitor and reduce their GHG emissions. These themes currently include:

- Carbon Footprinting and Modeling Tools
- On-shore Power Supply
- Environmental Shipping Index
- Cargo-handling Equipment
- Intermodal Transport
- Lease Agreement Template

The Tool Box complements and supports the WPCI website by providing a resource for GHG case studies and emission reduction strategies. As with a priority pollutant emissions inventory, establishing a carbon footprint will guide ports to strategies that have the greatest reduction potential at their facility. The WPCI Carbon Footprinting Working Group is currently preparing a Guidance Document that will assist ports interested in developing their carbon footprint.

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Navigating the Tool Box

This Tool Box is constructed with two main sections: air quality and greenhouse gases. These topics are accessible from tabs on the main page. The additional tab, "Integration," describes how and when strategies from each of the toolboxes create "co-benefits;" strategies that accomplish the goals of both subjects. Links embedded among many of the strategies in each toolbox also provide a path for understanding co-benefits. Key sections of each Tool Box are described below:

Priority Pollutants Tool Box

Learn what ports are doing to improve air quality through successful clean air programs. Click "Case Studies" to learn more about port clean air programs.

Looking to reduce diesel emissions from cargo handling equipment or trucks? There are a number of strategies that can help you improve air quality. Click "Improving Air Quality Through Effective Strategies" to learn more.

Ready to create your own port clean air program? This Tool Box provides steps you can take to begin putting your program into action. Click "Creating Your Clean Air Program" to get started!

Need information on engine standards, air quality monitoring or a glossary of terms? This Tool Box provides valuable resources to help address questions you might have. Visit our "Air Quality Tools and Resource Library."

Greenhouse Gas Tool Box

Learn about the International Context for efforts to curb the threat of climate change and what international maritime and other partnerships are supporting the cause.

Learn about ways to reduce your carbon emissions in "Strategies for Reducing Greenhouse Gas Emissions".

Start creating your own GHG plan using information and approaches described in "Developing a Climate Protection Plan."

Share your port's experiences and projects by filling in a simple form -- or find out what others are doing in the "Climate Change Project Forum."

Greenhouse Gases (GHG's) and Ports: An Overview

Climate Change Background

Climate change is a global concern. During the 20th century, global average temperatures increased about one degree Celsius. Over the next 100 years, temperatures may increase another three to seven degrees Celsius. This phenomenon has been clearly linked to a build-up of Greenhouse gases (GHGs) in Earth's environment. GHGs affect climate as they concentrate in the atmosphere and trap heat by blocking some of the long-wave energy normally radiated back to space.

While some GHGs occur naturally, there is agreement among climate scientists internationally that human activity has significantly increased the GHG's in the Earth's atmosphere, leading to accelerated global warming. Activities causing this warming include those that occur in and around a port, such as burning fossil fuels for operations, transportation, heating, and electricity. The potential consequences of global warming include longer and hotter summers, longer droughts coupled with brief periods of more intense rainfall, more devastating weather-related disasters, and shortages of water -- all of which threaten public health and worldwide economic vitality.

Climate change poses an extraordinary challenge that demands immediate action. While national and international regulatory bodies are constructing mechanisms that will reduce emissions across sectors, individual organizations can contribute significantly to reducing the threat by examining their own greenhouse gas emissions and finding opportunities to reduce them. For organizations like ports, whose existence is based on activities that are prime targets for regulatory efforts, early action to address these emissions will ameliorate the future effects of increased costs as market-based forces are used to reduce carbon emissions. Being integral in the worldwide logistics chain, a port can also serve as a catalyst for rapid change throughout the industry.

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Greenhouse Gas Emissions and Emission Scopes

The maritime transport industry's contribution to global GHG emissions has been estimated to be between 1.4 percent and 4.5 percent. A fraction of those emissions are associated with port operations. The emission sources that are directly controlled by a port authority are an even smaller fraction of overall port-related emissions, which also include emission sources under control of port tenants (i.e., ships, harbor craft, trucks, rail, and cargo handling equipment). In order to address the climate change impacts associated with all port-related operations, this Tool Box considers both direct port authority-related sources as well as the port tenants' sources.

GHG emissions for an organization like a port are often categorized in terms of "scopes" that indicate how directly (or indirectly) the emissions are generated. Such categorization is a common element of emissions models and different protocols may define the boundaries of the scopes in a variety of ways. Scope determination is a central consideration for WPCI's Carbon Footprinting working group and will further define how port sources are categorized. This Tool Box covers topics and measures that affect emissions falling under all three traditional emission scopes. The traditional definition of scopes, as outlined in The Climate Registry's Local Government Operations Protocol, is illustrated below as it may apply to emissions associated with a port.

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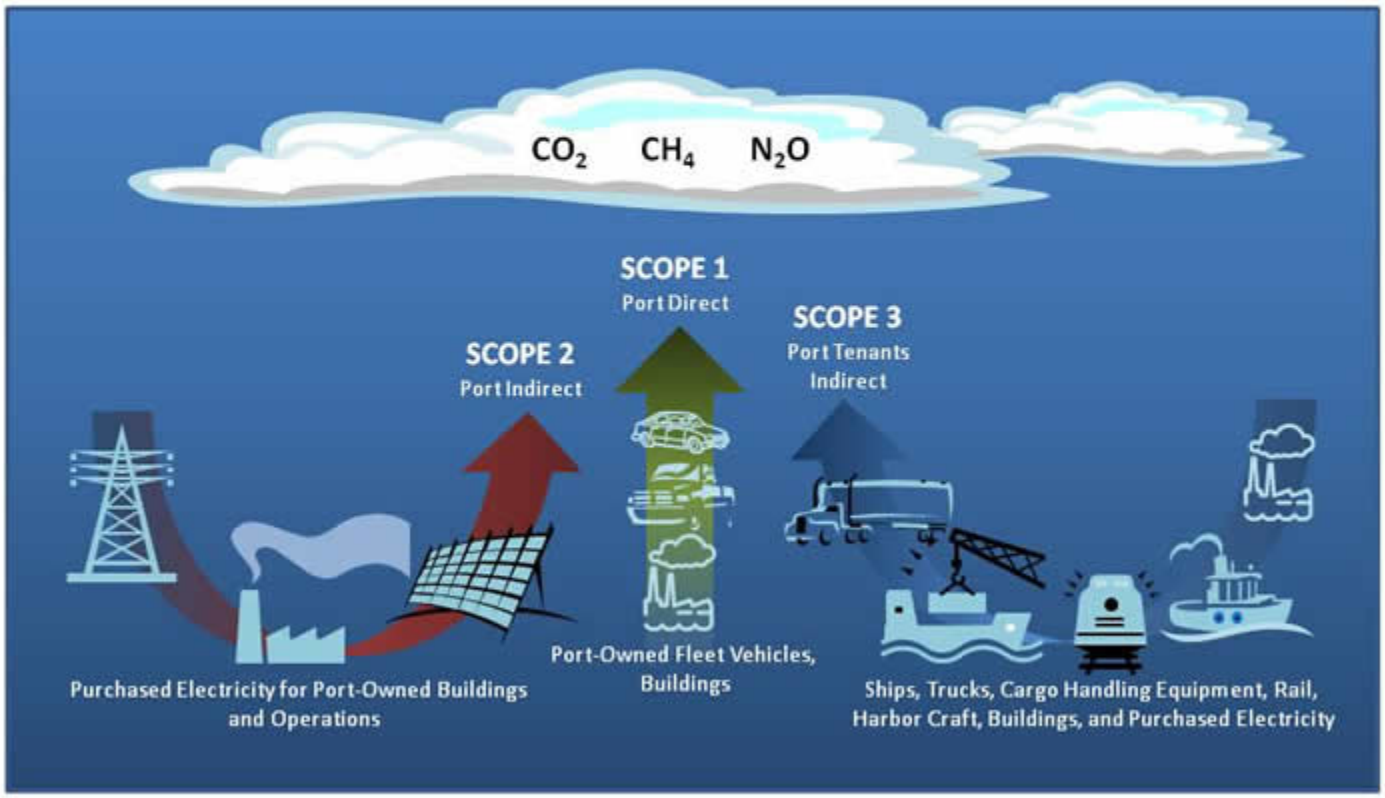
An Illustration of Scopes as They Pertain to Port Operations



Under this definition, Scope 1 includes all direct GHG emissions from a port's directly-controlled stationary and mobile sources. Examples of Scope 1 sources include port-owned fleet vehicles and port employees commute vehicles, stationary generators, and buildings (i.e., natural gas combustion). Scope 2 includes indirect GHG emissions associated with the import and consumption of purchased electricity by a port for its directly-controlled sources (i.e., electricity used for port-owned buildings and operations). Scope 3 accounts for emissions associated with the operation of port tenants. Although inclusion of Scope 3 emissions in a port's GHG inventory goes beyond what other organizations may include, they are an important part of developing a plan for management of GHG emissions on a port-wide basis. Scope 3 emissions include a port tenants' direct emissions from stationary sources (i.e., natural gas combustion in buildings), mobile sources (i.e., ships, trucks, rail, cargo handling equipment, and harbor craft), and indirect source emissions associated with purchased electricity (i.e., buildings, electric wharf cranes, and shore power for ships).

Scope 1 and 2 emission categories will likely represent a very small fraction of the port's overall emissions, while Scope 3 emissions associated with port tenants will likely account for the vast majority of the port-wide emissions. However, GHG emission reductions from all port-related sources are necessary to minimize the overall impact of the port-related operations on climate change. While Scope 1 and 2 emissions may be lower in magnitude, they are easier for a port to control and therefore may also be a good place to begin. Implementation of strategies for all port-related sources will achieve significant GHG reductions that will help reduce the adverse impacts of global climate change.

The actual scope of emissions at individual ports will differ significantly based on a wide variety of governance and operational models.

GHG Emission Control Measures

Introduction

This Tool Box describes control measures that ports can undertake to reduce GHG emissions both within the port authority and for port tenants. A port climate protection plan should be a comprehensive undertaking that establishes goals for reducing greenhouse gas emissions from all port-related emission sources. Ideally, such a plan would be implemented after a comprehensive port clean air plan and use many of the same mechanisms for inventorying emissions and implementing changes to reduce those emissions. Because ports vary widely in their authorities and resources, the focus of the control measures is mainly technical with a brief description of possible policy mechanisms for implementation. It is the intent of the "User Forum" section of the GHG toolbox that such peripheral issues may be discussed in the course of sharing experiences with the implementation of specific projects.

This section presents a broad range of strategies that a port may implement to achieve the goals of their climate protection plan. Because of the long-term nature of a climate protection plan and the magnitude of emission reductions needed worldwide, the measures presented here are intended to cover both near-term and long-term strategies, though the practicability and implementation time will vary widely among ports:

Short-Term Strategies and programs are those that a port can begin in the next several years. These strategies have the potential to be fully or at least partially implemented within ten years. Technologies for implementing these strategies have either been demonstrated or are in the demonstration phase.

Long-Term Strategies offer the potential to achieve significant reductions in greenhouse gas emissions over two to four decades from now. These strategies may require major technological breakthroughs and/or advancement of existing technologies, massive public and private financial commitments and infrastructure developments, and coordinated efforts among multiple jurisdictional bodies. These long-term strategies include options that would significantly change the way the cargo transportation sector operates and the equipment it uses. They also cover innovative strategies for ports to participate in developing electricity generation from renewable energy sources.

Each measure presented below includes a description of mechanisms that may be helpful for implementation. These mechanisms will likely evolve as strategies are added, revised, or replaced as experience is gained. Most likely, a combination of these mechanisms will provide the most effective approach and the maximum amount of flexibility in implementing a port's climate protection plan. Fundamental to each of the mechanisms is sound monitoring, recordkeeping, and reporting. Since strategies may affect both the port and the port's tenants, the mechanisms for implementing these strategies are varied.

Some of the implementation mechanisms would only apply to the port authority's operations (i.e., policies and programs, outreach) while others are intended for implementing strategies affecting a ports tenants (i.e., lease requirements, tariff changes, incentives, voluntary measures). While not addressed specifically in this Tool Box, carbon credits are an emerging option that could potentially be used both by a port and its tenants to meet goals in addition to or in lieu of other measures.

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Implementation mechanisms referenced in the strategies include:

Programs and Policies - Port's programs and policies to implement strategies for municipally-controlled sources (e.g., port's fleet vehicles, buildings, operations).

Lease Requirements - Port tenants required by lease to implement strategies and meet GHG emissions reduction requirements through renegotiated, amended, and new leases.

Tariff Changes – Uniform set of rates, charges, rules and regulations which are generally applicable to most or all port tenants.

Incentives - Incentive funding targeted toward specific sources to accelerate GHG emissions reductions beyond what is currently required by regulation or lease requirements and can come from several sources including the port, local and state regulatory programs, federal agency programs and grants.

Voluntary Measures - Voluntary implementation of strategies by port tenants encouraged by the port which are non-compensated actions agreed to and undertaken by port tenants, and are used or implemented by the participants without legal obligation.

Outreach - Outreach and education programs on climate change which would raise the awareness level and would prompt actions to reduce the port-wide carbon footprint.

Carbon Credits – Purchasing certified carbon credits or renewable energy credits to achieve net GHG reductions as an alternative to reducing direct and indirect port-wide GHG emissions.

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Relationship to Climate Change Project Forum:

Finally, the measures presented below are referenced according to the following seven categories. These same categories are also used to organize submitted projects in the Tool Box's Climate Change Project Forum. Such categorization will facilitate easier navigation of projects and measures as the measures and projects are appended in the future.

Category Code	Category
PDC	Port Policies and Directly Controlled Sources
GEN	Renewable Electricity Generation
OGV	Ocean-going vessels
HC	Harbor craft
CHE	Cargo handling equipment
HDV	Heavy-duty vehicles
RAIL	Rail locomotives
OTH	Other Projects

Measures

GHG Emission Reduction Measures

Category	Control Strategy
HDV	Performance Standards for On-Road Heavy-Duty Vehicles
OGV	OGV Vessel Speed Reduction (VSR)
OGV	Reduction of At-Berth OGV Emissions
OGV	OGV Main & Auxiliary Engine and Boiler Emissions Reduction
HDV	RFID / Terminal Gate Efficiency Measures
PDC	Electric/Hybrid Electric Vehicles/Plug-ins/AFVs
PDC	Employee Commuting
PDC	Building Standards/Retrofits/Water Conservation/Recycling
PDC	Operational Efficiency Improvements
PDC	Tree Planting
PDC	Community Redevelopment – Open Space/Brownfields
CHE	Electric Rubber Tired Gantry Cranes(RTG)

CHE	Electric Yard Tractor
CHE	Terminal Equipment Electrification
HC	Tug Staging Areas
HDV	Near-Term Zero-Emissions Technologies for Trucks
OGV	OGV Energy Saving Measures
GEN	Solar Power Generation
GEN	Renewable Energy Purchase
RAIL	Alt. Power Units (APU's) & Anti-idle for Switching Locomotives
RAIL	Hybrid Locomotives
PDC	On-Terminal Lighting
HDV	Electric/Hybrid Dray Trucks

Measure Title: Performance Standards for On-Road Heavy-Duty Vehicles

Strategy – Require that all trucks servicing the port meet most recent standards. A comprehensive program will maximize the associated emissions reductions and ensure that trucks have modern, safe, and fuel efficient engines.

Technical Considerations – Retire older vehicles that have mechanically controlled engines. Newer engines with electronic combustion controls and engines made with state-of-the art design and fabrication techniques ensure maximum efficiency. Newer trucks will also be more aerodynamic, a major factor in maximizing fuel efficiency and reducing CO2 emissions. Frequent maintenance of newer trucks is very important to maintain clean operation in addition to extending sustainable use of vehicle.

Options for Implementation – Implementation strategies may include; bartered agreements, tariffs, fees, and incentives.

Pros and Cons –The capital costs of replacing engines and/or vehicles may be prohibitive with new day-cab tractors costing on the order of US$90,000. Other maintenance and operating costs are reduced.

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Measure Title: Vessel Speed Reduction

Vessel Speed Reduction (VSR)

Strategy – This measure reduces emissions from Ocean Going Vessels (OGV's) during their approach and departure from a port. This would include a speed reduction possibly down to 12 knots or lower when OGV's are within the coastal waters of a port or within the port area.

Technical Consideration – No operational changes are required of the engine. Technical considerations may include updating existing radars and communication devices to communicate with local navigation and communication centers. Vessel speed at which emissions and fuel use per mile are lowest is based on limited data and likely to vary with vessel and engine.

Options for Implementation – Assure compliance through tariff reduction incentives, lease requirements for renewed lease agreements, or voluntary programs. Create a memorandum of understanding with shipping companies, ports and regulatory agencies.

Pros and Cons – VSR has many benefits. Since the load on the main engines affects power demand and fuel consumption, this strategy significantly reduces all pollutants. In addition to GHG's, PM, NOx, and SOx are also significantly reduced -- a key reason that VSR programs have been implemented at other ports. The fuel economy benefit may come at the expense of additional operational costs, including longer transit times and congestion. VSR programs have also been implemented in the Northeast of the United States to reduce the frequency of ships striking whales..

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Measure Title: Reduction of At-Berth OGV Emissions

Strategy – Shore power focuses on reducing dwelling (hotelling) emissions from OGVs while at berth. This strategy has two approaches 1) traditional shore-power -- transferring the electrical generation needs for OGVs while at berth to power generated by regulated/controlled stationary sources and 2) hotelling emissions reduction requirements through alternative technologies for ships that do not fit the shore power model. Shore power is best for OGVs that make multiple calls at a particular terminal for multiple years. The best candidates for shore power are container ships, reefer ships, and cruise ships.

Technical Considerations – Providing shore power requires significant infrastructure on-dock and on-board vessels. Determine necessary power needed and ensure adaptability. For maximum GHG emission reductions, consider the local power company that is providing the electrical power to the terminal. Shore power coming from coal-burning power plants will still result in approximately three times less GHG emissions than ship-generated power, but many power companies may be able to ensure a cleaner source of energy for a modest price premium. The WPCI, through its Onshore Power Supply (OPS) working group, is developing a web-based application that will provide guidance and information for ports, terminals, and shipping lines. Interested in developing OPS.

Options for Implementation – Lease Requirements, Tariff Changes, & Incentives

Pros and Cons – Positive emission reduction benefits while at port with shore power. Depending on the price of fuel, the capitalized shore-power system costs plus the cost of electricity may become competitive with the cost of burning distillate fuel at berth. A rough break-even price point for this is $1000/ton for distillate (e.g. MGO), but the actual price will vary widely with project capital costs and electricity costs. Challenges occur with infrastructure cost and shore power hook up. Shore power requires extensive infrastructure improvements.

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Measure Title: OGV Main & Auxiliary Engine and Boiler Emissions Reduction

Strategy – Undertake projects to repower/replace main engines, auxiliary engines and boiler equipment or refit these systems with emissions reduction equipment that are validated through regulatory agencies. The goal of this measure is to achieve GHG co-benefits from implementation of strategies which could further reduce PM, NOx, and SOx emissions below those levels required under MARPOL Annex VI, and lower the emissions of the existing OGV fleet prior to the implementation of these standards. Specific measures include the use of slide valves to enhance combustion efficiency and engine replacement or repower.

Technical Considerations - Operational and feasibility testing is required to ensure the function and appropriateness of any control technology in marine applications. Slide valves are a relatively new technology that may only be appropriate for certain engines. Engine repowering can be prohibitively expensive or unfeasible depending on the type of vessel being considered.

Options for Implementation: Lease Requirements, Tariff Changes, & Incentives

Pros and Cons – Positive emission reduction benefits in addition to modest reductions in GHGs. Challenges may occur with technology feasibility and costs of repower/replacement.

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Measure Title: RFID / Gate Efficiency Measures

Strategy - Redevelop infrastructure and use technology, such as radio frequency identification (RFID) and optical character readers (OCR), to enhance the efficiency of gates and terminals, relieve congestion and reduce all combustion emissions. Extended/off-peak terminal hours and moving more cargo to rail and water (via short sea shipping), where feasible, can shift heavy-duty truck traffic from peak daytime operations to nighttime and weekends resulting in fuel savings and GHG reductions.

Technical Considerations – Ensure technical feasibility. Cost of technology versus benefit achieved should be a consideration in assessing potential improvements. Deploying RFID tags or similar equipment to a large and diverse trucking fleet may be logistically challenging.

Options for Implementation –Incentives, Lease Requirements, and Voluntary Participation

Pros and Cons – Some of these options involve capital investment; others could increase terminal operating costs. However, if designed and planned properly, can result in a significant return on investment due to enhanced operational efficiencies.

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Measure Title: Electric/Hybrid Electric Vehicles/Plug-ins/AFVs Initiative

Strategy – Expand the use of Alternative Fueled Vehicles (AFVs) including electric vehicles, hybrid electric vehicles, hybrid plug-ins and other alternative fuels (e.g., CNG, LNG) in fleet vehicles operated by a port and the port's tenants.

Technical Considerations – Many promising AFVs are new to the market and may lack substantial infrastructure penetration. For electric vehicles, fast-charge infrastructure would have to be installed for frequently-used equipment. For natural gas vehicles, a natural gas source and filling/compression infrastructure is required. Hybrid vehicles are most easily implemented into a fleet but may have the least overall emissions benefits. Maximum benefits may require operator training.

Options for Implementation – Port Programs and Policies, Lease Requirements, and Voluntary Participation

Pros and Cons – Alternative fueled vehicles are generally more expensive than standard vehicles for similar applications and offer a more limited selection. Additional capital costs are unlikely to be offset by fuel cost savings over the life of the vehicle but the value of emission reductions to a port may shift this balance. An alternative to AFVs may be a vehicle "right-sizing" program that seeks to ensure that only the smallest and lightest vehicles that can adequately perform their intended function are used.

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Measure Title: Employee Commuting

Strategy – Employee commuting programs developed by a port can be extended to port tenants, providing incentives for employees to use commute trip reduction measures such as carpooling, vanpooling, public transportation, bicycling, and walking. A port may also provide carpooling vehicles, dedicated shuttle services, and/or dedicated parking or bike storage for participants.

Technical Considerations – Programs can be very simple with minimal coordination or investment required. More extensive efforts may use tools to coordinate employee carpooling based on residence location, create dedicated bicycle lanes and storage, and provide vehicles for car or vanpools. For bicycling commuters, locker-room type amenities may also need to be provided.

Options for Implementation – Programs and Policies, Incentives for Employees, Lease Requirements and Voluntary Participation

Pros and Cons – Compared to other measures, employee commuting measures may have minimal effect. The greatest benefit may be as a mechanism to remind employees to be vigilant about energy efficiency and to seek emission reduction opportunities in their primary job functions. Walking and bicycling have health benefits that translate to better job performance. Providing bus passes, carpooling coordination, and/or shuttle services can be considered an enhancement to employees' overall compensation packages. Reducing employee vehicles also relieves congestion and parking requirements at the port.

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Measure Title: Building Standards, Retrofits, Water Conservation, Recycling, Green Purchasing

Strategy – Implement "green" policies and standards such as Green Building Standards for new and existing buildings, Water Conservation, Recycling, and Green Purchasing Policies for the port and port tenants to reduce greenhouse gas emissions.

Technical Considerations – Specific "green" building standards can vary among countries and localities depending on available materials and expertise. A "baseline" survey will need to be done for existing buildings to identify existing water/energy use and identify opportunities for improvement. Recycling depends heavily on what external facilities are available to collect and process the materials. Green purchasing depends on disclosures from suppliers that may require additional investigation. Water saving measures can require simple equipment, like aerating faucet heads, to more complex systems that capture and store rainwater for landscape irrigation. The "Leadership in Energy and Environmental Design" (LEED) certification is a basis for design guidance that has been applied to buildings around the world.

Options for Implementation – Programs and Policies, Lease Requirements and Voluntary Participation

Pros and Cons – Capital costs for retrofits may be high but can generally be recovered over time through energy savings from appropriately designed projects. Depending on the age of the building, it may be more cost effective in the long run to replace, rather than refit, the structure. Green purchasing requires an additional level of complication to the transaction and may incur a price premium. This type of purchasing practice has many indirect human and environmental benefits by creating positive market forces.

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Measure Title: Operational Efficiency Improvements

Strategy – Implement terminal operational efficiency improvements as a means of reducing energy demand and greenhouse gas emissions. This strategy generally seeks to have a port authority facilitate initiatives for or among tenants that will enhance the efficiency with which goods are moved through the overall port. A port may be better positioned to monitor emerging industry practices and identify initiatives that may result in air quality benefits and enhanced efficiency. The port would also take a role in monitoring practices and outcomes to ensure that efficiency measures and improvements are realized.

Technical Considerations – Not all practices at a given port may be transferrable to another port. Sufficient technical and design expertise should be sought during project development.

Options for Implementation – Programs and Policies, Lease Requirements and Voluntary Participation

Pros and Cons – Complicated systems may require more rigorous and time consuming methods to track progress and document outcomes. Given the long life spans of terminals, incorporating improvements for efficiency into major maintenance or reconstruction projects may delay these measures.

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Measure Title: Tree Planting & Green Landscaping

Strategy – Seek opportunities to add trees and other plants and "green" landscaping features within the footprint of the port and in peripheral environs. Develop a landscape maintenance plan that maximizes tree growth and vitality to ensure maximum carbon sequestration.

Technical Considerations – Specific equipment and expertise will be required to plant and maintain trees. Landscaped areas may restrict those areas for many types of use. Creative designs, like permeable concrete and concrete lattice that permits moss or grass growth, can allow some areas to be used for light-duty vehicle applications. Surrounding communities may already have landscaping programs that can be leveraged for cooperation.

Options for Implementation –Programs and Policies, Voluntary Participation by Community Members, Port Tenants, Employees, and Through Capital and Maintenance Improvements

Pros and Cons – Trees and other plants have significant additional benefits including air quality improvement, noise reduction, and, if placed properly near buildings, energy efficiency benefits. On-going maintenance can add additional operating costs and "green" areas on port property may restrict use for other port activities. While this measure may have little effect on GHG emissions or sequestration relative to other port measures, robust natural features in the port area serve to remind employees and visitors to consider the environment as they make decisions in the course of their primary job functions.

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Measure Title: Community Redevelopment

Strategy – Pursue development and mitigation plans that favor creation of open, natural spaces and other areas that have joint community and environmental benefits. Port development plans should seek renovation of community properties that are not otherwise naturally viable or useable for the community. These include old industrial sites and brownfields.

Technical Considerations – Old industrial sites and brownfields may have deep soil contamination that requires additional remediation. Areas that are designed for dual public/port use need special security and safety infrastructure.

Options for Implementation – Port Programs and Policies

Pros and Cons – Ports are integral to the vitality of their surrounding communities and can have significant impacts, beyond being an economic engine, while remaining within the rules of their charter. Development and infrastructure decisions related to land use can have significant impact on the ability of an area to sequester carbon. Creating opportunities for public and environmental benefits in the process of development may help give the port license for other initiatives.

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Measure Title: Electric Rubber Tired Gantry (ERTG) Initiative

Strategy – Convert diesel-powered RTG's to electric or "ERTG's".

Technical Considerations – ERTG's require moderate to significant infrastructure addition. Current versions of electric RTG's require either overhead catenary lines, rail-mounted electric supply buses or side mounted cable-reels. The first two options especially, will reduce the flexibility of RTG operation by restricting them to a specific space of operation. Additional electric supply and transformers will be required beyond what would likely be available in the immediate vicinity of where the RTG's operate.

Options for Implementation – Lease Requirements & Voluntary Participation

Pros and Cons – As long as diesel fuel costs more than US$1.00 per gallon or electricity costs less than US$0.25 (assume diesel is US$2.50), ERTG's will have significant fuel savings associated with them that could make the return on capital investment occur within just a few years. ERTG's reduce operational flexibility somewhat, but may be cheaper to operate and maintain.

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Measure Title: Electric Yard Tractors

Strategy – Replace diesel yard tractors with electric yard tractors

Technical Considerations – While one company is currently manufacturing electric yard tractors for terminal operations, they are not yet equipped with modern batteries that have the longevity and charge performance required to be a direct replacement for the diesel version. Emerging battery technology, such as those being implemented in passenger electric vehicles slated for market release next year, will likely offer adequate performance to allow a more seamless replacement. Given the relative simplicity of the technology it is conceivable that existing yard tractors could simply be retrofit with an electric drive system, in the manner of existing RTG retrofit packages, rather than be replaced. Such an option would also create life-cycle GHG benefits by reducing the need to scrap otherwise useable vehicle frames and bodies.

Options for Implementation – Lease Requirements & Voluntary Participation

Pros and Cons – Current electric yard tractors are expensive – over twice the cost of a diesel yard tractor. It is commonly assumed that electric vehicles with advanced battery technology will ultimately cost 50% more than their petroleum driven counterparts when manufactured at scale. This additional cost would easily be made up for in fuel savings over the life of the vehicle even when battery replacement costs are considered. For GHG's, even with electricity that is sourced from supplies that are heavily coal dependant, the electric yard tractor reduces overall GHG emissions by ~2/3 compared to diesel.

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Measure Title: Terminal Equipment Electrification Initiative

Strategy – Replace diesel terminal equipment with electric terminal equipment as it becomes available.

Technical Considerations – While electric versions of most types of terminal equipment do not currently exist, recent advances in battery technology and charging systems indicate that such replacements are technically feasible. Given the impending rapid emergence of electric vehicles for the passenger market and the developing prototypes for the heavy-duty market, battery or fuel cell powered electric versions of existing equipment could be available in 5-10 years. Because ports are still a niche market for heavy-duty equipment, the port sector will have to take leadership in encouraging industry to develop the prototypes that will precede market availability. The development of the Balqon electric yard truck is a good example of how public-private partnerships can develop mutually beneficial technologies. In advance of these technologies being available, terminals and infrastructure should be designed in such a way as to assume the installation of fast-charge stations and dedicated equipment charging areas.

Options for Implementation –Lease Requirements & Voluntary Participation

Pros and Cons – The clear benefit of electrified terminal equipment is the potential for truly zero-emission operation if the vehicles are charged with power that comes from renewable sources. While these and other technologies are not yet available, combating climate change is a long term challenge that will need similar long-term approaches. Planning for the case where maximum performance meets minimum emissions, as this measure implies, may be the most prudent and productive strategy.

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Measure Title: Tug Staging Areas (TSA) Initiative

Strategy – Use tug staging areas with shore power infrastructure or equivalent emissions reduction strategy where diesel powered harbor craft operating at the ports would turn off their engines while waiting to be deployed.

Technical Considerations – TSA's would require dedicated waterfront access be available with an appropriate area to tie up. Electrical infrastructure would need to be accessible at the point of moorage. Security and safety accommodations are required for personnel to move on and off vessels while moored.

Options for Implementation – Incentives & Voluntary Participation

Pros and Cons – Waterfront space at most ports is at a premium, especially if it can be developed for moorage with appropriate electric infrastructure and access. Therefore, the use of a tug staging must be based on an agreement with tug service providers. Additional agreement will be needed for maintenance and electric costs as the TSA will likely be operated directly by the port, rather than a third party.

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Measure Title: Near-Term Zero-Emission Technologies for Trucks

Strategy – Use zero-emission technologies for transporting cargo between terminals and local intermodal rail yards, warehouses, and distribution centers within several miles of a port. Similar to the measure for electric yard tractors, this measure uses battery powered drayage trucks to transport containers from the terminal to local destinations on low to moderate-speed public roadways.

Technical Considerations – The current generation of electric drayage trucks use batteries that may not allow operation for a full day before requiring a four-hour recharge. Therefore, operations may need to be adjusted or multiple vehicles would need to be purchased. Charging infrastructure and dedicated space would need to be located at either the terminal or destination.

Options for Implementation –Incentives & Voluntary Participation

Pros and Cons – Electric trucks are currently very expensive – over twice the cost of standard diesel drayage trucks – and cannot be run continuously through multiple operational shifts. Lower fuel costs may offset high capital costs in the long run, but the current level of performance will limit their application to relatively low or moderate-demand applications.

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Measure Title: OGV Energy Saving Measures

Strategy – Undertake actions that will reduce fuel consumption in OGV's main and auxiliary engines and boilers, resulting in reduced GHG emissions. These actions include: Hydro-dynamic ship designs, hull and propeller maintenance and advanced bottom paints, use of MDO vs. HFO or LNG if available, operational controls such as route optimization and steady speeds, fleet planning, cargo pooling, ocean current exploitation. Emerging technologies such as SkySails may offer unconventional opportunities to reduce emissions.

Technical Considerations – All existing vessels have distinct opportunities and limitations in which efficiency enhancement opportunities are available at reasonable cost.

Options for Implementation – Voluntary Participation, Incentives, Lease Requirements

Pros and Cons – Individual actions listed above have the potential to reduce vessel consumption between 4 and 40 percent depending on the action, vessel and condition. Implementing these changes can be prohibitively expensive and not all vessels or conditions will yield maximum fuel savings.

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Measure Title: Solar Power Generation

Strategy – Install solar power panels on existing rooftops and parking lots throughout port property to replace a portion of electricity provided by the local electric grid.

Technical Considerations – Significant structural and electrical integration considerations. Solar power may not be optimal in all climates. Current solar panels require relatively low maintenance, but will require dedicated service and monitoring regime to ensure optimum performance.

Options for Implementation –Port Policy Changes (for authority-controlled areas), Lease Requirements and Voluntary Participation.

Pros and Cons – Solar energy is still significantly more expensive (2-3 times) than grid-purchased electricity but the current technology is expected to decrease in price by half over the next decade. Locally-produced electricity has the benefit of price stability and supply consistency. Significant tax incentives are available in some countries.

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Measure Title: Renewable Energy Purchase Initiative

Strategy – Seek opportunities to purchase 100 percent of required power from renewable generation sources

Technical Considerations – Even if electricity suppliers have sufficient renewable sources in their generation portfolio, it may be difficult to reserve or account for specifically sourced power.

Options for Implementation –Voluntary Participation, Tariffs

Pros and Cons – Without specific, dedicated power generation for the port, it is difficult to ensure that supplied power is entirely renewable. Many power companies will offer an opportunity to pay an additional "green" fee that will promote the development of renewable power sources but does not necessarily translate into actual renewable power. Voluntarily paying higher rates for electricity may create a "reverse incentive" by reducing the benefits of electrifying equipment.

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Measure Title: Auxiliary Power Units (APU's) & Anti-idle Equipment for Locomotives

Strategy – Install equipment on switching and line-haul locomotives to minimize emissions when the locomotive is not active. This type of equipment includes 1) engine heating systems that keep fluids at operating temperatures while the engine is shut off 2) Automatic Engine Start/Stop (AESS) systems that automatically shut-down idling engines and 3) Auxiliary power units that generate enough energy to run control equipment and maintain engine fluid temperatures without running the main engine. Auxiliary systems

may be powered by a small diesel motor mounted on the locomotive or plugged-in to a trackside power supply.

Technical Considerations – Systems are able to be retrofit onto a wide variety of locomotives. Custom enclosures may have to be built for individual applications. Larger units will require installation on the peripheral walkway of the locomotive, potentially limiting access to some areas. Installation may require specialized skills or a technician provided by the manufacturer.

Options for Implementation – Incentives & Voluntary Participation

Pros and Cons – Locomotives, especially switching locomotives that may be used at or near port areas, are required to spend significant amounts of time idling during the course of operations. Idling the engine is often only necessary to ensure that the locomotive can return to service quickly or to provide power and heat for the operator. Auxiliary power units and other anti-idle equipment are available in a variety of configurations and can provide the operations needs while reducing unnecessary engine operation. APU's and similar devices can be installed on most locomotives at a cost that produces a return on investment in 2-5 years by reducing fuel consumption. The effectiveness of these systems depends heavily on the types of operation.

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Measure Title: Hybrid Locomotives

Strategy – Replace diesel locomotives with battery-hybrid or electric locomotives in switching yards. Standard locomotives are already "series hybrid" by common definition because they use a diesel engine to generate electricity to drive a traction motor – there is no mechanical connection between the engine and wheels. A "hybrid" locomotive adds a rechargeable energy storage system to the series hybrid configuration giving it the ability to recapture energy from braking and deceleration and supplement power during acceleration. An electric switching locomotive lacks a main diesel power plant and requires external power supply infrastructure.

Technical Considerations – Hybrid locomotives are able to perform the same functions as existing switching locomotives with minimal operational changes. Many versions of hybrid locomotives have been developed worldwide and the primary technical hurdle continues to be the battery or similar regenerative power source.

Options for Implementation – Incentives & Voluntary Participation

Pros and Cons – Hybrid locomotives can reduce the amount of fuel used in switching operations by eliminating idle emissions, recapturing energy, and improving energy efficiency. The main problem with hybrid locomotives is that they are very expensive compared to their diesel equivalent. While maintenance and fuel costs may be lower, lifetime operating costs for hybrids have not shown to balance the capital cost of the locomotive and the replacement cost of batteries. This balance may change as fuel costs rise, capital costs drop, or emissions reductions become more valuable.

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Measure Title: On-Terminal Lighting Initiative

Strategy – Increase the use of energy efficient lighting for terminals

Technical Considerations – Most terminals still use high-pressure sodium (HPS) lights as the preferred, energy efficient alternative for terminal lighting. While the yellow light offers less effective visibility per lumen than lights with bluer hues like metal halide lamps, HPS will re-light instantly in the case of power interruption, a key concern for many terminals. In addition to re-lamping, lighting can be enhanced by using high-mast lighting and well placed reflectors to direct light appropriately and prevent light pollution.

Options for Implementation – Lease Requirements & Voluntary Participation

Pros and Cons – Replacing terminal lights can be disruptive to operations and may require special permitting in the vicinity of the shore. New high-intensity LED area lights have been demonstrated recently that have a 10-year life span, excellent visibility spectrum, and 50% lower energy use. While only having been developed for demonstration so far, it is expected that these lights will become widely available for municipal area lighting in several years.

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Measure Title: Hybrid/Electric Trucks

Strategy – Use hybrid-electric and electric trucks for mid-range and long-range transportation between port terminals and off-dock intermodal yards, distribution centers, and warehouses.

Technical Considerations – Mid and long-range capable electric trucks capable of hauling maximum container weights at arterial speeds are not yet available. Hybrid trucks are being developed for market and smaller (<15 ton GVW) mid-range electric trucks are in production. Full sized electric trucks would be costly, given currently available battery technologies and production levels, but are technically feasible. Widespread implementation of electric trucks to replace the existing fleets will require extensive charging infrastructure.

Options for Implementation –Tariffs, Lease Requirements, Incentives

Pros and Cons – Replacing the mid and long-range trucking fleet would be an extraordinary undertaking for most ports, requiring significant investment and incentives. Electrified heavy-duty trucking would be a boon to many sectors and a significant improvement to local air quality around ports that are heavily dependent on trucks. Hybrid trucks will be a more economically and technically tenable option in the near term and would be ideal for application where idling and frequent stop-start travel is common.

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CLIMATE ROTECTION PLAN DEVELOPMENT

Prelude to a Plan :

"Why act now when there's still so much uncertainty?"

Managing the "shifting sands" of regulatory development and external programs:
It is simple to find reasons *not* to act now – or to simply implement "actions" that defer hard decisions by continuing to study the issues without committing significant resources. Addressing climate change is expensive, the issues are complex, and the regulatory environment is still evolving. But in this case, early action is critical, cost effective, and strategic for the following reasons:

1) **Stay ahead of regulation.** The ports and maritime sectors are well known as significant emitters of greenhouse gases. These sectors are a prime target for regulators because the industry has undergone relatively less direct regulation due to its complexity and international reach. By taking early action and implementing robust plans, the ports and maritime community may avoid regulations that create more burdensome, inappropriate, or costly mandates.

2) **Create Precedent.** In developing regulations that may affect a port, regulating agencies will often investigate what programs are already in place to manage the subject of regulation. Well conceived and implemented measures and strategies are much more likely to be incorporated into regulatory policies. Contributing with specific, successful examples as policies are being developed will result in more productive regulation than trying to amend the regulation after it is developed.

3) **Document Early Action.** In addition to the public relations benefits achieved by being proactive on an issue that is routinely rated as a top public priority worldwide, undertaking early actions and documenting them rigorously gives regulators a tool by which to give credit for early action. This sort of credit may in the form of credit toward future carbon trading programs, less drastic regulation, more lenient timeframes for implementation, or an opportunity to offer a stronger voice in the development of regulations.

4) **Lock in Talent.** The nature of the challenge of combating climate change, especially as it relates to the complex set of political and technical issues faced by ports, is that there are relatively few people and organizations available with the real experience and expertise to understand the issues and help develop the best plan. Consultants will be teeming to portray themselves as experts in this rapidly growing field, but the organizations with the most appropriate talent will be locked in by early actors. Likewise, if the program is

sufficiently large that it warrants staff augmentation, the most qualified program managers and subject matter expertise will become committed early on.

5) **Start Improving Infrastructure.** The sooner a strategic plan is in place to manage GHG emission reductions over the long term, the sooner a port can begin to adjust its infrastructure development program to ensure that appropriate systems can be implemented in coming years. Retrofitting terminals and infrastructure after the fact can incur far greater costs and disrupt operations.

6) **Invest Now, Save Sooner.** The majority of strategies for reducing greenhouse gas emissions focus on reducing fuel use and conserving energy. Many of these strategies will create a positive return on investment by reducing fuel and energy costs. An important side effect of improving fuel and energy efficiency is that it reduces the impact of fuel price increases and variations allowing better long term planning and program viability.

WHERE TO BEGIN

Establish a port-wide vision:

Before any progress can be made towards developing and implementing a climate protection plan, the port has to commit to a vision that will guide the port's overall response to climate change. This commitment is especially important among the port's management and major stakeholders. Everyone involved must recognize the potential dire consequences of climate change on international goods movement and on the vitality of port operations. Inaction would result in economic and societal losses with devastating effects internationally. It must be recognized that operations involving cargo movement contribute to climate change and these operations will produce a much greater impact with an increasingly interdependent global economy.

Committing to address the climate change impacts must include all port-related operations in order to maintain current levels of operation or accommodate growth while minimizing the contribution to this global problem. An ambitious vision will seek to create an emissions-free port that not only addresses the environmental impacts of its own operations but serves as an example to the larger maritime and goods movement community. Such a port will be more competitive, efficient, and able to thrive in a changing economic environment.

Develop internal coordination – identify relevant existing programs and potential synergies.

Undertaking a climate protection program is greatly aided by having other programs and policies in place that can be leveraged for either existing efforts to improve energy efficiency and emissions reduction or for frameworks that facilitate quicker implementation of GHG emission reduction actions. Examples of programs and policies that will enhance a climate protection plan include:

Environmental Program Policy: This is the policy or set of policies at the core of a port's environmental mission. It guides how resources are used and ho a port conducts developments and operations in both an environmentally and fiscally responsible manner. This policy seeks to implement business practices that improve quality of life and minimize the impacts of development and operations on the environment and surrounding communities. This is accomplished through the continuous improvement of its environmental performance and the implementation of pollution prevention measures, in a technically feasible and cost effective manner that is consistent with a port's overall mission and goals, as well as with those of its customers and the community.

Environmental Management System (EMS): An EMS weaves environmental decision-making into the fabric of an organization's overall business practices, with a goal of systematically improving environmental performance. An EMS follows the "Plan-Do-Check-Act" model of continual improvement. An EMS may be limited in scope to specific facilities or functions at a port or It may be integral to all aspects of the ports business.

Green Development Policy: This policy aims to promote responsible growth while implementing innovative and environmentally sustainable development practices. This policy utilizes sustainable building design and construction guidelines based on established standards that have been developed to promote buildings that are environmentally responsible, profitable and healthy. An example is the LEED Green Building Rating System, a voluntary green building rating system based on existing, proven technology that evaluates environmental performance in five categories:

- Sustainable Site Planning
- Improving Energy Efficiency
- Improving Water Efficiency
- Materials and Resources Conservation
- Embracing Indoor Environmental Quality

Green Purchasing Policy: An "Environmentally Preferable Purchasing Policy" implements a process for establishing a baseline for all purchases, researching environmentally preferable products to replace current items, and evaluating new products using environmentally oriented criteria.

Sustainability Plan: In its most basic form, sustainable development is defined as development that meets the needs of the present without compromising the ability of future generations to meet their own needs. Sustainability at a port seeks to balance environmental sustainability with economic sustainability (jobs and profits) and social sustainability (community and neighboring residents). A viable sustainability plan will cover specific criteria for evaluating plans and actions.

Economic Development Plan: An overall economic development strategy will focus on business development for the port and its stakeholders, redevelopment of unused or inadequately used assets, and workforce development. The plan will seek to maximize use of the ports assets in accordance with its governing principles and core values.

Create a Climate Protection Plan:

A climate protection plan establishes specific goals (i.e., near-term, mid-term, and long-term) for reducing greenhouse gas emissions from port -related operations and provides a framework for developing emission reduction strategies. A plan will include existing strategies with GHG emission benefits and add new near-term, mid-term and long-term strategies based on advanced and innovative control technologies. It may rely on a diverse set of implementation mechanisms including investment in the development, demonstration and integration of new/cleaner technologies, and a comprehensive monitoring and tracking program that will document progress on all of these elements. Achieving the plan's long-term goals will necessitate significant changes and adaptation of existing policies and practices. It may also include planning to include strategies that presume the future availability of technologies and process that are not yet available in the market.

A climate protection plan must be based on specific principles that may include the following:

- The climate protection plan will build upon past efforts, will be updated regularly and will be improved by incorporating the most recent available emissions inventory and technology information
- The plan will remain open to and supportive of new technologies and other advancements to meet the climate protection plan's emission reduction goals
- The port undertaking the plan will seek to maximize and accelerate greenhouse gas reductions from all port-related operations and will work closely with tenants, shipping lines, and other key players in the maritime and freight communities.
- The port will coordinate the implementation of the climate protection plan with local and regional regulatory agencies or other authorities and seek input, where appropriate, from stakeholders and the public.

A basic methodology for creating a climate protection plan is described in the following section.

METHODOLOGY

A comprehensive climate protection plan will address both a port's directly controlled sources as well as the port's tenants' sources. The overall methodology in developing and implementing a plan may include six steps which are briefly described here:

1. Develop Current Inventory – In order to have a better understanding of the contribution of the existing port-related sources to climate change, a port should develop a comprehensive inventory of greenhouse gas emissions or a "carbon footprint" for both the port's directly-controlled sources as well as sources controlled by port tenants. For the purpose of creating a plan, the port should select an appropriate base year to develop its current inventory. The baseline greenhouse gas inventory should be categorized into three GHG emission scopes[1]:

a) Scope 1 includes all direct GHG emissions from a port's directly-controlled stationary and mobile sources. Examples of Scope 1 include port-owned fleet vehicles and port employees commute vehicles, stationary generators, and buildings (i.e., natural gas combustion);
b) Scope 2 includes indirect GHG emissions associated with the import and consumption of purchased electricity by a port for its directly-controlled sources (i.e., electricity used for in port-owned buildings and operations); and
c) Scope 3 accounts for emissions associated with the operations of a port's tenants. Although inclusion of Scope 3 emissions in the Port's GHG inventory is optional, it provides an opportunity for overall management and control of GHG emissions on a port-wide basis. Scope 3 emissions include a port's tenants' direct emissions from stationary sources (i.e., natural gas combustion in buildings), mobile sources, and indirect emissions associated with purchased electricity. Mobile source emissions include emissions from cargo handling equipment operating on a port's property, rail locomotives and on-road trucks transporting cargo to or from a port up to the cargo's first point of rest within a defined regional boundary, and commercial marine vessels operating within the vicinity of a port and up to a chosen over-water boundary.

A basic GHG emission inventory will include only direct exhaust emissions from stationary and mobile combustion sources as well as indirect source emissions associated with the consumption of purchased electricity. Ideally, these emissions would include all of the "Kyoto Six," referring to compounds identified by the 1997 Kyoto Protocol: carbon dioxide, methane, nitrous oxide, sulfur hexafluoride, hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). Life cycle emissions associated with extraction, production, processing, and distribution of fuels used in mobile and stationary sources and for electricity generation may be included in the most comprehensive plans but need much greater resources due to the additional research and accounting required.

[1] Local Government Operations Protocol for the quantification and reporting of greenhouse gas emissions inventories, Version 1.0, September 25, 2008

2. Establish Emissions Baseline and Forecast – This step requires looking into the past and looking into the future – both of which can be complicated. Establishing a baseline greenhouse gas emissions inventory is a critical step, though, for a climate protection plan because it provides a benchmark from which progress can be measured. Ideally, a plan would establish a baseline for the 1990 calendar year consistent with the GHG baselines under Kyoto Protocol and other programs. The Kyoto Plan sets a reduction goal from the 1990 levels in 2010-2012 timeframe.

While international-level discussions have yet to determine exactly which goals will be in place beyond 2012, national and local-level programs may set long-term reduction goals that seek emission reductions of over 80% below 1990 levels. Reductions of such magnitude are anticipated to be necessary to prevent the most severe effects of climate change by stabilizing the amount of greenhouse gas emissions in the atmosphere. By undertaking early, voluntary efforts, organizations or regions will ease the transition into the impending carbon-constrained economy. Since a 1990 GHG emissions inventory is unlikely to have been developed in the past and 1990 activity data may not be readily available, a strategy may be to "back-cast" a current inventory. This is done assuming that 1990 port activity levels are known, incorporating changes in emissions standards and operations protocols, and by assuming that GHG emissions are proportional and scalable to activity.

Projecting for future milestone years (i.e., 2020 and 2050) can be done in a similar manner using the latest published cargo forecast and existing and any adopted or future regulations affecting the various source categories. Development of the emissions forecasts is critical for monitoring how a port's overall carbon footprint is expected to change in the absence of additional GHG control programs and for determining the level of additional reductions needed in the future to achieve the Plan's goals. A forecast is also key to designing abatement strategies that are tuned to expected changes in activity among specific source categories. It is important to recognize that cargo forecasts developed in the past year may not accurately account for the most recent global economic changes and may result in overestimations. These forecasts may be useful, though, in providing an upper-bound for a revised forecast, and indicate levels that the most stringent measures would have to achieve.

3. Set Goals – The next step in developing a climate protection plan is to set goals to achieve emission reductions for a port's direct operations as well as on a port-wide basis to include the port's tenants' emissions. A climate protection plan should establish specific near-term, mid-term, and long-term goals, for example for the years 2020 and 2050, or other timeframes corresponding to local or national programs. These reduction targets will be set against the previously described 1990 baseline GHG levels. Examples of goals for reducing port-wide GHG emission during the various timeframes are as follows:

2020: Meet 1990 GHG emissions levels
2050: Achieve GHG emission levels 80 percent below 1990 levels

These figures correspond roughly to various national and international targets that have been proposed, though actual values will likely vary. By adopting such ambitious targets, a port illustrates their commitment to addressing climate change from their sector and signals the need for action to the broader maritime and freight transportation industry.

4. Develop Strategies – This toolbox includes a suite of strategies aimed at reducing GHG emissions from port-related operations to help achieve a port's climate protection plan's goals. The strategies range from those that may already be in place to improve air quality (see section on Integration and co-benefits) to other near-term and mid/long-term strategies that are specifically aimed at GHG emission reduction. These strategies are based primarily on integration of advanced zero-emission or near-zero-emission technologies (e.g., electrification, Maglev, hybrids). It also includes other innovative long-term strategies (e.g., offshore wind farms and wave power generation) which offer the potential for achieving significant levels of additional greenhouse gas emission reductions beyond existing programs and regulations. Some of these strategies may seem drastic or overly-costly, but there is no easy path. The reality is that to meet prescribed goals, a port of the future will look and operate much differently than they do today. Different ports will have different needs and capabilities, though, so these strategies can be considered a-la-carte options to be combined or adjusted to suit specific conditions. These strategies are intentionally general due to the wide variety of ports and goods-movement operations. They are meant to provide a starting point for internal discussions and planning about how an individual port may best build a robust and appropriate set of strategies.

As critical as identifying which strategies are technically appropriate for a port is understanding how these strategies may be implemented. Nobody wants to spend money, though many of the strategies result in long-term financial benefit. A port's primary role may be less in providing technical direction and more in helping to bridge the distance between project capital costs and eventual cost savings. Several general mechanisms are presented for implementing the strategies outlined in this plan and individual strategies indicate which mechanism may be appropriate to that strategy. These mechanisms include augmenting a port's policies and programs, adjusting lease requirements, implementing tariffs, providing incentives and initiating voluntary measures.

5. Monitor Progress – The level of progress in implementing the overall climate protection plan as well as its individual strategies should be tracked and documented in regular updates. These updates should occur at least every two to three years given how quickly economic conditions, available technologies, and regulatory requirements are changing. In these updates, the current and future inventories of GHG emissions from all sources should be updated to reflect the latest activity level, growth forecasts, and understanding of the success of various strategies. New and evolving technologies and existing strategies should be evaluated for applicability and old strategies may be revisited to re-assess costs and appropriateness. It also may be prudent to provide regular updates on the progress of implementing the plan to port stakeholders and interested local and regional authorities. These updates may be provided in brief reports, several times a year, which would detail significant progress for implementation of all plan strategies. Alternately, a web site that is regularly updated with the plan status and milestones for individual strategies may be a simple and effective way to communicate progress without the formality of an interim report. Also, this site provides an opportunity to upload information about specific on-going or completed projects that may be useful to other ports. All members are encouraged to use this function to add information that will increase the collective understanding of how to implement successful strategies.

6. Adaptation Planning – Given a ports' inherent vulnerability to climate change impacts associated with sea level rise, increased temperatures, shifting precipitation and extreme weather events, a climate protection plan should include provisions for an adaptation strategy. A viable adaptation strategy would be developed and implemented in parallel with the specific control strategies identified in the climate protection plan in order to ensure that the long-term goals of the plan are achieved.

Developing a specific adaptation strategy helps a port prepare for and reduce vulnerability to climate change impacts. Development of such a strategy would entail conducting a detailed vulnerability assessment for the port (human populations, infrastructure, economy, natural habitats), identification of areas for further research and data collection, and development of specific adaptation strategies for both existing infrastructure and new developments. An adaptation plan that is developed in conjunction with regional plans will be especially robust. A port may reach out to prominent universities to determine existing research underway that may be applicable to the port and maritime sector and explore opportunities to partner on future studies.

INTEGRATION

Air Pollutant Reduction Strategies in Clean Air Plans and Their Effect on Greenhouse Gases

Introduction

Many strategies to reduce emissions under Port clean air plans also affect emissions of greenhouse gases (GHGs). Often, the effect is to decrease the amount of GHGs emitted in addition to reducing air pollutant emissions. These are referred to as strategies that have "co-benefits." In some cases, however, clean-air strategies may result in an increase to GHGs, either directly from the operation, or indirectly through increased energy or material use – a "co-disbenefit." This section of the toolbox describes general circumstances leading to co-benefits and disbenefits to GHG emissions that arise from implementation of air pollution reduction strategies.

Because they are more common, and desirable, this section focuses on co-benefits. It begins with a general discussion of circumstances leading to co-benefits and follows with a description of four general clean air strategies that also have distinct GHG benefits. Brief discussions of co-disbenefits and cases where benefits may be uncertain are included in some of the co-benefit discussions. For a quick-reference, all of the strategies listed in the Air Pollutant Toolbox have been put into a table at the end of this section that succinctly describes their effect, if any, on GHG emissions.

GHG Co-Benefits from Air Pollutant Reduction Strategies

Although air pollution reduction strategies are primarily designed to achieve reductions in diesel emissions and other toxic pollutants that are detrimental to public health, some of these strategies also result in concurrent GHG emission benefits. These strategies should play a key role in achieving the goals for both clean air and climate protection plans. Well understood examples of clean air plan strategies with GHG co-benefits include the use of shore power for hotelling operations and reduced cruising speed for ocean-going vessels. GHG emission benefits associated with these strategies have already been quantified and reported in many ports' clean air plans. So for a climate protection plan, these same strategies may only need minimal revision to focus on GHG benefits.

Other clean air strategies may provide slight reductions in GHG emissions that may require in-depth investigation to discern if a GHG co-benefit exists. For example, requiring the use of low sulfur fuel in OGV engines and boilers may result in slightly decreased CO_2 emissions because of the higher energy to carbon content of the distillate fuel compared to heavy fuel oil. However, there may also be small increases in fuel-cycle CO_2 emissions because of the increased energy at the refining stage to produce the distillate fuels which may offset the small CO_2 benefits. Discerning GHG effects for measures like these are dependent on local supplies and conditions, requiring significant research and effort to calculate. While the most intensive study may seek to discern such details, strategies being developed with limited resources may find it more prudent to focus on only the measures that have clearest and most significant co-benefits associated with them.

The single most prominent mechanism for co-benefits from clean air plan strategies is reducing fuel consumption. This can be accomplished through a wide variety of methods, most of which fall into one of four categories:

1. Improving the efficiency of the vehicles by requiring purchase of newer/cleaner vehicles
2. Operational improvements that accomplish equivalent tasks using less fuel
3. Substituting a lower or zero-emission fuel for a higher emission one
4. Add-on technologies that reduce vehicle emissions

These four categories are described in the following sections:

Co-Benefit Strategy #1)
Improve Vehicle Efficiency with Newer, Cleaner Vehicles

While most port equipment and vehicles will last ten to twenty years or more before they need to be replaced, a program to hasten the turnover can greatly reduce both air pollutant and GHG emissions. Such programs may achieve their goals through financial incentives for operators or performance mandates, but their underlying motivation is to take advantage of significant technology improvements that have occurred in recent years (and continue to occur) that have resulted in cleaner, more efficient vehicles and equipment. A fleet of newer equipment that is replaced more frequently has significant operational benefits including reduced down-time, but it can be capital-intensive to undertake.

Example: Truck Fleet Modernization

In the United States, requiring that all trucks servicing a port meet national 2007 standards will significantly reduce NOx and PM because of improved vehicles emissions technologies that are required to be present on all new vehicles of that year. For most ports in the US, the age of trucks bringing containers to and from terminals is greater than 10 years, meaning that post-2007 technologies could reduce emissions of both NOx and PM by at least 90% for most trucks. Technology that removes NOx will also reduce N_2O, a potent greenhouse gas. The main GHG reduction, though, comes from these newer trucks being more fuel efficient, translating to an equivalent reduction in CO_2 emissions.

Co-Benefit Strategy #2)
Operational Improvements to Reduce Energy Use

Operational improvements are adjustments made to a given system that result in the functions of that system being accomplished with fewer overall emissions. Any system that consists of vehicles or equipment engaged in repeated tasks likely has some potential to increase the efficiency with which those tasks are accomplished. There may also be opportunities to reduce emissions from equipment operating in the system that have minimal effect on the function and efficiency of the system as a whole but greatly reduce pollutants. Looking at a port and its related operations as a series of distinct, interacting systems is common practice in the industry because it allows for optimal coordination of logistics functions. The same approach can also be a robust strategy for identifying opportunities to reduce emissions.

For instance, container terminals are designed to optimize the movement, organization, and dwell of containers as they transition from water-side vessels to land-side transportation. Optimal terminal layouts use the least amount of space and energy to accomplish this transition. Likewise, a terminal optimized for emissions reductions may seek to accomplish the transition with minimal equipment acceleration and deceleration. It also may position electrification infrastructure and choose sub-systems that allow for maximum electrification of operations. Overall, a systems approach to reduce emissions of both air pollutants and GHGs will seek to minimize need for speed and frequent acceleration, minimize distance traveled, and maximize availability of electrification infrastructure. The following example illustrates these concepts applied to vessels as they come to berth.

Example: Vessel Speed Reduction

A Vessel Speed Reduction (VSR) program requires participant vessels to slow down as they approach or depart a port. The primary objective of the VSR program is to reduce emissions from OGVs during vessel transit near a port. When ships slow down, the load on the main engines decreases considerably, compared to the engine load at higher speeds, leading to a decrease in the total energy required to move the ship through the water. This energy reduction in turn reduces emissions for this segment of the transit. Since the load on the main engines affects power demand and fuel consumption, this strategy significantly reduces all pollutants including PM, NOx, SOx, and GHG emissions. Though VSR reduces fuel consumption and may save operating costs, these savings and the emission reduction benefits must be balanced by the increase in time it will take for a vessel to reach the port and the costs associated with that delay.

Co-Benefit Strategy #3:
Reducing Emissions with Cleaner Energy

Fuel and energy costs are among the highest costs associated with operating vessels and ports. Therefore, discussions about the best energy source have been fundamental to the industry throughout its history. The incentive to reduce energy costs drove the industry to use the cheapest form of fuel available to power the ships that move millions of containers around the world. Up until recently, shore-side equipment around the world was also using some of the least refined fuels that would allow their modern engines to function with sufficient power. Development of targeted regulations are forcing changes to how and when vessels and equipment burn various types of fuel, but significant progress can be made beyond even the most stringent regulations to reduce emissions of both air pollutants and GHGs even further.

In many cases, key air pollutants can be reduced through the use of more refined, desulfurized, or plant-derived fuels. These options often have minimal or unclear effects on GHG emissions because their GHG impacts require investigation of "life-cycle" emissions that can vary significantly with source and process. While these types of fuel may be desirable for other reasons, incorporating them into a climate protection plan should be done with caution. To alleviate this problem, "low-carbon fuel" standards are currently being developed to help rigorously and uniformly identify the potential GHG benefits associated with alternative fuels. Switching to natural gas has the advantage that reductions to both air pollutant and GHG emissions are well understood.

The ideal approach to reducing both air emissions and GHGs with cleaner energy is to switch from hydrocarbon-powered engines to electric power. Even in the worst case scenario, where electricity is sourced from minimally controlled coal-fired power, electric power offers significant benefits over hydrocarbon-based power:

- An electric motor is 2-3 times more efficient, per unit energy, than the equivalent diesel engine and is better suited to operations with frequent high torque requirements
- The coal fired power plant is often located away from population centers while the diesel engine emissions will be emitting closer to where people are concentrated
- Coal fired power plants can reduce their emissions with control equipment while it is expensive and logistically difficult to refit controls on all equipment and vessel engines
- Existing coal sourced power *could* be replaced with clean energy sources in the future. Coal power will likely become more expensive as emerging carbon markets drive up the cost of dirty energy and reduce the cost of clean energy.
- The variety of sources for electricity make for a much more secure power source that will fluctuate less in price from season to season
- Widespread electrification will reduce the potential for oil spills around sensitive waterways and reduce the amount of oil that is introduced to aquatic ecosystems nearby ports through stormwater run-off

Example A: Shore Power for At-Berth OGV Emission Reductions

Based on the above description of the benefits of electrification, the preferred approach for reducing at-berth emissions is shore-power -- transferring the electrical generation needs for OGVs while at berth from onboard diesel-electric generators to the cleaner shore-side power grid, which generates power through regulated/controlled stationary sources. Reducing emissions occurring during dwelling (hotelling) from OGVs while at berth has significant air quality and GHG emission co-benefits because it eliminates almost of all of the ships' direct emissions. The shore-power approach is generally best suited for vessels that make multiple calls per year, require a significant power demand while at berth (a function of dwelling load and time at berth), and will continue to call at the same terminal for multiple years. The most common ship types that are good candidates for shore-power are large string-service containerships, cruise ships, reefer ships, and specially designed crude tankers that have diesel-electric powered pumps.

Shore-power requires extensive infrastructure improvements onboard vessels that would use the system, as well as on the terminal side for supplying the appropriate level of conditioned electrical power. The onboard infrastructure costs are dependent upon the candidate vessel's current configuration, conduit space, and electrical panel space. Despite the broad range of applications and complex technical concerns, working groups and standardization efforts over the last 3 years have led to draft guidelines that have been finalized by the ISO and are now being reviewed by the International Electrotechnical Commission (IEC). The draft report is expected to be publically available by mid-2009.

Example B: Electric Trucks

Trucks that move containers in and around terminals are ubiquitous and generate significant GHG and air pollutant emissions over thousands of hours they each operate in a given year. They represent an ideal target for emissions reductions both for this reason and because they fit within an operational profile that corresponds to the capabilities of current electric vehicle technology. During their short range of travel, they are required to stop and start frequently and idle about 50% of the time. Electric trucks eliminate idle emissions and will regenerate electricity every time the truck stops. On acceleration, electric motors deliver starting power much more efficiently than diesel engines. By switching to electric trucks, not only is the fuel cleaner, but the overall process is much more energy efficient. Prototypes of electric trucks are currently being tested in real-life terminal operations. Several types of hybrid trucks, including a plug-in serial hybrid, have also been announced by manufacturers.

Co-Benefit Strategy #4:
Add-on Technology to Increase Efficiency and Reduce Emissions

Any equipment or process that can be added to existing equipment that improves the efficiency of that equipment is likely to result in co-benefit emission reductions. Most add-on equipment for air-quality improvement, however, adds additional engine loads or external power requirements that may lead to a co-disbenefit for GHGs. This is because things like pumps, heaters, and blowers add a parasitic load to an engine that reduces the power available to the engine's primary function. With these additional loads, the engine has to work harder to accomplish the same task and operate these systems or energy has to be introduced externally to power them. In either case, additional load implies additional emissions either directly from the engine or indirectly through power generation.

In some cases, the add-on equipment can make up for inefficiencies in the original system. These inefficiencies could exist because the more efficient technology was not available at the time of the original design or because the capital cost of the technology exceeded the perceived future benefits at the time of purchase. A clear example of this type of add-on technology is a hybridization package for rubber-tired gantry cranes (RTGs). In this case, a basic hybrid system, consisting of electric motor, battery, and control equipment, is refit to the existing RTG and functions to capture power generated by containers as they are lowered. The electric motor, then, is used to supplement power for raising containers and other movements where the diesel engine is less efficient. By recapturing energy and allowing the diesel engine to operate more efficiently, manufacturers have claimed a ~70% reduction in fuel use and related air pollutant and GHG emissions. Increasing interest in electrification and rapid improvement of battery and other energy storage systems will make such hybrid and electrification refit options even more cost effective.

Example: OGV Engine Retrofits

Numerous technologies for reducing vessel engine emissions are currently under development and testing. Much of the focus has been placed on reducing NOx emissions. Technologies such as selective catalytic reduction (SCR), sea-water scrubbers, dry low NOx combustion, humid air injection, water fuel emulsion, direct water injection, exhaust gas recirculation, electronic engine controls, etc. can be used for NOx, but none of these also contribute to significant decreases in GHG emissions. Slide-valves, on the other hand, are relatively new, more efficient types of fuel injectors that reduce emissions of NOx and PM by minimizing the sac volume in the fuel-valve nozzle tip. Slide-valve technology was introduced in 2002 and today most MAN Diesel main engines are delivered with this technology. Slide-valves can also be retrofit in to existing MAN Diesel main engines. Because slide valves increase the combustion efficiency, they also reduce GHG emissions.

Source Category	General Strategy / Specific Strategy	Co-Benefit	Co-disbenefit or Uncertainty
Ocean Going Vessels			
	• Vessel Speed Reduction	GHG Benefit due to reduced overall emissions	
	• Operational Improvements	Likely GHG Benefit, but depends on specific strategy	
	Reconfigure Terminals	Likely, if overall operation is more efficient or favors lower fuel use	
	Deepen Channels, Improve Access, On-dock Rail	Larger ship capacity and direct rail transfers can reduce emissions	
	Speed Up Vessel Load/Unload Reduce Vessel Dwell Time	Likely, due to increased efficiency, less ship hoteling time	
	Improve Electrical Infrastructure for AMP, Regen Cranes, Etc.	Not directly, but facilitates strategies that bring co-benefits	
	• Clean Fuels	Depends on fuel	
	LNG	Yes, due to lower intrinsic GHG production in combustion	
	Low-Sulfur Fuel	Higher energy density may enhance combustion efficiency	Low S fuel processing adds emissions, may not enhance combustion

	• **Emission Control Technologies**	Depends on Technology.	
	Slide Valves	Likely, due to enhanced combustion	
	Seawater Scrubbing		Adds parasitic load to operate system
	Engine Upgrades, Repower	Likely, due to increased efficiency and enhanced combustion control	
	• **Shore Power**	GHG Benefit	

Harbor Craft			
	• Engine Replacement with Engines Meeting Cleaner Standards	Likely GHG benefit, but depends on technology	
	• Clean Fuels	Depends on fuel	
	O2diesel/Bio-Fuels	Benefits possible through life-cycle production, but varies with source	Biodiesel has higher direct emissions due to lower fuel density.
	Low-Sulfur Fuel	Higher energy density may enhance combustion efficiency	Low S fuel processing adds emissions, may not enhance combustion
	Emulsified Fuels		Can reduce efficiency by reducing overall fuel energy content
	• Emission Control Technologies	Controls that improve combustion will reduce GHG emissions	Treatment retrofits may add load to the engine, decreasing efficiency
	• Electrification (including Shore Power and Hybridization	GHG Benefit	

Cargo Handling Equipment			
	• **Equipment Replacement with Engines Meeting Cleaner Standards**	GHG Benefit most likely	
	• **Clean Fuels**	Depends on fuel	
	LNG/CNG	Yes, due to lower intrinsic GHG production in combustion	
	O2diesel/Bio-Fuels	Benefits possible through life-cycle production, but varies with source	Biodiesel has higher direct emissions due to lower fuel density.
	Low-Sulfur Fuel	Higher energy density may enhance combustion efficiency	Low S fuel processing adds emissions, may not enhance combustion
	Emulsified Fuels		Can reduce efficiency by reducing overall fuel energy content
	• **Emission Control Technologies**	Technologies that improve engine efficiency will bring co-benefit	DPFs, DOC, SCR, etc. may cause minor additional engine loads

Heavy Duty Vehicles – Trucks			
	• Equipment Replacement	Benefit likely, newer equipment will have maximum efficiency	Important to account for emissions from vehicle disposal or re-use
	• Operational Improvements	RFID/OCR Systems and gate flexibility reduce truck idling	
	• Clean Fuels	Depends on fuel, See CHE Section	
	• Emission Control Technologies	Controls that improve combustion will reduce GHG emissions	Treatment retrofits may add load to the engine, decreasing efficiency
	• Idle-Reduction Technologies	Yes, due to eliminating unnecessary engine operation	
Light Duty Vehicles			
	• Equipment Replacement, maintenance	Benefit likely, newer equipment will have maximum efficiency	Important to account for emissions from vehicle disposal or re-use
	• Operational Improvements	Benefit likely, through optimal fleet use and maintenance plans	
	• Clean Fuels	Depends on fuel, See CHE Section, Also Electric Vehicles soon available	
	• Emission Control Technologies	Controls that improve combustion will reduce GHG emissions	Treatment retrofits may add load to the engine, decreasing efficiency
	• Idle-Reduction Technologies	Stop/Start Systems, driver education, and idle reduction yield co-benefits	

Locomotives and Rail			
	• Equipment Replacement	Benefit likely, newer engines are more efficient, hybrids available	Important to account for emissions from vehicle disposal or re-use
	• Operational Improvements	On-dock rail and reduction of system bottlenecks reduce idling	
	• Clean Fuels	Depends on fuel, See CHE Section	
	• Emission Control Technologies	Controls that improve combustion will reduce GHG emissions	Treatment retrofits may add load to the engine, decreasing efficiency
	• Idle-Reduction Technologies	AESS, APUs, DDHS, & Plug-ins shut down main engines during lulls	

Construction Equipment			
	• Equipment Replacement	Benefit likely, newer engines are more efficient	Important to account for emissions from vehicle disposal or re-use
	• Operational Improvements	Benefit likely due to Reduced Operating Times	
	• Clean Fuels	Depends on fuel, See CHE Section	
	• Emission Control Technologies	Controls that improve combustion will reduce GHG emissions	Treatment retrofits may add load to the engine, decreasing efficiency
	• Idle-Reduction Technologies	Stop/Start Systems, driver education, and idle reduction yield co-benefits	