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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