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Maritime transport and the climate change challenge

Note by the UNCTAD secretariat

Executive summary

Climate change is a global challenge and a defining issue of our era. Compelling scientific evidence and a better understanding of the economics of climate change have moved the issue to the forefront of the international agenda. Greenhouse gas (GHG) emissions from international shipping are increasingly drawing attention and possible mitigation measures are being considered, both at the regulatory and industrial levels. At the same time, the effects of climate change and their implications for maritime transport – as well as for access to cost-efficient and sustainable international transport services – need to be properly understood to ensure that appropriate adaptation measures are taken. This is crucial given the special needs of the most vulnerable countries, namely the least developed countries (LDCs), the landlocked developing countries (LLDCs) and the small island developing States (SIDS). Against this background, the present note raises some relevant issues for the consideration of experts. It (a) argues the importance of a climate policy for international maritime transport that takes into account sustainable development objectives as well as the need for transport efficiency and improved trade competitiveness of developing countries; (b) highlights the underlying issues at the interface of international shipping and climate change; (c) identifies, from the perspective of maritime transport, some of the potential impacts and opportunities arising in connection with climate change; (d) describes the current state of play in terms of the regulatory and institutional framework of relevance to climate change and shipping; (e) outlines some mitigation and adaptation options applicable to ships and ports; and (f) explores cross-cutting elements with a bearing on climate action, such as financing and investment, technology and energy security. Finally, experts are invited to consider a number of issues that may enable effective climate action in maritime transport as well as support efficient maritime transport services in support of sustainable development and enhanced trade competitiveness of developing countries.

Introduction

1. The Secretary-General of the United Nations has called climate change a defining issue of our era. It has in recent years emerged as an important global challenge. The compelling scientific evidence presented in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2007) and an improved understanding of the economics of climate change, including the potential costs associated with action and inaction, have placed the issue high on the international agenda. The climate change challenge remains a serious threat to humanity, with developing countries, in particular LDCs and SIDS, being the hardest hit. As the Kyoto Protocol is due to expire in 2012, a conference by the United Nations Framework Convention on Climate Change (UNFCCC) was held in Bali in December 2007 to launch negotiations on a post-Kyoto agreement. Set to conclude in December 2009, these negotiations provide a renewed opportunity for the international community to undertake meaningful commitments to combat climate change.

2. GHG emissions from international shipping – which carries over 80 per cent of world trade by volume – are increasingly drawing public attention. These emissions are not covered under UNFCCC, the international regulatory framework dealing with climate change. Rather, parties to UNFCCC asked the International Maritime Organization (IMO) to take initiatives that would address emissions from ships. While IMO leads international efforts on technical aspects and mitigation with a view to developing a binding instrument, there remains the need to address the potential policy, economic and trade ramifications of a new regulatory regime on GHG emissions from maritime transport, in particular for LDCs and SIDS. Moreover, greater attention needs to be drawn to adaptation requirements which have to date enjoyed limited attention.

3. As maritime transport grows in tandem with trade and economic activity, the challenge – especially from a sustainable development perspective, as well as a transport and trade facilitation perspective – is to cut GHG emissions from international shipping without undermining development objectives, including the Millennium Development Goals, and without jeopardizing transport efficiency and trade facilitation gains. In this context, not only is mitigation important, but also adaptation, which will be required as a result of observed and projected climate change effects.

I. The climate change challenge

A. Scientific evidence and observed effects[1]

4. The Kyoto Protocol covers six major GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorcarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Between 1970 and 2004, and weighted by their global warming potential, global emissions of theses gases have increased by 70 per cent, with growth in the transport emissions being the second largest.

Box 1. Global warming and some associated effects

The atmospheric concentration of CO_2, the most significant GHG, has increased from 280 parts per million (ppm) in the pre-industrial period to 379 ppm in 2005. Increased concentration of GHGs in the atmosphere and the associated warming effect are considered to cause climate change. Over the last century, the global average surface temperature has increased by around 0.74^{o} C. Under "business as usual" scenarios, IPCC climate models indicate a further temperature rise of 1.1–6.4^{o}C during the twenty-first century. To ensure that the global average temperature increase does not exceed 2^{o} C above pre-industrial levels – the threshold above which dangerous climate change effects are likely to be triggered (tipping point) – the atmospheric concentration levels of CO_2

[1] Unless otherwise stated, information in this chapter is based on IPCC, 2007.

should be stabilized at 350–400 ppm, while emissions should peak by 2015 and decline thereafter.

Observations from all regions and oceans show that many natural systems are being affected. The observed effects include a decline in mountain glaciers and snow cover, a change in the arctic ice coverage and a rise in the global average sea level. The sea level rise is thought to be caused by increased volumes of water in the ocean basins (due to melting ice) and thermal expansion of seawater. The average global sea level increased by 0.17 m over the last century. Relative sea level rise is particularly relevant and varies according to local conditions, including land subsidence. More frequent extreme weather conditions – such as storms, heatwaves, drought and increased intensity of tropical cyclones – are also being observed.

Scientists are also concerned about abrupt climate change effects. These so-called "surprise effects" relate, inter alia, to the instability of ice sheets and the planet's feedback mechanisms (self-reinforcing loop). The uncertainty of these effects is due to the limited information on the nature of climate–carbon cycle feedbacks. For example, reaching climatic tipping points could lead to a potentially "abrupt" effect known as the shutdown of the thermohaline ocean circulation or to an acceleration of global warming due to released methane from thawing permafrost.

5. Climatic changes entail impacts which vary regionally, with potentially positive impacts for some sectors and regions, and potentially negative impacts for others. Aggregated, however, the various impacts are likely to impose costs which increase with rising global temperatures. Potential implications relate to a broad range of areas including water resources, food security, biodiversity, infrastructure, trade, human settlement, health, living conditions, and international peace and security.[2]

6. Maritime transport is not insulated from climate changes; the type, range and magnitude of impacts vary according to local conditions, transportation systems, designs and policies, as well as the capacity to adapt and minimize the costs. Direct impacts are likely in relation to maritime transport infrastructure, operations and maintenance. Maritime transport services may also be affected indirectly, as a result of changes in demand, induced by climate change effects on trade, investment decisions, demographics, agricultural production, forests, energy exploration, energy demand and fishing activity.

7. To better understand the extent of the challenge for the maritime transport sector, the following section describes the fuel consumption and emissions profile of the sector, together with some trends.

B. International shipping emissions

8. Estimates of fuel consumption and GHG emissions from shipping vary in timescale, underlying assumptions and modelling techniques. As shown in table 1, emissions from international shipping are estimated to account for 1.6 per cent to 4.1 per cent of world CO_2 emissions from fuel combustion. IMO expects emissions from international shipping to increase by a factor of 2.4 to 3 between 2007 and 2050. Within the transport sector, maritime transport accounted for 10 per cent of emissions in 2005.[3] Road transport accounted for 73 per cent, followed by aviation (12 per cent), pipeline (3 per cent) and rail (2 per cent). Unchecked, emissions from the transportation sector are expected to double by 2050.

[2] United Nations Environment Programme (2007). Global Environmental Outlook. Human Development Report.

[3] Transport share expressed as a percentage of the 2005 International Energy Agency (IEA) total world CO_2 emissions from fuel combustion.

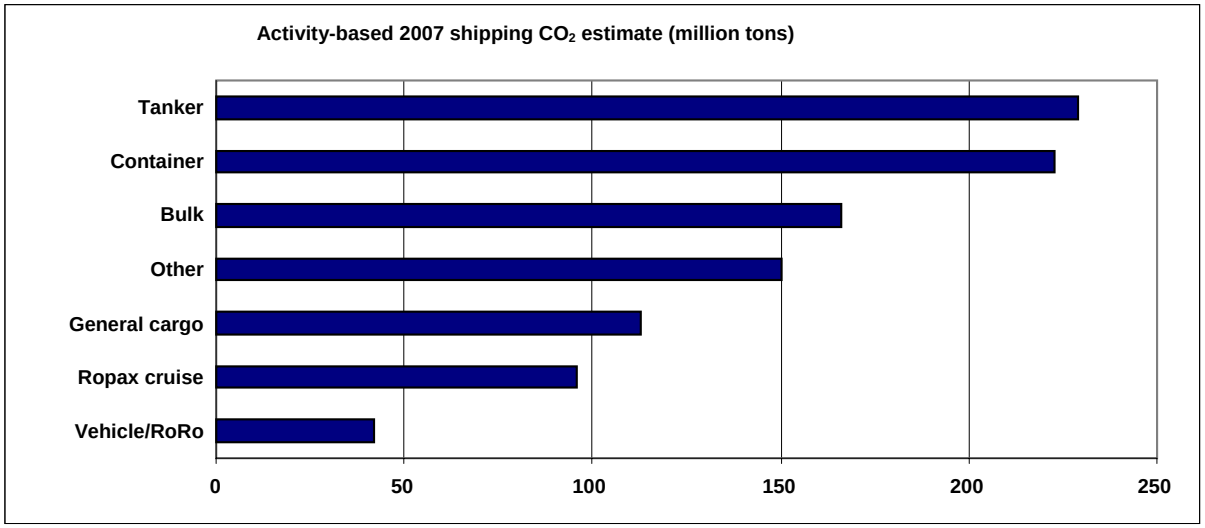
Table 1. Some estimates of fuel consumption, CO_2 emissions and projected growth

	Base year	CO_2 million tons	Fuel million tons	% of world fuel combustion[a]	Projected growth
IMO Updated Study (2008)	2007	843	277	3.1	By a factor of 1.1–1.3 by 2020 & 2.4–3 by 2050.
IMO/Group of Experts (2007)	2007	1,120	369	4.1	+ 30% by 2020
IMO GHG Study (2000)	1996	419.3	138	1.6	--
IEA (2005)	2005	543	214	2.0	--
TRT Transporti e Territorio	2006	1,003	NA	3.7	--
Endressen et al., 2007[b]	2002	634	200	2.3	+ 100–200% by 2050
Eide et al., 2007[b]	2004	704	220	2.6	+ 100–200% by 2050
Eide et al., 2007[b]	2006	800	350	2.9	+ 100–200% by 2050
Corbett et al., 2003[b]	2001	912	289	3.1	--

[a] World CO_2 emissions from fuel combustion, 2005 IEA data.
[b] From secondary sources including IMO Updated Study on GHG, 2008.

9. Figure 1 shows the carbon footprint of international shipping, broken down by ship type. The heavy reliance on oil, in particular heavy oil, for combustion underscores the relevance of greater energy efficiency and energy source diversification for mitigation action in shipping.

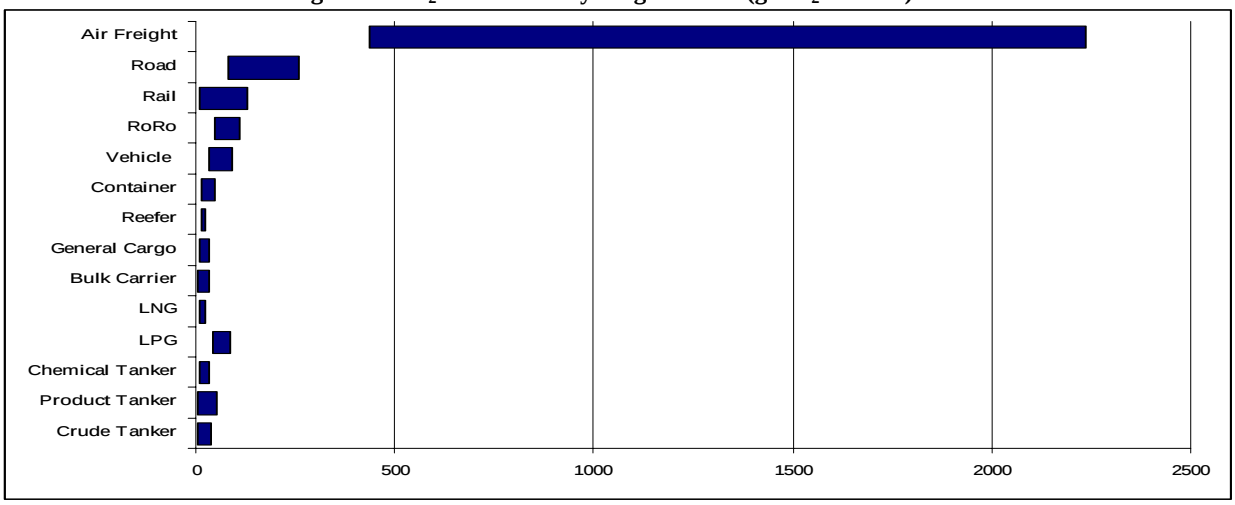
Figure 1. Shipping sector CO_2 emissions



Source: UNCTAD, based on IMO 2000 Updated Study on Greenhouse Gas Emissions from Ships, 2008 (IMO, 2008). Includes international and domestic shipping and excludes fishing and military vessels.

10. While in absolute terms GHG emissions from international shipping are significant, in relative terms maritime transport – in particular where larger ships are used – surpasses other modes of transport in terms of fuel efficiency and climate friendliness. On a per ton kilometre (km) basis and depending on ship sizes, CO_2 emissions from shipping are lower than emissions from other modes. For example, emissions from rail could be 3 to 4 times higher than emissions from tankers, while emissions from road and air transport could, respectively, be 5 to 150 times and 54 to 150 times higher. Equally, in terms of fuel consumption (kilowatt (kW)/ton/km), a container ship (3,700 twenty-foot equivalent units (TEUs)), for instance, is estimated to consume on average 77 times less energy than a freight aircraft (Boeing 747-400), about 7 times less than a heavy truck and about 3 times less than rail.

Figure 2. CO_2 efficiencies by cargo carrier (g CO_2/ton-km)



Source: UNCTAD, based on IMO (2008).

11. This suggests that increased use of shipping, including in multimodal transport and through modal shift, can achieve some CO_2 and energy efficiency gains. However, international shipping is unlikely to always offer a workable alternative to other more polluting modes, as it does not in general overlap with other freight modes. As different modes are used to carry different types of goods over varying distances, a modal shift may be an option, but only for specific market segments (e.g. short-sea shipping in Europe). It is also argued that improving the environmental performance of each freight mode is likely to be more effective than a modal shift. However, where a modal shift to shipping is technically feasible and economically viable, creating a government policy atmosphere supportive of a targeted and considered modal shift would be important.

II. Addressing the climate change challenge: a maritime transport perspective

A. The regulatory and institutional framework: mitigation and adaptation

1. 1992 UNFCCC

12. With 192 member States, UNFCCC sets an overall framework for international efforts to tackle climate change. The convention places a heavier burden on developed countries to reduce GHG emissions under the principle of "common but differentiated responsibilities". While developing countries are not bound by any specified emission reduction targets, by 2000 developed countries had to reduce their GHG emissions to 1990 levels. They are also required to promote and facilitate the transfer of climate-friendly technologies to developing countries and to countries with economies in transition.

2. 1997 Kyoto Protocol

13. The 1997 Kyoto Protocol enhances many of the commitments under UNFCCC. While UNFCCC encourages developed countries to stabilize GHG emissions, the Kyoto Protocol sets specific commitments, binding 37 developed countries over 2008–2012. These countries need to cut their GHG emissions by about 5 per cent from 1990 levels, including through cost-effective emission reduction mechanisms available under the protocol: the Clean Development Mechanism (CDM), the Joint Implementation (JI) and

emission trading via a cap and trade system. Negotiations are also currently being held under the Kyoto Protocol to set further emission reduction targets for developed countries by 2009, analyse the effectiveness of means to achieve these targets, and further operationalize the protocol's Adaptation Fund.

3. Post-Kyoto 2012

14. In December 2007, a conference was held in Bali to launch negotiations on a new international climate change agreement. UNFCCC adopted the "Bali Roadmap", which includes the "Bali Action Plan". The plan covers mitigation, adaptation, technology and financing, and provides for a new negotiating process on climate change to be completed by 2009. A new Ad Hoc Working Group on Long-Term Cooperative Action (AWG-LCA) – which was established at the conference to carry out the "Bali Action Plan" – has held four meetings in the course of 2008 (Bangkok, Bonn, Accra and Poznan).

15. According to discussions at the AWG-LCA meetings, there seems to be no opposition to including international shipping in a second commitment period, but views differ with respect to the appropriate forum (i.e. UNFCCC or IMO). Some, especially the most vulnerable developing countries, have questioned how the principle of "common but differentiated responsibilities" could be applied in the context of international shipping.

4. A shipping perspective: IMO

16. Although no mandatory instrument has been adopted as yet, IMO has recently intensified its work on GHG emissions from ships. The aim is the adoption in 2009 of a binding, coherent and comprehensive IMO regulatory framework on GHG emissions from ships. IMO's Marine Environment Protection Committee (MEPC) agreed that, among other things, the framework should be (a) effective, binding all flag States; (b) cost-effective; (c) practical; (d) transparent; (e) fraud-free; and (f) easy to administer. It should have limited competitive distortion, support technical innovation, promote sustainable development and not penalize trade. It should also adopt a goal-based approach and promote energy efficiency. Views differed somewhat about the scope of a future IMO regime, with some countries arguing that the principle of "common but differentiated responsibilities" under UNFCCC was not compatible with a global regime on GHG emissions applying equally to both developed and developing countries.

17. The MEPC has already considered a report by the intersessional Correspondence Group on Greenhouse Gas-related Issues outlining a range of possible short-term and long-term measures for curbing emissions from international shipping. A Working Group on Greenhouse Gas Emissions has also been established and has commenced its work.

18. Possible short-term measures under discussion include a proposal to establish a global levy scheme applicable to all ships engaged in international voyages. Other potential short-term measures under consideration include wind power, speed reductions and onshore power. Possible long-term measures include technical measures for ship design, use of alternative fuels, a mandatory CO_2 design index for new ships, a mandatory CO_2 element in port infrastructure charging and an emissions trading scheme.

5. National and regional initiatives

19. In addition to international efforts, action has been taken at the national and regional levels. While some national and subnational initiatives deal specifically with transportation (e.g. the 2004 California regulations on GHG emissions from motor vehicles and the Japan green taxation plan for automobiles), others are not sector-specific. Examples include (a) a climate change levy in the United Kingdom; (b) a 2005 climate change plan for Canada; (c) Australia's GHG abatement programme; (d) a carbon tax and negotiated GHG agreement in New Zealand; (e) a 2005 law on renewable energy in China; (f) a national biodiesel programme in Brazil; (g) GHG action plans in 30 states in the United States; (h) California laws on a State-wide cap on GHG emissions; and (i) coal-generated electricity.

20. At the regional level too, initiatives are not necessarily transport-specific. An important regional climate change action is underway at the European Union (EU) level, where steps to address GHG emissions have been taken since the early 1990s. In March 2000, the European Commission launched the European Climate Change Programme which has led, inter alia, to the launch of the 2005 EU emission trading scheme (ETS). In 2007, a directive was adopted setting an overall binding target for the EU of 20 per cent renewable energy and a 10 per cent minimum target for the market share of biofuels, by 2020. More recently, in North America, the Western Climate Initiative – a cap and trade programme binding seven American States and four Canadian provinces – has been announced.

B. Potential approaches to mitigation in maritime transport

21. An important consideration in relation to mitigation options for international shipping is the complexity inherent in this sector, since CO_2 emissions are largely generated outside national boundaries and ships may be linked to different nations through registration, beneficial ownership and operation. Table 2 below highlights some possible mitigation measures potentially applicable to maritime transport.

22. Each option entails opportunities and challenges, with a key challenge relating to potentially extensive costs as well as the fact that many potential win–win solutions (e.g. alternative cleaner fuels) are at preliminary stages of development. In respect of these, time and significant investments are required to ensure commercial viability and wide diffusion. In particular, from developing countries' perspectives, there may be concerns about the cost implications of the various mitigation measures and, where applicable, the capacity to adopt and implement a number of technology-based measures. Increased costs are likely to exert additional pressure on the maritime industry and, by extension, on transport costs, which are already disproportionately higher in developing countries and entail implications for trade competitiveness. As may be recalled, the industry is already facing increased expenditures associated with supply chain security requirements, trade facilitation measures, other environmental regulations (e.g. of air pollutants) as well as highly volatile fuel prices.

1. Technology and energy use improvements

23. *Technology and energy use improvements* can reduce emissions by replacing older, less energy-efficient or higher-polluting equipment and engines. The potential of technical measures (e.g. technologies affecting hull, propeller and machinery) to reduce fuel consumption and CO_2 emissions is estimated at 5–30 per cent in new ships and 4–20 per cent in old ships.

24. A significant shift to *alternative fuels and energy sources* could be difficult in the short term, as most promising alternative techniques cannot yet fully compete with diesel engines. In some cases, a switch from diesel to natural gas is possible (e.g. inland ferries in Norway and offshore supply vessels operating on the Norwegian Continental Shelf). As to biofuels, concerns over their production processes and related implications for food security, climate change and sustainability make their future uncertain. Their uptake will depend on progress made in the field of less controversial biofuels which are not yet widely available (e.g. waste-based). Solar panels and sails – as well as hydrogen-propelled ships and fuel cell power for auxiliary engines – constitute long-term options. Carbon capture and storage technology could also be further developed and applied to the transport sector.

25. *Ports*, as key nodes in the transport chain and given their ability to leverage other partners, can reduce their own emissions as well as emissions that occur along the supply chains. This can be achieved by, inter alia, collaborating with other transportation and logistics players, and co-investing in land equipment and vehicles such as feeders, barges

and rail solutions. Recently, ports' commitment to a lighter carbon footprint culminated in the adoption of the World Ports Climate Declaration in July 2008.[4]

26. Along the supply chain, *optimizing vehicle utilization* could help mitigate emissions through (a) telematics; (b) intelligent transport; (c) new vehicle and engine design; and (d) information and communications technology-enabled scheduling, planning and routing. Equally, *trade facilitation solutions*, such as computerized customs data (e.g. Automated System for Customs Data (ASYCUDA)) could have a role to play. Experiences with customs automation and Single Window projects have shown that the volume of energy consumed during waiting times at border crossings and in ports can be significantly reduced.

Box 2. ASYCUDA programme

The ASYCUDA programme is UNCTAD's flagship technical assistance programme. It is the leading media of customs modernization worldwide and is operating in nearly 90 countries in all regions of the world. ASYCUDA makes it possible to electronically process declarations and clear goods, facilitate risk management operations, support transit operations, apply risk management and selectivity to all steps of the clearance process, and produce timely and accurate statistical data for fiscal and trade policy objectives. It facilitates the exchange of electronic documents and data between the national customs administrations and other governmental agencies and traders, as well as between different customs administrations via the Internet. For over 20 years, ASYCUDA, by using electronic processing of transactions and thus saving on paper, has been adding to the conservation of the environment.

2. Operational measures

27. *Operational measures* are also important for mitigation since they are estimated to have a short-term CO_2 reduction potential of up to 40 per cent through, for example, re-routing and speed reduction. Vessel speed reduction to save fuel consumption and, by extension, reduce GHG emissions, is a key cost-cutting strategy for shipping. Slowing down by 10 per cent can lead to a 25 per cent reduction in fuel consumption. A number of shipping companies have relied on this approach to cut their operating costs during the 2008 record rise in oil and bunker prices. Operators have reduced sailing speed, reviewed route scheduling and entered into partnerships and alliances to take advantage of economies of scale by consolidating existing loops and deploying more fuel-efficient larger vessels. As a side effect, these cost-cutting strategies have helped somewhat in containing the rise in freight rates which might otherwise have negatively impacted trade, including that of developing countries.

28. In ports, improving operations may entail, for instance, reconfiguring terminals to improve barge access, enhance on-dock rail capabilities, speed up loading and unloading, reduce congestion, and provide shore-side electricity.

3. Market-based programmes

29. *Market-based programmes* may include measures such as taxation, differentiated port fees and emissions trading programmes (cap and trade and emissions credits). One analysis estimates that a creative market-based instrument covering all ships could deliver significant and differentiated benefits and could raise between $10 billion and $45 billion annually. If such revenues were channeled towards a mixture of adaptation, technology transfer and emission mitigation projects, benefits of such policies for developing countries could equal two to five times their costs. That being said, many issues need to be addressed before any definite conclusions are drawn on the full implications of these types of measures. Many developing countries have called for further analysis and thorough assessment of the various proposals under consideration at IMO. Concerns relate in

[4] See www.wpccrotterdam.com.

particular to trade competitiveness, as well as technical assistance and capacity-building requirements.

Box 3. Selected market-based mitigation measures

Cap and trade programmes include the JI and CDM under the Kyoto Protocol, the EU ETS and an International Maritime Emission Reduction Scheme (IMERS) proposed by Norway at IMO's MEPC 56. Current discussions at IMO highlight the challenges associated with a cap and trade approach for shipping. These include the geographic and substantive scope of coverage (i.e. which pollutants and how much of the shipping fleet would be subject to the scheme), whether emission reduction credits from-land based sources would be allowed, the baseline and allowance allocation.

A fuel tax, or a levy such as the current proposal discussed at IMO, poses a challenge, given the risk of evasion: ships may avoid the tax by taking fuel on board outside the taxed area. Offshore bunker supply is already common practice to avoid paying port fees or being constrained by loading limits in ports. Hence, a global fuel tax may be difficult to implement given the international dimension. Issues to be addressed include, for example, (a) the point of application of the charge; (b) responsibility for collecting the proceeds; and (c) the question of how such proceeds would be distributed among countries and for which purpose (e.g. mitigation, adaptation and technology). A fuel tax for international shipping without an equivalent levy for other modes could also undermine the relative cost advantage of shipping and may impact different trades. This may have implications for transport costs and trade competitiveness, including for developing countries that are major bulk commodity exporters and non-bulk commodity importers.

Measures that involve port infrastructure charging include port dues and other charges which can be differentiated to take into account the environmental performance of users (e.g. environmentally differentiated fairway dues in Sweden, the Green Award scheme in a number of world ports, the Green Shipping bonus in Hamburg, and environmental differentiation of tonnage tax in Norway). Support measures such as grants, low-interest loans and favourable tax treatment can also help mitigate GHG emissions from shipping (e.g. California Air Quality Investment Programme). Shipbuilding subsidies could also be increased if new ships incorporate GHG control technologies or are built to meet emission performance targets.

30. *Industry-led voluntary initiatives* include, for example, committing to an average emissions rate, known as the *benchmark*, as well as promoting specific emission control technologies (e.g. West Coast Diesel Collaborative Marine Vessels) and preferential contracting of cleanest carriers whereby shippers (e.g. IKEA) require shipowners and ports to compete in terms of environmental performance, as well as in terms of costs.

Table 2. Potential mitigation options

Scope of intervention	Measure	Example
Technology and energy	• Efficient and lower-emitting propulsion systems • Clean fuels and alternative energy sources • Ship design (structure, hull and machinery) • Emission control technologies (e.g. after exhaust treatment, carbon captures and storage)	• EU and IMO sulfur emission control areas • Solar Sailor 2006 and Skysails 2006 • Switch from diesel to natural gas
Operational	• Speed reduction • Route selection • Monitoring of weather and sailing conditions • Collaboration among ports, carriers, other modes and other players in the supply chain • Cold ironing or onshore power	• NYK announcement in early 2008 to reduce the speed of all vessels in the fleet by 10% to cut fuel consumption by up to 25% • Vessel sharing agreement between Maersk MSC and CMA-CGM on transpacific trade
Market-based	• Environmentally differentiated rates/dues • Cap and trade • Taxation • Subsidies • Industry-led voluntary schemes	• Fairway dues in Sweden, Green Award Scheme, Green Shipping Bonus, differentiated tonnage tax in Norway • Kyoto CDM and JI • EU ETS and proposed IMERS • Potential global fuel tax • California Air Investment Programme • Preferential contracting

Source: UNCTAD based on literature review.

C. Potential climate change impacts and approaches to adaptation in maritime transport

31. Mitigation alone is not sufficient to effectively address the climate change challenge. Adaptation remains a necessity to minimize the effects of irreversible climatic changes. Adequate adaptation measures for maritime transport require information on likely vulnerabilities and a good understanding of relevant climatic impacts, including their type, range and distribution across different regions and parts of the industry. Given the high vulnerability and low adaptive capacity of many developing countries, adaptation costs are likely to impose a significant burden for these countries' economies and trade. The following section highlights some climate change impacts, their potential implications for adaptation needs in maritime transport, and some potentially relevant adaptation measures (see also table 3).

1. Impact on maritime infrastructure and equipment

32. *Higher temperatures* are likely to affect maritime transport infrastructure, vehicles and equipment. Extreme temperatures and large variations, together with more frequent freeze and thaw cycles, could, for example, result in a deterioration of ports' paved areas. Heat could also cause damage to equipment (e.g. cranes), especially when made from metal with limited heat resistance. Ports may also experience increased energy consumption and CO_2 emissions due to refrigeration needs for perishable goods and air conditioning.

33. *Rising sea levels, floods and inundations* entail heavy consequences for transport infrastructure and may involve damage to terminals, intermodal facilities, freight villages, storage and warehousing areas, containers and cargo. Extreme weather events (e.g. extreme storm surges) may also disrupt the intermodal supply chain and undermine transport connectivity through damage to port hinterland connections. This would be of particular concern to LLDCs, whose trade depends on well-functioning transportation networks in transit and coastal countries.

Box 4. High exposure and vulnerability of coastal and low-lying areas

Coastal areas, especially low-lying parts with high-exposure possibilities (e.g. people, port assets and cargo) and significant vulnerability (e.g. low adaptive capacity) are at greater risk. While covering only 2 per cent of the world's land area, low elevation coastal zones contain 10 per cent of the world's population and 13 per cent of the world's urban population (e.g. small island countries, which are often also LDCs, and countries with heavily populated deltas). An Organization for Economic Cooperation and Development (OECD) study assessed the exposure of the world's largest port cities to coastal flooding and found that in 2005 the top 10 cities in terms of exposed population were Mumbai, India; Guangzhou, China; Shanghai, China; Miami, United States; Ho Chi Minh City, Viet Nam; Kolkata, India; New York, United States; Osaka-Kobe, Japan; Alexandria, Egypt; and New Orleans, United States. The most vulnerable port cities in terms of exposed assets were Miami; New York; New Orleans; Osaka-Kobe; Tokyo, Japan; Amsterdam, the Netherlands; Rotterdam, the Netherlands; Nagoya, Japan; Tampa–St. Petersburg, United States; and Virginia Beach, United States. The total value of assets exposed across all 136 port cities examined was estimated at $3 trillion.

34. *Increased sediment mobility and changes in erosion/sedimentation patterns* around harbours and access channels could also complicate operations and raise costs through the need for dredging. Beyond direct costs, damages caused by sea level rise, floods and inundations could lead to port shutdowns, disruption of service, delays and further economic losses.

2. Impact on maritime transport services

35. Extreme weather events, such as intense storms, could disrupt services, including in ports, as well as challenge sailing conditions and potentially pose hazards to navigation, ship, cargo, crew and the environment. Difficult sailing conditions could also lead to a modal shift – when technically feasible and economically viable – if other modes are deemed less vulnerable to weather. This may entail further implications for infrastructure investments, fuel consumption and GHG emissions, as well as transport efficiency and trade facilitation.

36. A potentially positive impact of climate change relates to shipping routes, since rising temperature in the Arctic could open some new opportunities for shipping. Although existing trade lanes are likely to continue serving the bulk of international trade, new trade may emerge with some existing trade being diverted towards northern routes. By 2080, the ice-free season of the Northern Sea Route (NSR) could increase by up to 80 days per year. A fully operating NSR would reduce the sailing distance between Rotterdam and Yokohama via the Suez Canal by more than 40 per cent. This would impact on seagoing trade, fuel consumption and GHG emissions, fuel costs and freight rates. It would also entail some implications for ship order books (i.e. ice-class ships), icebreaking services and associated fees.

37. In the summer of 2007, according to the European Space Agency, satellite images showed that sea ice in the North-west Passage (NWP) had shrunk to its lowest level since satellite measurements began in 1978. Many experts expect the Arctic to be ice free before the date projected by the IPCC (i.e. mid-2070). While one recent study concluded that the Arctic would be ice free in the summer as early as 2013, recent satellite images show that "Open water now stretches all the way round the Arctic, making it possible for the first time in human history to circumnavigate the North Pole".

38. Currently, ships sail on the main shipping routes using the Panama Canal, South-east Asian straits or the Suez Canal. If the potential Arctic sea lanes were fully open for traffic, savings on distance, time and costs could be achieved. A navigable NWP offers a route between Tokyo and New York that is 7,000 km shorter than the route through the Panama Canal, thus saving on time, fuel and transit fees. Taking into account canal fees, fuel costs and other relevant factors that determine freight rates, the new trade lanes could cut the

cost of a single voyage by a large container ship by as much as 20 per cent, from approximately $17.5 million to $14 million. The savings would be even greater for the megaships unable to fit through the Panama and Suez Canals and currently sailing around the Cape of Good Hope and Cape Horn. One shipping company (Beluga Group) announced that it would send the first ship through the Arctic in 2009.

39. These potential shortcuts could foster greater competition with existing routes, including through a cut in transport costs, thereby promoting trade and international economic integration. Changing transport and trade patterns are likely to affect infrastructure investments. Ports and terminals in the Arctic need to be able to berth ice-class ships, equipment needs to be sturdy and adequate, and labour needs to be skilled and specialized.

40. A navigable North is also likely to promote resource exploration activities in the region. World shipbuilders, including in developing countries, may therefore be expected to receive more orders for ice-capable ships. In 2006, a total of 262 ice-class ships were being built, with an additional 234 ice-strengthened ships expected for delivery by 2012. However, opening the NWP for navigation may also give rise to conflicting territorial claims by countries in the region as well as involve some governance and regulatory considerations.

41. To sum up, an Arctic open for navigation holds many opportunities and challenges. These, however, need to be fully assessed to ascertain their potential implications for trade and competition among routes, shipbuilding, labour, port development, offshore activity and human settlement. Implications for the Arctic's ecosystem, local communities, possible territorial disputes and governance also need to be assessed.

Table 3. Potential impacts and adaptation in maritime transport

Climate change factor	Potential implications	Adaptation measures
Rising temperatures • High temperatures • Melting ice • Large variations (spatial and temporal) • Frequent freeze and thaw cycles	• Longer shipping season (NSR), new sea route (NWP) • Shorter distance for Asia–Europe trade and less fuel consumption • Additional support services and navigation aids such as ice-breaking search and rescue • Competition, lower passage tolls and reduced transport costs • New trade, diversion of existing trade, structure and direction of trade (indirectly through impact on agriculture, fishing and energy) • Damage to infrastructure, equipment and cargo • Increased construction and maintenance costs; new ship design and strengthened hulls; environmental, social, ecosystem-related and political considerations • Higher energy consumption in ports • Variation in demand for and supply of shipping and port services • Challenge to service reliability	• Heat-resistant construction and materials • Continuous inspection, repair and maintenance • Monitoring of infrastructure temperatures • Reduced cargo loads, speed and frequency of service • Refrigeration, cooling and ventilation systems • Insulation and refrigeration • Modal shift • Transit management scheme and regulation of navigation in northern regions • Ship design, skilled labour and training requirements
Rising sea levels • Flooding and inundation • Erosion of coastal areas	• Damage to infrastructure, equipment and cargo (coastal infrastructure, port-related structures, hinterland connections) • Increased construction and maintenance costs, erosion and sedimentation • Relocation and migration of people and business, labour shortage and shipyard closure • Variation in demand for and supply of shipping and port services (e.g. relocating), modal shift • Structure and direction of trade (indirectly through impact on agriculture, fishing, energy) • Challenge to service reliability and reduced dredging, reduced safety and sailing conditions	• Relocation, redesign and construction of coastal protection schemes (e.g. levees, seawalls, dikes, infrastructure elevation) • Migration • Insurance
Extreme weather conditions • Hurricanes • Storms • Floods • Increased precipitation • Wind	• Damage to infrastructure, equipment and cargo (coastal infrastructure, port-related structures, hinterland connections) • Erosion and sedimentation, subsidence and landslide • Damage to infrastructure, equipment, cargo • Relocation and migration of people and business • Labour shortage and shipyard closure • Reduced safety and sailing conditions, challenge to service reliability • Modal shift, variation in demand for and supply of shipping and port services • Change in trade structure and direction	• Integrate emergency evacuation procedures into operations • Set up barriers and protection structures • Relocate infrastructure, ensure the functioning of alternatives routes • Increase monitoring of infrastructure conditions • Restrict development and settlement in low-lying areas • Construct slope-retention structures • Prepare for service delays or cancellations • Strengthen foundations, raising dock and wharf levels • Smart technologies for abnormal events detection • New design for sturdier ship

Source: UNCTAD based on literature review.

3. Some adaptation options for maritime transport

42. Adaptation involves enhancing the resilience of infrastructure and operations through, inter alia, changes in operations, management practices, planning activities and design specifications and standards. The extended timescale of climate change impacts and the long service life of maritime infrastructure, together with sustainable development objectives, imply that effective adaptation is likely to require re-thinking freight transport networks and facilities. This may involve integrating climate change considerations into investment and planning decisions, as well as into broader transport design and development plans.

43. To better deal with *extreme weather events*, emergency evacuation procedures need to be integrated into operations. Preparing for service delays or cancellations may contribute to minimizing impacts, while smart technologies could be used to detect abnormal events and therefore allow for appropriate actions to be taken in time. Investing in infrastructure and equipment able to withstand extreme weather events such as storm activity, flooding, corrosion and heat will also be crucial (e.g. new, more heat-resistant construction and paving materials and construction techniques). Managing these events may involve continuous inspection, better monitoring of infrastructure temperatures, increased maintenance, reduced cargo loads, reduced speed and frequency of service, and changes to ship design. Ships, ports, terminals, warehouses and storage areas may require increased refrigeration, cooling systems and ventilation, resulting in higher energy consumption and CO_2 emissions. Finally, stronger ships able to better withstand extreme weather events will probably be required.

44. The potential full operation of the NWP and NSR would require a transit management regime, regulation (e.g. navigation, environmental, safety and security) and a clear legal framework to address potential territorial claims that may arise, with a number of countries having a direct interest in the Arctic.

45. Adaptation in the context of *rising sea levels* may involve relocating facilities (e.g. warehouses, storage areas and other services offered on the port side could be relocated further inland), rerouting traffic, redesigning structures or retrofitting with appropriate protection, including through elevation, defences, levees, seawalls and dikes. Using flood defences is estimated to reduce losses for high-risk properties by 70 per cent. Land planning polices need to ensure that risks associated with further settlement and port infrastructure investment in vulnerable areas are better assessed and taken into account.

D. Cross-cutting issues

46. An international regime on GHG emissions from shipping cannot succeed if some underlying cross-cutting issues are not sufficiently considered. These include addressing costs through adequate financing and technology transfer to help, in particular, developing countries build, as a matter of priority, their adaptive capacities. There is also a need to further explore and capitalize upon the potential win–win solutions that could be achieved by linking climate policy imperatives with other objectives, such as in relation to energy security, transport efficiency and trade facilitation, within a broader sustainable development framework.

1. Costs and financing

47. Addressing climate change requires significant global investment and financial flows, including those that are private sector-driven; yet the cost of inaction is estimated to be much higher (5 per cent to 20 per cent as compared to 1 per cent of gross domestic product annually). Although the current global financial crisis and economic downturn might change the perceived relative cost of climate change policy and sideline the fight against climate change, postponing action is not a viable option. Necessary funding, including in maritime transport, needs to be mobilized with an urgency equivalent to that of the global credit crisis. While a “bailout package” for climate change remains crucial,

there is, nevertheless, a concern about climate change objectives being put "on the back burner", with potential implications for the outcome of the Bali negotiating process.

48. Current financial flows for both mitigation and adaptation from the UNFCCC and Kyoto Protocol financial mechanisms remain, however, inadequate in comparison with the challenge. As of March 2008, funds pledged to UNFCCC's Special Climate Change Fund totalled $90 million while those pledged to the Least Developed Countries Fund totalled $173 million. The Adaptation Fund under the Kyoto Protocol could have $80 million–$300 million per year for adaptation projects and programmes in developing countries during 2008–2012. Given the projected mitigation and adaptation requirements, scaling up financial assistance is key.

49. Additional funds needed for mitigation are estimated at $81 billion to $249 billion in 2030, equivalent to only 1.1 per cent to 1.7 per cent of projected global investment in 2030. About 50 per cent of these amounts will be required by developing countries, where mitigation options are considered less costly but where adaptation needs are greater. Costs of mitigation in maritime transport are also likely to be significant. Climate-related expenditures affecting maritime transport operations, equipment and infrastructure can be expected to pose an additional financial burden for the maritime industry, and could affect transport and trade costs. That being said, a thorough assessment of cost implications for the maritime transport sector is as yet to be completed and will depend on the type of measures adopted as well as their scope of application.

50. Additional financing required globally for adaptation in five sectors, including infrastructure and coastal protection, are estimated at $49 billion–$171 billion in 2030, with $28 billion–$67 billion of this total being needed in developing countries. Other estimates of adaptation costs for developing countries include those by the World Bank ($9 billion–$41 billion), Oxford Institute for Energy Studies ($2 billion–$17 billion), Oxfam (greater than $50 billion), and the United Nations Development Programme ($86 billion). Irrespective of the divergence of these estimates, the bottom line is that current funding levels are dwarfed by the billions of dollars that will be needed, especially by developing countries, to adapt to climate change.

51. Adaptation in maritime transport is likely to require important financial resources, especially in the most vulnerable developing countries where, very often, existing transport infrastructure and equipment lack the resilience necessary to withstand the various projected climatic impacts. Adaptation costs in maritime transport are not yet fully understood given the important knowledge gap in terms of adaptation needs, geographic distribution and required response measures. Ensuring adequate financing for adaptation in maritime transport is likely to also achieve some collateral benefits (e.g. transport efficiency and trade facilitation), which could help partly offset the adaptation costs.

2. Technology

52. Promoting large-scale development and deployment of technology in support of climate change action is challenging yet crucial for developing countries, especially since the "Bali Action Plan" provides that – within a context of sustainable development – mitigation action is also required from developing countries. Achieving reduction targets necessary to prevent dangerous climate change effects requires massive mobilization of technology across different sectors, including maritime transport.

53. The "Bali Action Plan" emphasizes the need to remove barriers to financing and technology transfer, and for developing countries to have access to such technologies. Specific actions include faster deployment and diffusion of green technologies, and cooperation on research and development. Economic opportunities offered by a "green revolution" and a revision of the global financial system may provide a new departure for climate policy investments. Coordinated international action on climate change has the potential to raise global incomes and provide additional rural employment, especially in areas with limited alternative opportunities in developing countries.

54. Other mechanisms outside UNFCCC that could mobilize a global technology revolution include the World Bank Group's Clean Energy for Development Investment Framework, the IEA Programme and bilateral agreements to promote technology (e.g. EU–China, the United States–Russian Federation). Technologies used in trade facilitation and supply chain security could also be leveraged to achieve climate policy gains in transport. The challenge, however, is for many of these initiatives to translate into a real technology transfer to developing countries. Indeed, much remains to be done to ensure measurable, reportable and verifiable diffusion of these technologies.

3. Energy

55. While climate-led policies and those related to energy security may have different objectives, they are nevertheless interconnected and entail important synergies. Relieving global dependency on fossil fuel sources and reducing GHG emissions from fossil fuel combustion are two faces of the same coin. World primary energy needs are projected to grow by 55 per cent over 2005–2020 (IEA World Energy Outlook 2007). IEA estimated the cumulative required investment in energy infrastructure at $22 trillion over the period 2005–2030.

56. However, whether and how future energy demand will be met remains unclear, given concerns about fossil fuel supply levels and increasingly converging views about the prospect of a peak in global production levels with production declining thereafter (Peak Oil). Unavailable or unaffordable oil and gas make more polluting coal and unconventional fossil fuel sources more attractive and competitive. While biofuels hold important potential, their implications for sustainability need to be addressed to ensure that their attractiveness is not undermined and that a balance is struck between energy security objectives, climate policy and achieving the Millennium Development Goals.

57. As maritime transport relies predominantly on oil for fuel, energy security and oil price volatility are of particular relevance for this sector. Typically, fuel costs account for 20–25 per cent of total ship operating costs, although this share increased to over 50 per cent when oil prices reached record highs in mid-2008. Energy prices – through their impact on shipowners' operating costs and thus freight rates – could provide incentives for effective de-carbonization through significant investment, including from the private sector, in technologies to save energy and increase energy efficiency. These could lead to other benefits such as transport cost reduction and trade promotion, especially for the shipping-dependent trade of developing countries.

III. Conclusion and expected outcome

58. Climate change is happening and its impacts are already being felt, in particular in the more vulnerable countries. Unchecked, climatic changes can reach tipping points resulting in disastrous and irreversible consequences for humanity. The wide-ranging impacts of climate change and their potential implications for development underscore the need for integrating climate considerations into development and transport planning and strategies. Thus, urgent, concerted and considered action is required at all levels to ensure effective control of GHG emissions and establish the requisite adaptive capacity, especially in developing countries.

59. Like other economic sectors, maritime transport, which is vital to globalized trade, has a role to play in addressing this challenge. At the same time, access to cost-efficient and sustainable international transport services must be safeguarded and enhanced – especially for LDCs, LLDCs and SIDS.

60. Against this background, and to contribute to the debate, deliberations at the meeting may help identify relevant policy actions that serve the purpose of climate change mitigation and adaptation in maritime transport without undermining transport efficiency and trade facilitation gains. One objective of the meeting is to gain a clearer vision of the format, scope and content of a potential new regime on GHG emissions from international

shipping and help ascertain the economic and policy implications of various mitigation measures, including on trade competitiveness of developing countries. To this end, and with a view to providing substantive policy guidance in the context of UNFCCC conference in December 2009, discussions are expected to help, inter alia:

(a) Assess impacts on/implications for transportation systems, in particular ports and ships;

(b) Improve the understanding of required adaptation measures;

(c) Explore the potential for synergies between transport and trade facilitation measures and climate policy, including in relation to technology;

(d) Outline best practices in terms of mechanisms used to integrate climate change considerations into transportation policy, land use planning, as well as infrastructure investment decisions, and development strategies; and

(e) Identify current climate change-driven cooperation mechanisms between maritime industry stakeholders and explore their potential expansion in developing countries.