
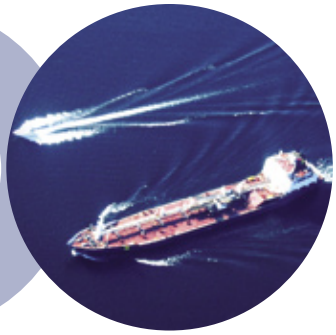


Air Pollution and Greenhouse Gas Emissions from Ocean-going Ships:

Impacts, Mitigation Options and Opportunities for Managing Growth

EXECUTIVE SUMMARY

icct
THE INTERNATIONAL COUNCIL ON CLEAN TRANSPORTATION

The goal of the International Council on Clean Transportation (ICCT) is to dramatically reduce conventional pollutant and greenhouse gas emissions from personal, public, and goods transportation in order to improve air quality and human health, and mitigate climate change. The Council is made up of leading regulators and experts from around the world that participate as individuals based on their experience with air quality and transportation issues. The ICCT promotes best practices and comprehensive solutions to improve vehicle emissions and efficiency, increase fuel quality and sustainability of alternative fuels, reduce pollution from the in-use fleet, and curtail emissions from international goods movement.

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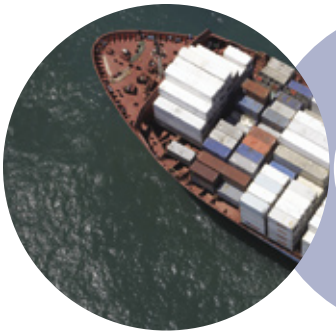

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In a world of global supply chains and rapidly expanding trade, ocean shipping—currently the dominant mode of transport for international cargo—is becoming an increasingly important source of air pollution and greenhouse gas emissions.

Today, ocean-going vessels transport 90 percent of all trade by volume to and from the 25 members of the European Community (EC), and nearly 80 percent by weight of all goods shipped in and out of the United States (EC 2006, US DOT 2003). Over the last three decades, activity in the marine shipping sector, as measured in metric ton-kilometers, has grown on average by 5 percent every year, as shown in Figure ES-1. Since emissions from ocean-going vessels have only been moderately controlled, this growth has been accompanied by a commensurate increase in the sector's contribution to local and global air pollution.

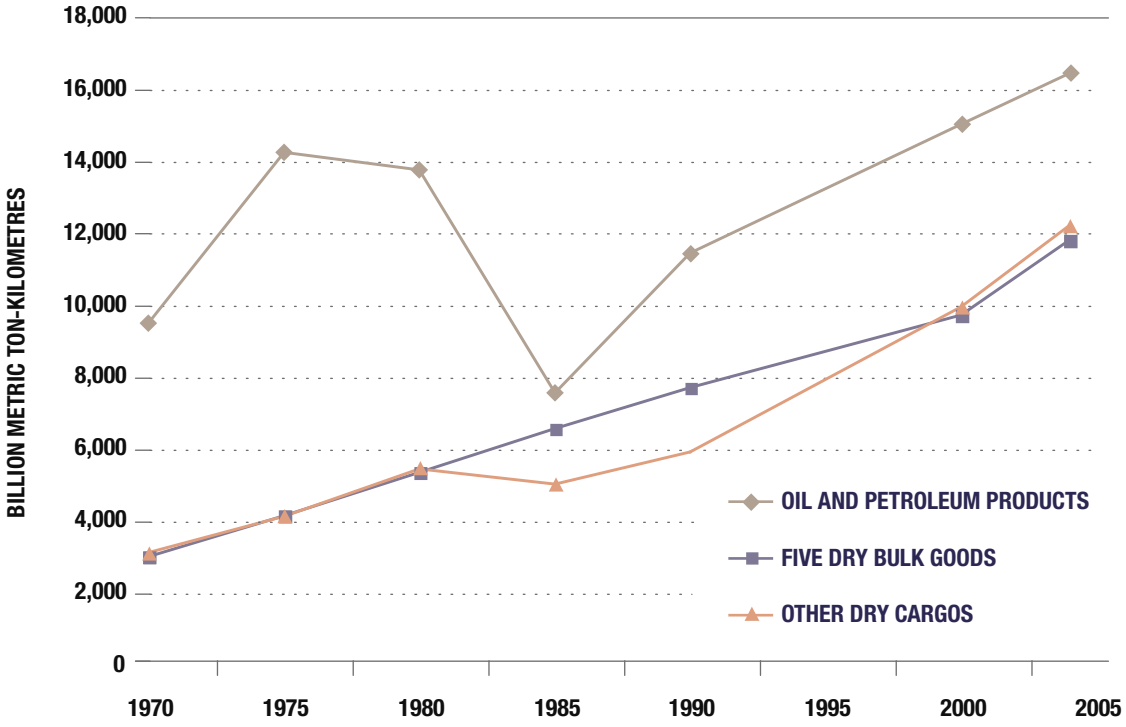

FIGURE ES-1. World Seaborne Freight Transport in Metric Ton-Kilometers by Type of Freight (UNCTAD 2005)

Ocean-going vessels contribute significantly to global emissions of nitrogen oxides (NO_x), sulfur oxides (SO_x), and particulate matter (PM). Indeed it is estimated that by 2020, ship emissions contributions to the European Union (EU) NO_x and SO_x inventories will surpass total emissions generated by all land-based mobile, stationary and other sources in the twenty-five nations (EC 2005). Figure ES-2 and Figure ES-3 show projected NO_x and SO_x emissions from marine and land-based sources in Europe. Air quality impacts from ocean-going vessels are especially significant in port cities and nations with extensive coastlines adjacent to shipping corridors. Studies making use of geographic marine activity data have estimated that about 70–80 percent of all ship emissions occur within 400 km (248 miles) of land (IMO 2000, Corbett et al. 1999). Pollutants such as NO_x, SO_x, and PM have been linked to a variety of adverse public health outcomes, including increased risk of premature death from heart and pulmonary diseases and worsened respiratory disease. Marine emission sources are therefore responsible for a growing share of the public health impacts of exposure to air pollution in many regions. Although ocean-going vessels are among the most efficient modes of freight transport, they also generate substantial quantities of greenhouse gas emissions. Currently, carbon dioxide (CO_2) emissions from the international shipping sector as a whole exceed annual total greenhouse gas emissions from most of the nations listed in the Kyoto protocol as Annex I countries (Kyoto Protocol 1997).

Relative to other sectors, the regulation of commercial marine vessels represents a significant political and legal challenge as ships

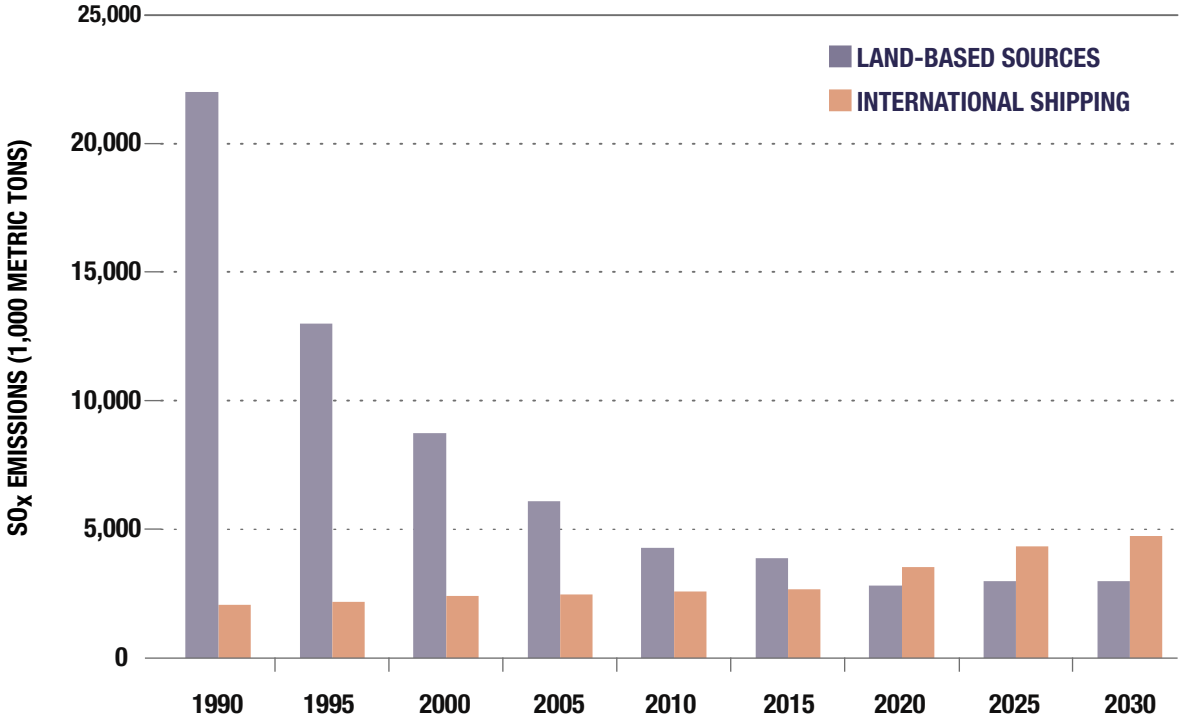

FIGURE ES-2. Inventories and Projections of SO_x Emissions in Europe from Land-based and International Shipping Sources (EC 2005)

operate largely outside of national boundaries. Ocean-going vessels are mainly subject to oversight by the International Maritime Organization (IMO), under the purview of the United Nations. Unfortunately, IMO efforts to mitigate environmental impacts of emissions from global shipping have not kept pace with the industry's growth and the evolution of control technologies for controlling emissions. The international process for establishing new regulatory requirements is further complicated by the complex relationships that exist between those nations to which most ships are registered under so-called "flags of convenience" and the large shipping interests (typically headquartered in other nations) that own most of the ships. As a result, the IMO adopted standards in 1997 that represented only a modest improvement in emissions from unregulated engines. When these standards entered into force they reflected levels already achieved by the average in-use engine. The IMO's current fuel sulfur limit of 4.5 percent is almost twice the average sulfur content of fuels in use in ships today and several thousand times the sulfur level of fuels used on-road in Europe and North America. These standards at best codify the industry's existing practices.

Under these circumstances, accelerated adoption of cleaner marine fuels and wider deployment of existing pollution control technologies and emission reduction strategies could dramatically improve the environmental performance of the shipping sector. To explore these opportunities, the ICCT undertook a review of the status of pollution control measures and programs

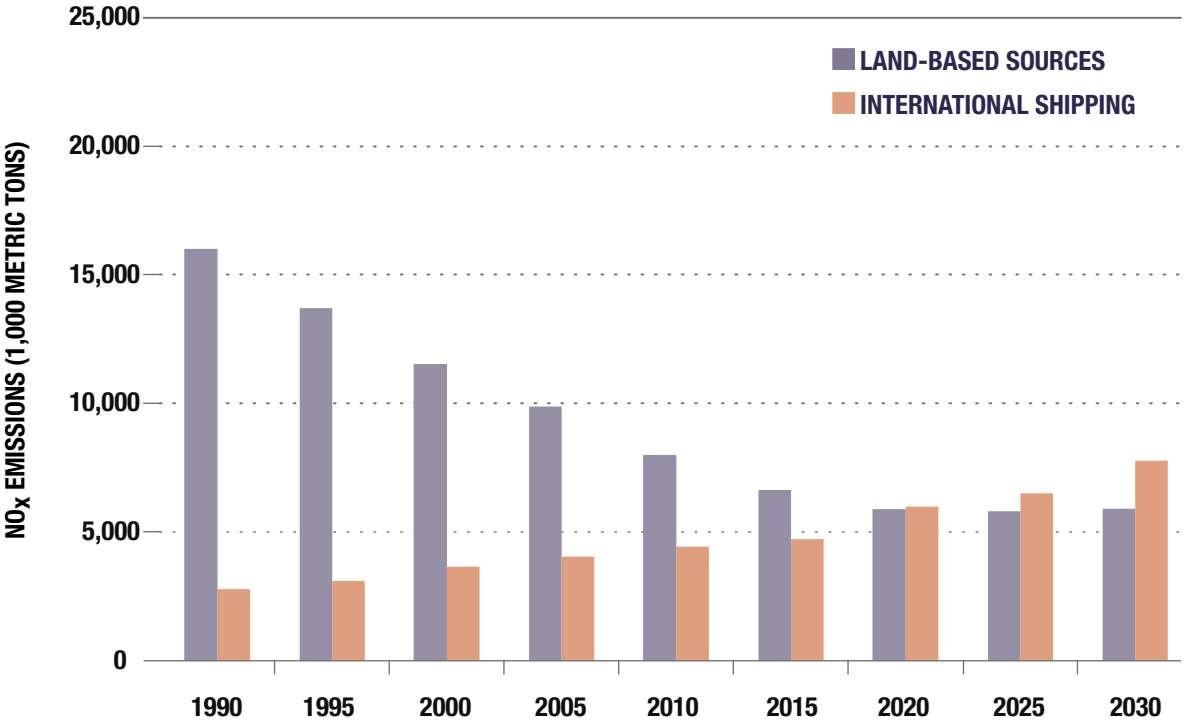

FIGURE ES-3. Inventories of NO_x Emissions in Europe from Land-based and International Shipping Sources (EC 2005)

implemented to date throughout the world. This report describes the results of the ICCT review, focusing on the emission-reduction potential, feasibility, costs, and cost- effectiveness of available environmental mitigation measures for the shipping sector. It also analyzes the legal context within which local, regional, and international programs can be developed. The report concludes with a series of policy recommendations aimed at achieving steady, incremental progress towards reducing emissions from marine vessels that will result in significant environment and public health benefits.

Lower sulfur fuels, optimized engines, and exhaust after-treatment, such as selective catalytic reduction (SCR), have been shown to significantly improve the environmental performance of marine vessels. Other measures such as shore-side electricity and improved auxiliary engines can reduce so-called "hotelling" emissions—that is emissions generated while ships are docked at port. The feasibility and cost-effectiveness of these measures has been demonstrated at several ports. As shown in Figure ES-4, available options for reducing marine NO_x emissions are very cost-effective compared to remaining pollution control options for other mobile and stationary sources, especially in countries that have adopted a range of regulations to limit land-based emissions.

Nations in Europe and North America—along with port cities throughout the world—have deployed a suite of strategies to address air pollution from ships. These strategies have included

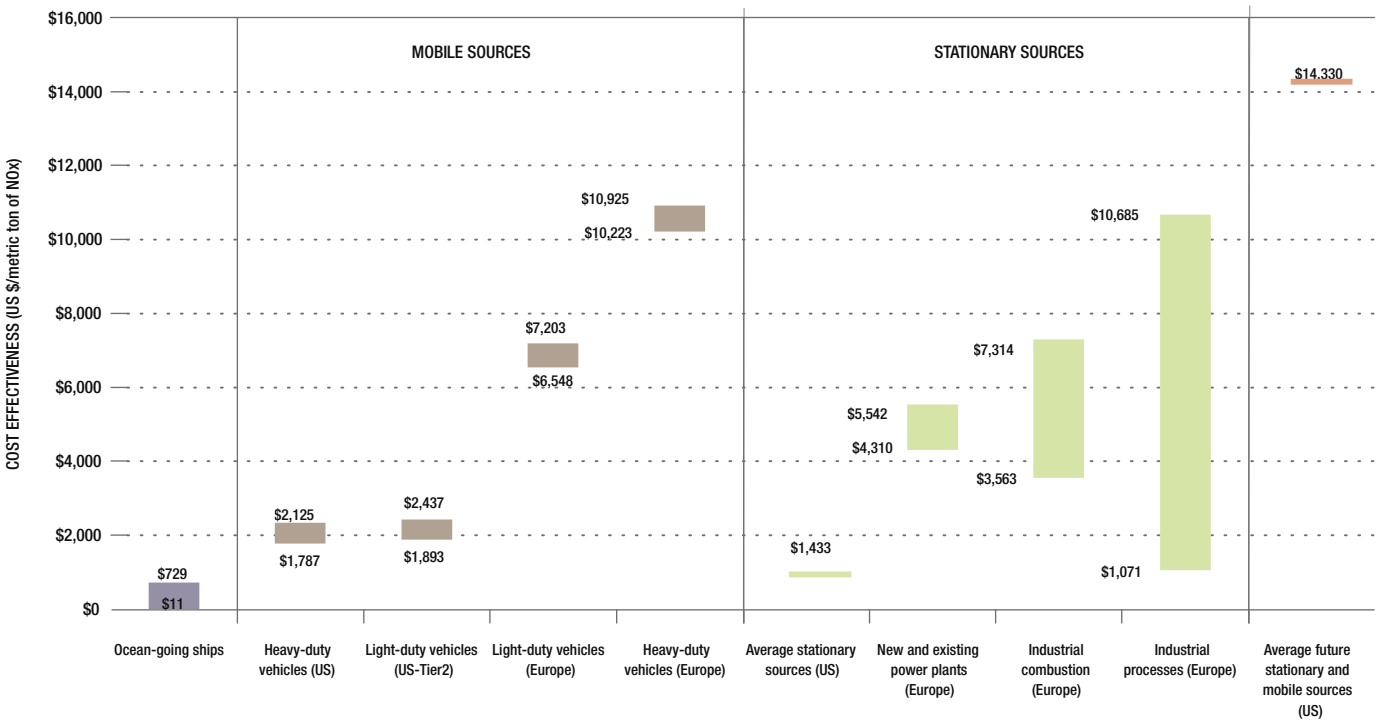

FIGURE ES-4. Comparing the Cost-Effectiveness of NO_x Control Options for Various Source Categories (Entec 2005b, US EPA 1999, 2000, 2005)

regulations, voluntary programs, and market-based programs. Examples of regulatory approaches have included national engine standards for the domestic vessel fleet and fuel sulfur standards for vessels operating in coastal waters and harbors. The voluntary harbor speed limits implemented in the San Pedro Bay by the ports of Los Angeles and Long Beach provide an example of a voluntary approach. Meanwhile, Sweden has experimented with a market-based approach by imposing a system of environmentally differentiated fairway and port dues that vary with ship emissions. This successful program has led to increased use of lower-sulfur fuels and to the installation of SCR systems on a number of ships calling on Swedish ports.

The recommendations advanced in this report identify implementation milestones in each of several distinct categories: (1) marine fuels, (2) new engines, (3) new vessels, (4) existing engines and vessels, (5) greenhouse gas emissions, (6) and in-port emissions. In the near-term, these recommendations generally call for widespread adoption of proven best available technologies in the 2010 timeframe. The ICCT's medium-term recommendations propose intermediary steps to be taken between 2012 and 2017. Finally, technology-forcing, long-term recommendations are proposed for the post-2020 period. Implementing these recommendations will require the active engagement of numerous stakeholders, including ship owners and operators, ports, and regulators. Leadership from the businesses that demand shipping services is also crucial. Shipping customers are uniquely positioned to create incentives for improved performance in the shipping sector because they can require that their goods be transported with the least possible impact on the environment.

MARINE FUELS

Reducing fuel sulfur content is an essential component of any strategy aimed at reducing SO_x and PM emissions from marine vessels. Lower sulfur fuel also enables the use of advanced after-treatment for NO_x reductions. Existing plans to implement SO_x Emission Control Areas (SECAs), starting in 2006 in the Baltic Sea and expected in 2007 for the North Sea and English Channel, mean that a portion of the world's ships are now or will soon be using 1.5 percent sulfur fuels or equivalent after-treatment. In the short term, the ICCT recommends including other major shipping areas, such as the Mediterranean and parts of the North Atlantic and Pacific Rim, in the SECA program. Moreover, decisions concerning future SECAs should take into account sulfur- and particle-related public health impacts as well as impacts on land and sea ecosystems. Finally, ICCT recommends that the fuel sulfur limit in SECAs be lowered from 1.5 percent to 0.5 percent to achieve further emissions reduction in the 2010 timeframe and to facilitate the shift to lower sulfur fuels on a global scale.

As a next step, the ICCT recommends that a uniform global fuel sulfur standard of 0.5 per-

cent be introduced in the medium term. Relative to the 2.7 percent average sulfur content of current marine fuel, this step alone will reduce SO_x emissions by approximately 80 percent and PM emissions by a minimum of 20 percent. At this level of fuel quality, selective catalytic reduction (SCR) will be fully enabled. Although SCR can function at higher fuel-sulfur levels, durability is significantly improved at lower levels.

Some uncertainty remains regarding the widespread availability of lower sulfur fuels in the recommended timeframe. However, there has been significant momentum among various stakeholders to reduce the global fuel sulfur limit. For example, some industry groups have recently expressed support for a global fuel standard requiring the use of 1 percent sulfur distillate fuel in the near term (INTERTANKO 2006). In addition, current regulations in California and Europe require low-sulfur fuels in coastal waters, inland waterways, and at ports ahead of the ICCT-recommended dates. For example, the California auxiliary engine program requires the use of 0.5 percent sulfur fuel in the state's coastal waters and at port by 2007. The allowed sulfur level is lowered to 0.1 percent by 2010. Fuel with 0.1 percent sulfur content will also be required in ports and inland waterways in Europe by 2010

Adoption of a lower global fuel sulfur limit would provide the refining industry the clear signal it needs to invest in upgrading production facilities and ensure increased fuel availability. The ICCT also encourages further efforts to implement lower sulfur fuel ahead of the recommended schedule in coastal waters, inland waterways, and at ports. These programs can facilitate a transition to fleet-wide use of lower sulfur fuels while ensuring emissions reductions in proximity to the potentially impacted populations. In the long-term, fuel standards for marine fuels should be harmonized with standards for on-road fuels (500 ppm to 10–15 ppm).

NEW ENGINES

The IMO's recent decision to review NO_x standards for ocean-going vessels represents an opportunity to make significant progress in improving the performance of marine engines. The ICCT recommends requiring new engines to achieve NO_x limits that are 40 percent lower than the current standard in the near term. This level can be reached primarily through engine upgrades. New engine standards should also be set to ensure significant reductions in PM emissions. A medium-term standard set at a level 95 percent below current standards for NO_x would require the use of additional emission control technologies, including after-treatment controls. Further PM reduction should also be required. These near- and medium-term standards should be adopted at the same time to give manufacturers sufficient lead time to prepare for compliance and to direct their research and development activities accordingly. In addition to more stringent standards, the ICCT recommends that manufacturers be (1) required to

certify engines using fuels that reflect actual in-use fuel quality; (2) be liable for in-use compliance and subject to in-use testing; and (3) be required to demonstrate the durability of emission control systems used to achieve compliance.

The production and use of engines that are significantly cleaner than the proposed standards should be encouraged both in the short and medium term through incentives to engine and technology manufacturers as well as vessel operators. Support for early technology demonstrations is necessary to ensure viable technology options are available to meet increasingly stringent standards. In the long term, the ICCT recommends deploying incentives and other strategies to further promote the use of advanced technologies, especially technologies that achieve near-zero emissions, in promising applications.

NEW VESSELS

Many opportunities exist during a vessel's design and construction phases to make changes that would facilitate the use of low-emission control technologies. In the near term, the ICCT recommends that engine rooms be designed with enough space to allow for retrofit technologies including SCR as well as tank capacity for fuel switching in SECA and coastal areas. New vessels, especially ferries and cruise ships with regular routes and ports of call, should be built with the needed on-board equipment to utilize shore power when port-side facilities exist. Standardization of international shore power requirements is also needed to ensure compatibility between shore-side facilities and ships. The ICCT supports the ongoing efforts within IMO to develop guidelines for shore-side electricity. In the long term, the ICCT encourages the use of advanced vessel design concepts that optimize energy efficiency as well as emissions performance and that incorporate propulsion from renewable energy sources including solar and wind power, where feasible.

EXISTING VESSELS AND ENGINES

Control measures targeted at existing vessels and engines are necessary to significantly impact fleet-wide emissions. A low fleet turnover rate means that the largely uncontrolled vessels that make up the majority of the international marine shipping fleet today will continue to pollute for several decades before they are retired. Most existing control technology options have been developed and demonstrated on in-use vessels, suggesting that a large-scale retrofit program should be technically feasible. In the near term, the ICCT recommends that in-use standards reflecting best available control technologies be developed within the IMO. These standards would allow, for example, future market-based programs (including the range of possible differentiated fee programs) to harmonize their emission requirements. The ICCT further recommends that any in-use standards used in market-based programs be designed to become more stringent over time so as to provide ongoing incentives for adopting the newest control technologies as they become

available, proven, and cost-effective. The program should provide additional incentives to demonstrations of advanced technologies that provide emission reductions beyond the adopted in-use standards. Also in the short term, the ICCT recommends exploring the feasibility of early ship retirement as an extension of the ship recycling programs being developed by the IMO. If determined feasible, this type of program could be implemented in the medium to long term.

GREENHOUSE GASES

The shipping sector's contribution to gases and particles that impact the Earth's climate is only beginning to be fully understood. Here, the ICCT recommends that near-term efforts focus on developing a baseline for the climate impacts of the world's vessel fleet. Once a baseline is established, market-based measures to reduce greenhouse gas emissions can be introduced, also in the near term. If cap and trade programs are developed for GHGs, they should only cover shipping sources and not include land-based sources. If the shipping sector becomes a source of credits for greenhouse gas emissions reductions, steps must be taken—as with any source of credits—to ensure that reductions are recognized only to the extent that they are quantifiable, enforceable, surplus to otherwise mandated reductions, and permanent. The ICCT also recommends that the IMO develop fuel economy standards for ships applicable to new vessels in the near term and existing vessels in the medium term.

AT PORT

The ICCT recommends that emission mitigation measures should be adopted at all major port facilities and be fully integrated with local and/or regional air quality plans. Each port type has access to a range of implementation mechanisms to reduce emissions from ships at berth. For example, landlord ports can include emission reduction requirements in their lease agreements with tenant operators. Operating ports can directly implement some infrastructure measures.

Providing shore power is often the most effective emission-reduction option for vessels while at port. In some locations, however, pollution impacts from electricity generation may make this option less attractive. The ICCT recommends that port authorities and regulators select the strategy or combination of strategies that cost-effectively provides the most environmental benefits. If shore power does not meet these criteria, other options should be implemented including requiring hotelling ships to use the lowest sulfur on-road fuels available and/or engine emission controls. The implementation of shore power and alternative mitigation technologies should prioritize new terminals as well as those that are near residential areas.

In the medium-term, the ICCT recommends that incentives be provided for utilizing low-carbon sources for shore-side power (including renewable solar and wind generators). In

the long-term, the development of cost-effective energy storage technologies and advanced low- or non-carbon generating options should make it possible to achieve near-zero hotelling emissions.

Table ES-1 summarizes the ICCT recommendations towards mitigating the impact of ocean-going vessels on air quality and climate change.

In conclusion, supplemental international action within the IMO is necessary to produce reasonable progress in addressing ship impacts on local air quality and global climate change. National and regional policy-makers are increasingly seeking to accelerate the introduction of emission control technologies and cleaner fuels into the international marine sector. Within the IMO process, several countries including Sweden, Norway, and Germany have emerged as proponents of further measures to reduce emissions from ships. The few environmental organizations that have obtained consultative status with the IMO have also been leading efforts to accelerate progress on these issues. Other environmental NGOs with related activities and expertise should consider applying for consultative status to bolster these efforts. Finally, these efforts within the IMO must be brought to the attention of the larger public. Greater public awareness of the environmental impacts of routine ship activity will undoubtedly result in added pressure to reduce emissions in much the same way that highly publicized oil spills led to an increased focus on accident prevention, impact mitigation, and accelerated phase-out of single-hull tanker ships by the IMO. Best practices and local or national successes should be shared with a global audience to demonstrate that dramatic reductions in emissions from marine vessels, both at sea and in port, are not only feasible but also cost-effective. In the end, collaboration between the public and private sectors and across a wide set of stakeholders will be essential to forge support for sustainable long-term measures to mitigate the public health and environmental impacts of shipping around the world.

TABLE ES-1. ICCT Recommendations for Ocean-Going Vessels

ICCT RECOMMENDATIONS		IMPLEMENTATION MECHANISM
Fuels	— Short term: ○ Lower fuel sulfur level in SO_x Emission Control Areas (SECAs) from 1.5% to 0.5%. ○ Include SO_x/PM related health effects in addition to impacts on air, sea, and land as justification for SECA. ○ Expand SECA program to high ship-traffic areas in Mediterranean, Pacific Rim and North Atlantic. ○ Regional limits in coastal areas, inland waterways, and at ports — Medium term: 0.5% sulfur fuel globally — Long term: Harmonization with on-road diesel fuels (500 ppm to 10-15 ppm over time)	— International standards (IMO)
New engines	— Short term: ○ NO_x standards 40% percent below current IMO standards (2000 level). ○ PM standards ○ Encourage new technology demonstration — Medium term: ○ NO_x standards 95% percent below current IMO standards (2000 level) ○ PM standards further reduced ○ Encourage new technology demonstration — Long term: Encourage the use of advanced technologies, especially near-zero emission technologies in promising applications	— International standards (IMO)
New vessels	— Short term: ○ Adopt international requirements for shore power standardization. ○ All new ships built with shore-side electricity capability, especially cruise ship and ferries — Long term: Promote the use of advanced vessel design concepts in promising applications	— Preferential contracting of cleanest carriers — Environmentally differentiated fees and charges — International regulation (IMO)

Table continues on next page

TABLE ES-1., continued

ICCT RECOMMENDATIONS		IMPLEMENTATION MECHANISM
Existing vessels and engines	— Short term: ○ Adopt emissions performance standards by vessel class and engine characteristics based on demonstrated retrofit potential. ○ Study feasibility and potential impact of programs to promote early ship retirement and environmentally sound disposal	— International standards (IMO) — Preferential contracting of cleanest carriers — Environmentally differentiated fees and charges
GHG	— Short term: ○ Develop GHG emission inventory and fleet baseline ○ Market-based measures for vessels ○ Implement fuel economy standards by vessel class and engine characteristics for new vessels — Medium term: Implement fuel economy standards by vessel class and engine for existing vessels	— Preferential contracting of cleanest carriers — Environmentally differentiated fees and charges — Cap and trade program for shipping sector only — International standards (IMO)
At port	— Short term: Select strategy that provides maximum emissions reduction benefits depending on local fuel availability and environmental performance of electricity generation ○ Shore-side electricity ○ Lowest sulfur on-road fuel and NO_x and PM after-treatment — Medium term: Market-based measures to promote low- or non-carbon energy sources to supply shore-side electricity for docked ships	— Port authority requirement — Preferential contracting of cleanest carriers — Environmentally differentiated fees and charges

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