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Options for the Integration of Ocean Transport in a Greenhouse Gas Regime post 2012

- Final English Version –

Part I

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Part 1

Background Report

1. Introduction

International ocean transportation is the most energy efficient way to transport goods and people in terms of freight and person transported per kilometer. Furthermore, the international ocean transport sector's share of global carbon dioxide (CO_2) emissions is only about 2% of total global greenhouse gas emissions. Nevertheless, the contribution of international ocean transport to greenhouse gas emissions such as CO_2 should not be underestimated. First, this 2% is approximately equivalent to the emissions of countries such as France or Australia. Moreover, CO_2 emissions from the transport sector are increasing over-proportionally and this increase is particularly pronounced in the freight transport sector, which constitutes the major share of international shipping's transport activities. This increase is primarily caused by changes in the framework of the global economy, including improved communications and low transportation costs.

States cannot ignore greenhouse gases from international transport if the aim is to stabilize greenhouse gas emissions in the atmosphere in order to protect the global environment. Indeed, in today's global economy, this stabilization of greenhouse gases may also require changed consumer behavior, altered production processes, and the implementation of different technical and operational measures. Yet until today, neither the bodies of the United Nations Framework Convention on Climate Change (UNFCCC) and the parties to the Kyoto Protocol, nor subsequent sessions of the Subsidiary body for Scientific and Technological Advice (SBSTA) have been able to reach agreement on how to incorporate internationally travelling aircrafts and ships in a climate policy regime.

This report is split into two parts: Part I to provide background information and Part II to discuss options for addressing greenhouse gas emissions from international shipping after 2012. A list of concluding bullet point after each section eases the reading.

The international ocean transportation industry is one sector that has been traditionally global, and has been regulated since 1958 through the International Maritime Organization (IMO). The international character of the IMO is both its strength and weakness. Its existence offers a global policy framework. However, differing state interests and the resultant slow implementation of environmental policies through the IMO is unsatisfactory, considering the necessity of immediate action to protect the global climate from further warming and disruptions.

The international law that has given the IMO its mandate nevertheless offers an important framework for creating potential solutions. The UN Convention on the Law of the Sea (UNCLOS) sets the juridical stage and provides legal justifications to protect the commons of the open oceans and coastal regions. However, the political and juridical framework for regulating international ocean transport requires consideration of international trade law, regional and national laws as well. This report outlines all of these legal frameworks and presents potential windows for action.

Furthermore, the report analyzes the presented options for integrating ocean transport in a climate change regime on the basis of the principles of the UNFCCC, including those pertaining to justice, sustainability and development. The UNFCCC's interpretation of sustainability includes principles that have been previously established in the UN Conference on Environment and Development, namely the precautionary and the polluter pays principle.[1] The application of all of these principles provides guiding questions for evaluating the different options. For example: Where do the limits of state-based responsibility and authority lie? Who is the party responsible for transport activities? Who causes the emissions? How can the support of the countries of the global South[2] be won? Where do the cost effective potentials lie for minimizing ship-borne greenhouse gas emissions and under what conditions can these potentials be realized?

The report also investigates today's production and consumption patterns and the related trade activities. The majority of global trade occurs between the countries of the "triad"[3], while a significant percentage of ship operators and ship owners are located in countries of the global South. Furthermore, transnational corporations and their globally integrated production networks are increasingly dominating global transport demands. Thus, the report focuses on who in the different options would bear the costs of the greenhouse gas reductions and what consequences this would entail for the global economy.

The report emphasizes only CO_2, rather than all six Kyoto greenhouse gases, because CO_2 is by far the most primary greenhouse gas emitted by international ocean transportation (IMO 2003). The report recognizes that ships, particularly those that use residual marine fuels, contribute significantly to local environmental pollution problems, including high sulphur-, nitrogen oxide and particle emissions as well as CO_2. Furthermore, international transport is responsible for other negative effects such as the introduction of invasive species, land use issues and others. However, consideration of these emissions and effects is beyond the scope of this study.

In Chapter 2, the report provides background information on the characteristics of international ocean transportation. Chapter 3 focuses on the existing regulations of shipborne emissions, in particular air emissions. Chapter 4 highlights the dynamics of inter-

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1 Precautionary principle :
"In order to protect the environment, the precautionary approach shall be widely applied by states according to their capacities (…)" (Principle No. 15, Rio Declaration on Environment and Development)

Polluter pays principle:
"National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investments." (Principle No. 16, Rio Declaration on Environment and Development).

2 This report uses the terms "North" and "global South" as well as countries in transition instead of the terms "developed" and "developing", "1st World" and "3rd World" or "industrialized" and "developing" countries. The use of the terms North and global South is less discriminating and sidesteps terminology that lacks a precise definition, such as "developed". Also, the frequently used terms 'advanced industrial countries', 'emerging markets' and 'heavily indebted poor countries' imply some typical development paths. The terms "1st World" and "3rd World" stem from a Cold War context in the middle of the 20th century and are no longer current. Countries of the North and countries of the global South also emphasizes the geographic relationship between the countries that are named "developed" and "developing" in the UNFCCC and underlines the global characteristic of the global economy.

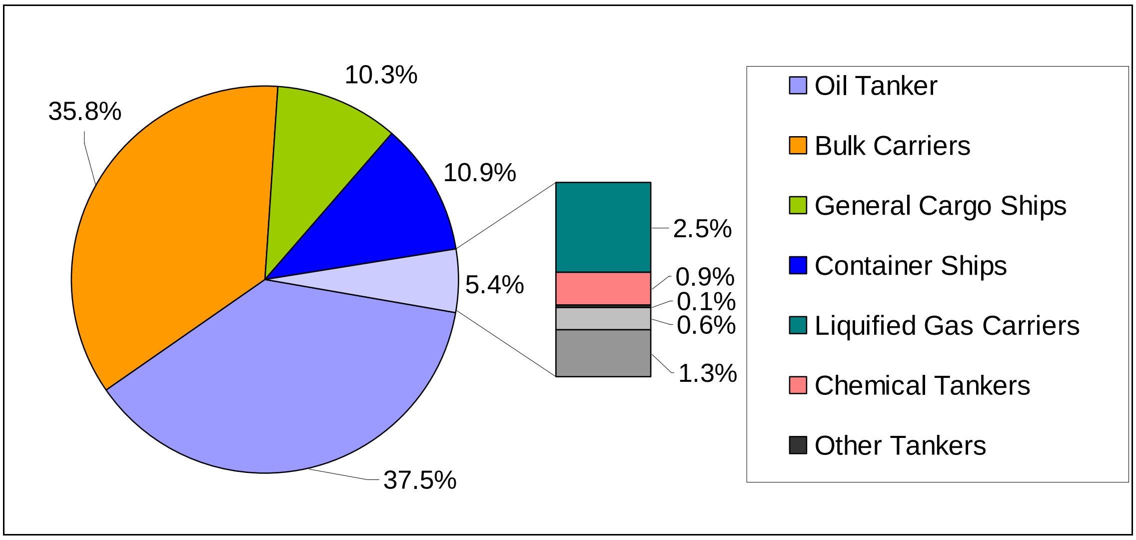
3 The countries of the triad are the states of the European Union, of the North American Free Trade Zone (USA, Canada and Mexico) as well as states in south east Asia, including Japan.

national trade that "causes" transport activities. This analysis is followed by a brief overview of the possibilities for reduction of greenhouse gas emissions from ocean going ships (Chapter 5). Finally, in the separate Part II, the report discusses several options for integrating international ocean transport in a post 2012 greenhouse gas regime.

2. Background on international ocean transport

Approximately 85,000 ships are registered as internationally travelling ships with a gross register tonnage (GRT) of more than 100. About 40,000 of those ships are non-freight-ships, such as research vessels, fishing vessels etc. (Endersen, 2003). The international ocean transport industry includes ship categories[4] tanker (crude oil and product carrier), bulk carrier (e.g. or-, coal- and corn-bulk carriers) general cargo ships (e.g. refrigerated carriers, roll-on roll-off (ro-ro) ships), container ships (packaged goods), passenger ships, ferries and other ships (e.g. LNG carriers, chemical tankers, fishing vessels etc.). Based on the world tonnage, 38% of the global fleet are oil tankers, 36% are bulk carriers, 10% are general cargo ships and 11% are container ships (Figure 1)

Figure 1 World shipping fleet by ship categories in percent



Source: UNCTAD 2005, table 6, page 21. Own depiction.

Tankers and bulk carriers represent 73.3% of the global ship tonnages. While the tonnage capacity of general cargo carrier has declined over the past years that of other ship types - in particular containerships - has increased significantly. The tonnage capacity of container vessels increased from 2003 to 2004 by 8.4% and has now reached a share of 10.9% of the global fleet's tonnage capacity (UNCTAD 2005). Moreover, the monetary values of the goods transported by container ships are significantly higher than those transported by bulk carriers. The value of consumer goods that are transported by ships represents about 50% of the value of all goods transported, while they only make up about 3% of the tonnage of transported goods (Clarkson 2004).

4 As ships in the international trade are all

International ocean transportation has experienced continuous growth over the past years.[5] Therefore, the climate-relevance of ocean transportation is increasing over-proportionally, despite the fact that ocean transport represents the most energy efficient form of transport. The intensity of ship-borne greenhouse gas emissions depends largely on the type of ships and cargo. Container shipping in particular shows a trend towards faster transport, which tends to increase fuel consumption and greenhouse gas emissions. According to an analysis of the Japanese government, about 31% of the globally used marine bunker fuels, and the respective greenhouse gas emissions, are used by tankers, 30% by bulk carriers and general cargo carriers and 32% by containerships.[6]

The international ocean transport sector underwent a few of significant changes over the past 50 years. Container shipping, the shipping in standardized containers, was introduced in the 1950s and increased the competitiveness and productivity of ships for transporting consumer goods. Moreover, the past decades have seen significant changes in the ownership structure.

Traditionally, ocean transportation has been suitable for heavy bulk cargo, whether liquid or solid. Consumer goods and investment goods manufacturing, meaning the manufacturing of finished refined products, has traditionally taken place in richer, more developed nations. However, the reduction in trade barriers and ability of capital to move relatively freely has promoted a global division of labor and created truly international production networks. These international production networks were fostered by low transport costs and improvements in communication infrastructure. The increased demand for container transport is one element of this development.

Containerization of freight transport has some attributes that indicate the position of today’s ocean shipping industry. It also points to some problematic issues, but also provides some opportunities:

- Container handling is relatively quick and cheap
- Containers are relatively safe
- Containers allow for the transport of temperature sensitive goods
- Containers allow for an effective multi-modal transport from door to door.

The attributes of containerized transport thus enable a time-sensitive international division of labor in production and consumption. The increasing efficiency and reliability of containerized transport has undoubtedly contributed to the relocation of manufacturing overseas. However, the good energy efficiency of ocean transport also provides opportunities for reducing greenhouse gases in freight transport by shifting in particular from air freight to ocean freight. The extent to which air freight could be shifted to ocean transportation under today's economic parameter remains to be seen (Oberthür et. al.

[5] Increases of ton-miles from about 20,000 million in 1994 to about 27,500 million in 2004 (Marisec 2006, using Fearnley data).

[6] According to a governmental note on the 46. MEPC of the IMO, 23 April 2001.

2003). Air freight today transports mostly perishable and time-sensitive goods. It could generally be assumed that companies avoid air freight if possible in order to keep transport costs as low as possible.

Modern production structures continuously put pressure on the time of delivery and thus the speed of freight transport. For example, virtual warehouses, just-in-time production, custom-made goods etc. shape in particular the consumer goods market. The relative benefit of better energy efficiency of ocean transportation would, however, decline over proportionally with an increase in ship speed.[7] The danger is that with increased competitive pressure, ocean shipping may be forced to increase its service speeds and thus the respective greenhouse gas emissions. On the other hand, it is likely that the more products that are able to be shifted from air freight to ocean ships, the closer the delivery times become.

Besides the changed competitive characteristics, the structures of ownership and organization have changed the ocean shipping industry over the past 50 years. The international ocean transport market is highly competitive and is economically considered rather volatile and instable, despite strong profit rates in recent years. Profits permanently risk erosion due to strong competitive pressure.

The high pressure to reduce costs has influenced the ocean shipping industry and its organizational structure. Today, only a portion of the ships run under the auspice of shipping companies. The big oil companies hold only about 7% of the tanker fleet in its ownership. Another 7% are operated under long-term charter agreements. Long-term charters are usually signed over a period of ten years or more, and are often signed prior to the delivery of the ship. Shorter agreements of 1 to 5 years are signed on the free charter market. Furthermore, a spot charter market covers the voyages where ships are hired per trip and cargo. Container ships and some special carriers, such as car carriers, run in a liner service, usually in ownership, long-term charter and spot charter agreements. On those liner services, the purchasers of transport buy slots (containers or units of volume) of cargo on vessels that operate on a fixed schedule and trade.

One major question in relation to the greenhouse gas problematic is the question as to who bears the responsibility for transport activities. The different stakeholders, such as freight owners, traders, ship owners, ship managers and ship brokers should be differentiated between in discussions about responsibility. Ship owners or -managers and cargo owners are often identical in the market of bulk transport. In other cargo categories, these functions are often separate. Chapter 2.2 will shed light on the legal differences between ship ownership and management. A detailed overview of the ocean shipping market is given in Clarkson (2004).

[7] The maximum velocity of container ships is about 25 knots, based on technical and hydro-dynamic reasons. Increases in speed are only possible with smaller ships and changed hull design. Currently, a transatlantic project aims to implement small freight ships with speeds of 40 – 50 knots. The project proposes to place itself between air and ship freight. The amount of fuel consumed is likely exponentially higher than those of conventional ships. (http://www.fastshipatlantic.com/index.htm).

2.1 The political and legal instruments in international ocean shipping

The legal framework under which the international ocean shipping operates is complex. National and supra-national competencies are limited. Technical aspects of the international shipping industry have been regulated since 1958 by the International Maritime Organization (IMO), which strengthened its mandate when the United Nations Convention on the Law of the Sea (UNCLOS) was adopted in 1982.[8]

The IMO, in which 167 states are represented, has the obligation of coordinating shipping related rules and standards of the different nation states. Furthermore, the IMO is the internationally recognized multilateral body that can adopt internationally binding technical standards. Although the UNCLOS only refers to the IMO once, it refers in general to the "competent international organization or diplomatic conference". The IMO sees itself as this competent international organization (IMO 2005a). The exclusive authority of the IMO for setting international standards, however, is not uncontested (see p. 12).

Furthermore, the UNCLOS regulates additional national and supra-national jurisdiction for activities to protect the oceans and coasts as well as using the maritime resources. The following chapters will introduce the legal background of UNCLOS in relation to the protection of the oceans and coasts as well as of the IMO and its activities.[9]

The UNCLOS may play an important role in designing a greenhouse gas regime that integrates ocean transportation, because of its important provision to protect the marine environment. The international and ex-territorial oceans are open common goods and freely accessible. However, the oceans are considered a scarce common good due to environmental degradation and climate change; national or supra-national measures to protect this common good are justified (WBGU 2002). The degree of protection by UNCLOS includes indirect emissions that have the potential to harm the marine environment and human resources, including its fisheries (Article 1 (4), Article 21 (2) and Article 192; excerpts of which can be found in the appendix).

The ecosystems of the oceans and coasts, both flora and fauna as well as the human use of the oceans and coasts, are in particular at risk due to the effects of global warming. The change in temperature of the oceans will have some devastating direct effects, for example on aqua cultures, as well as indirect effects such as increased corrosion by the rise of the sea levels (IPCC 2001b, 2007). Furthermore, global warming will also directly endanger the ocean transportation industry. Large investments in transport infrastructure with unknown costs are likely to be necessary due to the rise in sea levels. Some of the effects listed by the IPCC (2001b, 2007) make the threat to the oceans and coasts apparent:

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8 UNCLOS entered into force on 16 November 1994 following the signature of 60 states.

9 A detailed analysis of the national and international legal parameters by lawyers is highly recommended. This report cannot deliver concluding findings on legal issues. A comprehensive analysis of the legal structure can be obtained in the fourth appendix of BMT (2000).

- In the 20th century, the rise in sea level due to climate change is estimated at 0.17 – 0.22 m. The increase accelerated between 1993 and 2003.
- The retreat of ice coverage. Since 1900, the area covered by frozen ground in the northern hemisphere has decreased by about 7%, with peaks in spring of up to 15%.
- Increased ocean surface temperatures. Observations confirm that oceans have absorbed more than 80% of the heat added to the climate system.
- Changes in the physical parameters of the oceans, such as pH level, salt content etc.
- Increase of floods
- Increase of coastal erosion
- Negative effects on aquatic life
- Negative effects on aqua-cultures.

The UNCLOS thus provides nation states and international organizations with the foundation for limiting greenhouse gas emissions in order to protect the marine environment from further, avoidable degradation.

2.1.1 International legal background

The guiding principle according to the UNCLOS is the principle of flag states, which was, however, in part responsible for the blockade in the negotiations on climate change regarding international ocean transport. Flag states of the global South especially insisted to be treated differently to countries of the North with reference to the Kyoto Protocol and its Annex I country designation. However, the states that block progress in SBSTA negotiations are not limited to countries of the global South.

UNCLOS further defines port states and nation states jurisdiction, beyond that of the flag states. Whether these regimes will offer some room to act will be examined furthering more depth.

a) Ship ownership, operation and registration

According to the UNCLOS, each state has the right to own and operate ships in international waters. The states under which flag ships are operated are called flag states. Flag states have the duty to implement and adhere to the international technical and social standards (UNCLOS, Article 94). According to the UNCLOS, a real connection between the flag state and the ship must exist ("genuine link").

After the 2nd World War the world's commercial shipping fleet underwent a process of restructuring and liberalisation. In general, ship ownership, operations and management had been under the auspice of one nation ("genuine link"). However, since the 1950s, states who offered registry of ships without demanding that ship owners or operators would have a residency in those countries came to the fore. This practice of open registries is known as flag of conveniences and has drastically increased economic competition in the shipping industry. The main motivation for using flag of conveniences are lower costs for labor and partially lower technical standards, or at least a more relaxed control and monitoring ofcompliance. The most important states with open registries are Panama (20%), Liberia (8.5%), the Bahamas, 4.7%), Malta (4.1%) and Cyprus (3.6%). The largest ship-owning countries are Greece (18.5%), Japan (14%), Germany (6.9%), China (6.8%), the United States (5.5%), Norway (5.2%) and Hong Kong (China) (4.9%) (UNCTAD 2005).[10]

The United Nations Conference on Trade and Development (UNCTAD) aimed to dissolve the open registers in the early 1980s. Facing the declining support of states and a stiffening of international competition, UNCTAD dropped this goal and adopted the Convention on Conditions for Registration of Ships in 1986. This convention now formalizes the different registries and the outflagging of ships into third countries. It also sets the responsibilities of ship ownership, management and operation. Today, four main types of registries can be noted:

- Traditional home state registers: These registers generally require that the owner as well as the operator and all employees are citizens of the flag states.
- Traditional open registers: Open register states realize the 'genuine link' in different fashions and usually in such a way that the owner or operator of a ship do not have to be citizens of these flag states. For example, open registries operate offices in countries of north America and Europe, which manage the registration of ships under their flag and thus satisfy the connection between the nation of the owner, manager and crew with the flag state. States with open registries tend to be less developed countries of the global South, such as the Bahamas, Cyprus, Liberia, Malta and Panama.
- Offshore registers: Ship owners register their ships in the country of their citizenship, but enjoy large freedoms in terms of the nationalities of their hires due to the flagging in an offshore register. France and Great Britain are examples of countries with offshore registers.
- International registers: Several nations, in particular traditional sea farer nations, have introduced secondary registers that offer lower standards than their counterparts in the motherlands. Owners and operators are usually citizens of the mother countries. Examples of international register are Denmark (DIS), Germany (GIS), Norway (NIS) and Finland (FIS).[11]

The structure of ship registration undergoes permanent changes. The registration in countries of the North declines constantly and has dropped from a share of 65% in 1970 to about 27% in 2004. At the same time, the share of countries with traditional open registers is stagnating at approximately 45%. The share of registrations in countries of the global South is constantly increasing and lies currently at about 23% (UNCTAD 2005, Table 14). The outflagging percentage varies from country to country. About 84% of the German fleet but only 30% of the Italian fleet operate under a foreign flag. Also,

[10] Percentages based on gross register tonnage.

[11] The German GIS registry for example operates 76% of the German fleet (European Parliament 2000).

countries of the global South and countries in transition are increasingly using foreign flags for their shipping fleet in order to lower the costs, in particular with regard to crew hires.

b) Control of emissions

The UNCLOS is the primary legal text that sets the national and international jurisdictions for regulating internationally travelling ocean ships (Article 21). One important character of the UNCLOS is the dominance of international law over national law (BMT 2000). Above all, the UNCLOS aims to balance the interests of the international community, including balancing the use of resources, free trade and the protection of coastal states from negative environmental effects. Air-borne emissions are dealt with specifically in paragraphs 212 and 222. The pollution of the atmosphere by emissions from ships is explicitly named in those two paragraphs, whereas emissions are otherwise referred to as "discharges" into the marine environment, which may not necessarily refer to airborne emissions at all (See for example paragraph 194, 3(b); 211, 5(c); and 221). The dominance of international law over national law is reflected in the dedication of "competent international organization(s) or international conference" that solely owns the authority to set certain technical standards.

The IMO identifies itself as the responsible competent organization that has the right to establish the generally agreed rules and standards, although the IMO is only mentioned once directly in UNCLOS Annex VIII (IMO 2005a). This self-identification has been confirmed in most reports and analysis on the international shipping industry (e.g. Pisani 2002, Entec 2005). However, the UNCLOS interestingly refers to the competent international organizations in paragraph 212 and 222, which deal explicitly with air pollution, in plural. It can be concluded that other international organizations than the IMO might as well take the role of the competent international organization under the UNCLOS, in particular in regards to air-borne pollutants. UNCLOS remains often vague. (for a discussion of this, see BMT 2005, Annex 4, paragraph 76). The question of authority should at least be handled flexibly and with the best options for achieving results by the states that are represented in the IMO in mind.

The UNCLOS also identifies rights and duties of states to set laws and regulations for the protection of the oceans, besides identifying the jurisdiction to set technical standards on ships. Greenhouse gas reduction measures under the auspice of the UNFCCC and other national laws can certainly conform to the UNCLOS mandate. The German Advisory Council on Global Change concludes that national financial instruments do not conflict with UNCLOS or the world trade law (WBGU 2002).

The UNCLOS differentiates between flag states (flag state control – FSC), port states (port states control – PSC), and coastal states (coast states control – CSC) in the context of different responsibilities and authoritites.

The **flag state control** is the central instrument for the implementation of minimum environmental standards that travel with the ship, including the necessary certification and monitoring systems. The flag states have the obligation of implementing and complying with these standards.

The **port state control** is an instrument to complement the flag state control and to prevent ship safety and environmental standards not being implemented by flag states. The PSC is based on the sovereign right of each state to deny the entrance of ships to their ports, based for example on safety or environmental reasons The PSC also gives port states the possibility to monitor compliance with the technical standards, called construction, design, equipment and manning (CDEM) standards.

CDEM standards are binding technical standards that travel with the ship (for example the IBC code for the construction and equipment of ships carrying dangerous goods). The UNCLOS excludes states from further regulating CDEM standards except when they are expanded by generally accepted international rules or standards (GAIRAS) (UNCLOS Article 21, 2). GAIRAS are little defined. In the field of environmental protection, the International Convention for the Prevention of Pollution from Ships of 1973/1978 (MARPOL 73/78) is gnerally accepted as the agreed to GAIRAS (see also Chapter 2.1.3, p. 17).

The **coastal state control** is a very limited regime for implementing environmental measures. Ships have the right of innocent passage through the waters of the exclusive economic zones (EEZs)[12]. Although countries have the right to establish rules for the protection of the marine environment and enforce them in their territorial waters and potentially EEZs, the UNCLOS limits those rules to GAIRAS standards that are established by the IMO or other international conferences. EEZs exist in Europe in Denmark, Germany, France (Atlantic) Portugal and Spain (Atlantic).

The national jurisdiction of coastal states fully applies in the territorial waters, which covers the coastal zone of 12 nautical miles (~22 km) from the middle tide. However, with reference to CDEM and GAIRAS standards, the UNCLOS even sets limits here as to what additional standards can be set. This applies in particular as long as national rules would require permanent technical changes onboard ships.

The port state control regime and to some extend the coastal state control regime however gives nation states and supra-national organizations room to regulate shipping beyond the CDEM and GAIRAS.

Rules and standards that are adopted by the IMO and international conferences are seen as GAIRAS for ships (in particular MARPOL 73/78), expanding on CDEM, and are thus the maximum demandable standards that are enforceable by states. However, one exception is measures that cannot be defined as CDEM standards (e.g. fuel-related measures and standards) because they do not interfere with either the construction, design, equipment, or manning on ships. The European Union adopted its more stringent directive on the sulphur content in marine fuels on the basis that this fuel-based directive will not interfere with CDEM standards (EC 2005). The lower sulphur content in marine bunker fuels usually do not require any engineering changes on the ships. Thus, the European Union has the jurisdiction to set more stringent standards for the use of bunker fuels within their waters, based on this interpretation (BMT 2000, p. 15).

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[12] Defined in general as 200 nautical miles from the coastline of the middle tide.

Furthermore, national or supra-national standards, even technical standards, can be set in areas in which comparable international standards, that may constitute GAIRAS, do not exist. This is for example the case with regard to greenhouse gas emissions. Today there is no GAIRAS, for example in the form of an MARPOL Annex, that would control, monitor or regulate greenhouse gas emissions from ships.

Nation states seemingly also can set emission limits for ships calling at their ports or even traveling in territorial waters as long as no they do not prescribe specific technical standards. Nonetheless, national regulations on air emissions that are governed by the MARPOL Annex VI would likely overstep the jurisdiction of nation states and supra-national organizations. "The Member States have clearly not been concerned that any of these instruments raise any significant issues about external competence. It might be otherwise, however, with a directive which clearly goes beyond IMO standards established in MARPOL Annex VI" (BMT 2000, Annex 4, paragraph 425). A careful and cooperative approach is thus highly recommended.[13]

A national or supra-national policy measure based on emission limits can be for example financial instruments that are in conformity with the international trade law.[14] For example, in order to avoid the potential interpretation of a financial instrument as a hidden monetary tariff, it cannot be pegged on the country of origin or on specific goods directly (Meyer-Ohlendorf 2003).

A state needs to carefully establish the system boundaries and framework when implementing financial instruments such as fees, also to avoid setting illegal taxes. Taxes on fuel in international and inner-European traffic are currently not permitted (Article 14(1) b&c, EC 2003). Furthermore, the implementation of fees on shipping fuels is not permitted if an inseparable relationship between the fee and the fuel consumption has been established (dispensation of the European court on the prohibited taxes of aircraft and shipping fuels, referred to after Meyer-Ohlendorf 2003). This may be the case for CO_2-related fees. According to Meyer-Ohlendorf (2003) fees based on parameters such as distance or time can be considered as long as those are categorized and do not thus correspond with a direct distance or fuel consumption for a particular trade.

In general, states need to make sure that financial instruments adhere to international, European and national laws. This may lead to complicated legal constructs in practise. Meyer-Ohlendorf (2005) expands on these levels of law:

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13 "We are not suggesting that this will necessarily result in their opposing the measure, given the environmental concerns in particular of Northern Member States, although the issue might be invoked by opponents of strong Community measures. We do suggest, however, that it is a strong reason for early invocation of a Member States government experts' group and for overt adherence by the Commission to the principle of minimum harmonisation. This would send the message that the Commission is not seeking to extend the Community's competence as it were 'through the back door', nor to displace Member States' autonomy in the IMO, and that it accepts that the matter is one of mixed competence, requiring a partnership approach." (BMT (2000) Appendix 4, Paragraph 425).

14 The international freight transport is covered by the General Agreement on Tariffs and Trade (GATT) and the principles of the World Trade Organization (WTO).

- According to European law, financial instruments must be limited to national territory. However, evaluation parameters for establishing the financial burden can refer to international data, for example distance categories related to the travel of a ship.
- According to German law, setting fees on the use of ports is prohibited if no service is offered in return. Port fees in Germany are service-based fees and must remain in relation to the services offered. A fee on freight may face a similar challenge in national law.
- In addition, the national tax laws apply. Here the German tax law recognizes special charges, taxes and fees that benefit the group posed with these charges.

In summary, the most important environmental standards for international shipping are the MARPOL standards, which are especially based on the UNCLOS and are established by the IMO and its conferences. The MARPOL standards are considered GAIRAS that specify the CDEM codes. GAIRAS must be implemented by all flag states even those that have not signed MARPOL conventions due to the binding character of the UNCLOS. The IMO has also established special zones through MARPOL in which more stringent international GAIRAS standards are possible. Those currently focus on sulphur and nitrogen oxides. Coastal states are on the other hand limited to non-CDEM measures, for example for air pollutants where no such CDEM standards exist.

According to BMT (2000), it is likely that national PSC and CSC measures that go far beyond internationally agreed standards face resistance by the international stakeholders. This can be especially expected with regard to those measures that may influence CDEM standards that require permanent technical changes onboard ships. The legal frame under UNCLOS is drafted vaguely and leaves much room for interpretation. The UNCLOS certainly leaves room, for financial instruments, such as differentiated port dues and fairway dues. Furthermore, there is leeway for non-CDEM standards, such as emission standards with no direct relationship to specific existing technical measures or measures where no such CDEM or GAIRAS exist. The latter applies to emissions of greenhouse gases. Moreover, the reduction of greenhouse gas emissions from ships fully conforms to the goal of UNCLOS to protect the oceans and the coasts, which simplifies the development of measures.

2.1.2 The International Maritime Organization

The International Maritime Organization (IMO) was established as a convention by the United Nations in 1948 and entered into force in 1958. Today, 167 member states (representing about 98% of the global shipping tonnage) are represented in the IMO. The original focus of the IMO has been safety of international shipping traffic, in particular the surveillance and development of already existing conventions, such as the Convention for Safety of Life on the Sea of 1948. However, environmental topics, in particular those related to oil transport, were included from the beginning of the organization.[15] The IMO focuses to date on safety and environmental questions.

The authority of the IMO is exercised by the General Assembly of its 167 member states and 3 associate members (the Faroe Islands, Hong Kong and Macau) that meets every other year. The General Assembly transferes the authority in between conferences to an elected council with 32 members.

The IMO is a technical organization and the bulk of its work is conducted in committees. Currently active committees are the marine safety committee (MSC), the marine environmental protection committee (MEPC), the legal committee (LC) and the technical cooperation committee (TCC). The MEPC plays a special role in regard to environmental conventions, codes and standards. Proposals on changes to an existing convention or for new conventions have to first be passed by the specific technical committees.

The work in the technical committees is conducted by representatives of member states and by representatives of non-governmental organizations. The committees draw up drafts and proposals for conventions and standards that are then presented to the Council or the General Assembly. The latter can both authorize further steps on the drafts and proposals.

The formal adoption of a convention requires a conference of the parties. This conference is initiated by the General Assembly or the Council, who invites all member states of the United Nations to this conference, even those that have not signed the IMO convention. All governments have one vote in those conferences. Other representatives of UN organizations as well as of non-governmental organizations take part with an observer status. Member states and all other invited parties have the opportunity to submit comments and suggestions for changes to the proposals. A simple majority is then sufficient for the adoption of a convention.

In order for a convention to become a binding rule, it must be ratified by the member states and must fulfil certain criteria of ratification. The criteria differ case by case, but are generally more stringent, the further reaching a convention is. The criteria are usually a minimum number of ratifying states plus a minimum percentage of the global world tonnage represented by the ratifying states. Conventions are then binding to all states who sign them.

The necessity to sign a convention in order for it to apply to that state explains the importance of negotiation before it enters into force. This is because in order to achieve support from sufficient numbers of critical states, such as flag states, ship owning states and other states with important stakes in marine issues. Conventions that are only signed by a few relevant states would not be able to fulfil their goals. However, the implementation of a convention can therefore take many years.

[15] The first convention on the protection of the marine environment from oil spills entered into force in 1954, thus before the IMO did.

Changes to existing conventions can be implemented more easily. The IMO applies a method known as the tacit acceptance for any changes to existing conventions. Changes thereby enter into force after a set time frame if no minimum number of member states had filed their concerns. This instrument of tacit acceptance is a key instrument for adapting existing conventions to changed technical and political circumstances in a timely and efficient manner.

2.1.3 Environmental protection rules under MARPOL

In 1973, the IMO adopted a pollution prevention regime that did not achieve ratification from the states and only entered into force in 1978 after several changes. The "Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships from 1973 – MARPOL 73/78" sets rules for emissions from ships in the marine environment. MARPOL 73/78 represents the current status of GAIRAS and defines CDEM standards. It is primarily flag states that are obliged to implement the MARPOL standards. As described in Chapter 2.1.1 (p. 12), the UNCLOS also permits port states and coastal states to demand related standards, monitor ships and deny berthing if those standards are violated by ships.

There are six annexes to the MARPOL convention:

- Annex I: Prevention of pollution by oil;
- Annex II: Control of pollution by noxious liquid substances;
- Annex III: Prevention of pollution by harmful substances in packaged form;
- Annex IV: Prevention of pollution by sewage from ships;
- Annex V: Prevention of pollution by garbage from ships; and
- Annex VI: Prevention of air pollution from ships.

Compliance with Annex I and II is mandatory for all states, whereas the signature and ratification of any of the other Annexes remains voluntary.[16] Annex VI on air pollution from ships was adopted in 1997 by the General Assembly and entered into force on 19 May 2005, eight years after it had been adopted. If the Annex VI were to be changed, the IMO would satisfy the procedures with a tacit acceptance protocol. Changes to the annexes can be administered through the commissions or through conferences of the parties.

Annex VI is the protocol relevant to air pollution from ships. However, greenhouse gas emissions are not covered in Annex VI. Annex VI covers nitrogen oxides (NO_x), sulphur oxides (SOx) and ozone depleting substances. The NO_x thresholds set by Annex VI are generally seen as lax and it is fair to say that they prescribed the technical status quo of the 1990s. However, due to its commencement, Annex VI now opens up the opportunity for a swifter implementation of changes. Annex VI also includes the option of installing special zones for reducing sulphuric acid emissions and for implementing more stringent sulphur standards on marine bunker fuel, so-called sulphur emission con-

[16] As a consequence, the PSC enforcement regime might be limited for non-signatory states.

trol areas (SECA). The Baltic Sea and the North Sea (as of 22 November 2007) are two such special areas.

3. Regulatory Activity concerning Greenhouse Gas Emissions in International Ocean Transport

3.1 The IMO activities in relation to greenhouse gas emissions

In an amendment adopted in 1998, the Kyoto Protocol hands the responsibility for reducing emissions from international marine and air transport to the Annex I states of the protocol. This addition to the protocol emerged because states could not agree upon an allocation scheme for emissions from international marine and air transport. States were asked to work through the IMO and the international aviation commission in order to coordinate efforts for emission reductions (UNFCCC 1998).

In November 2003 the IMO adopted the resolution A.963(23) for working on greenhouse gases issues. In this way, the IMO reacts to the demands of the UNFCCC and the Kyoto Protocol on the Annex I states with regard to the minimization of emissions from international ocean transport by implementing measures through the IMO.

The resolution A.963(23) refers to the UNCLOS: "In accordance with Article 212 of the United Nations Convention on the Law of the Sea, 1982 (UNCLOS), resolution A.719(17) invited the Marine Environment Protection Committee (MEPC) to develop legally binding measures to reduce air pollution from ships through the preparation of a new Annex to the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78)".

The reference to Article 212 of UNCLOS is of interest, because this paragraph also contains some room for interpretation in regard to the authorities of nation states in their territorial waters and for the use of ports (BMT 2000). This is especially the case if the IMO is unable to adopt MARPOL Annexes that target the reduction of greenhouse gases. This means that the room for nation states to act might today be larger than when the IMO takes on the task of greenhouse gases in a new technical MARPOL Annex, which are likely to represent CDEM or GAIRAS standards.

The resolution A.963(23) demands that the Marine Environmental Protection Committee (MEPC) of the IMO takes concrete steps to reducing the emissions from greenhouse gases of ships. It specifically refers to the following tasks:

- The setting of a greenhouse gas emission baseline;
- The development of a methodology for monitoring and reporting greenhouse gas efficiencies of ships in the form of a greenhouse gas index;
- The development of guidelines for how such a greenhouse gas index can be implemented;
- The evaluation of technical, operational and market-based measures to reduce greenhouse gases from ships.

The activities of the IMO seem to focus on the greenhouse gas index (GHG Index) and the aim to set a greenhouse gas baseline. Negotiations on the other topics are not making headway. The goal of the guidelines for the GHG Index is a standardized approach in order to test such an index in practice. The index should make it easy for shipping companies and ship operators to calculate the greenhouse gas efficiency of their vessels. The proposed methodology suggests the calculation of greenhouse gas efficiencies in relation to the transport work per ship and per time frame. The normalization unit can be chosen individually (e.g. tonne, cubic meter, container unit etc.) and a default conversion between container and tonnage is recommended. It is expected that average efficiency will be reported for one year for existing ships and for six months for new ships.

The IMO fails to follow up on the demands put forward by the resolution A.963(23), except for the work on the GHG Index. Therefore, it can be concluded that there is currently no internationally agreed standard in accordance with UNCLOS for the control and minimization of greenhouse gases from ships. A potential integration of greenhouse gases in a MARPOL 73/78 Annex seems to be far off. Consequently, nation states and supra-national organizations, unilaterally or multi-laterally, can adopt rules and standards on greenhouse gas emissions from ships in order to protect the marine environment in accordance with the UNCLOS provisions.

Conclusion:

- The development of internationally accepted rules and standards by the IMO is a slow process.
- Potential emission limits are often set on the smallest common denominator.
- No binding technical standard (CDEM or GAIRAS) currently exist in regard to greenhouse gas emissions from ships. The IMO has failed to fulfil the demands of the international community of states in this respect.

4 International Trade and the Economic Character of International Ocean Transport

The transport of freight is the dominant transport activity in the context of international ocean transport, unlike in the aviation industry. The share of passenger ships and ferries in the global fleet is only 0.6% (UNCTAD 2005). The following analysis will therefore focus on freight transport. However, the strategies that will be developed later can nonetheless be transferred to other ships such as ferries. Only cruise ships may run in different patterns and methodological adjustments may need to be implemented.

It is important that the international trade patterns and transport dynamics be understood when the implementation of effective greenhouse gas reduction mechanisms is attempted. This analysis will provide some background information, although a comprehensive analysis would exceed the scope of the report. Some facts are interesting to consider in the comprehension of global transport dynamics:

- About 90% of the global trade is handled by vessels (IMO 2005);
- International ship traffic has trebled since 1970, from 10 trillion tonne-kilometers to nearly 28 trillion tonne-kilometers (UNCTAD 2005);
- World trade increased from 1980 to 1999 by 12% per year by value, while the costs of marine freight transport rose only by 7% in the same period. The consequence is falling transport costs per transport unit (MISS 2006);
- Freight costs for importing firms are - at 6% - average, based on the value of the goods (UNCTAD 2003)[17];
- Semi-product and consumer product transport with containerships has in particular seen large growth figures in the last years.

The increase in international, and in particular of the inter-continental trade, is foremost an expression of global production networks. Transnational corporations (TNCs), in particular in the clothing, electronics and automotive sectors, have segmented significant parts of their production and moved it overseas in order to benefit from local production and cost advantages. This outsourcing was in part possible because of easier access to foreign localities, better communications and low transportation costs. These global production networks are often described as economic globalization.

The liberalization of markets in the 1990s in particular enabled the expansion of TNC to international production networks, which led to growth in financial and goods traffic that continues to today. Production, division of labor and material flows, in particular in the branches above, are truly 'global', because production in peripheral nations offers significant competitive cost advantages compared to countries of the North. The market and cost advantages are mostly rooted in lower wages, but also fewer external "services" that are common to countries of the North societies (e.g. social insurances, infrastructure, environmental conditions etc.) The expansion of global production networks is thus an externalisation of costs for corporate players in order to improve the return on investment and the market positions. The resulting trade traffic is one element of this expansion of production networks. The indirectly caused greenhouse gas emissions (not caused by production itself) are therefore examples of the externalization of costs and negative environmental effects.

The trade of consumer goods and services continues to be concentrated between the countries of the North and some countries in transition, mostly those in south east Asia. Moreover, a significant share of international trade is intra-corporate trade. About 30% of the global trade is intra-corporate trade, which has experienced growth rates of 40% in the last 25 years. Another third of the global trade is trade between corporations (UNCTAD 2002, Achcar, G. et. al. 2003). This may lead to continuous trade traffic even if no further increase in consumption would occur, because raw, semi-finished and finished goods may switch its production site on multiple occasions before it reaches the end consumer.

Financial import and export balances are often deceptive, in particular for countries such as Germany, which occupied the first position statistically for exports in 2005

[17] Relative freight costs per import value of goods vary and are significantly higher for poor countries than for countries of the North.

based on export values, and the second position in terms of imports (WTO 2006). Far more raw materials, semi-finished and finished goods likely originate in countries with cost-effective production structures than import statistics might suggest. Goods with the label "made in Germany" may have led to a rapid increase in transport movements than the last shipment as finished goods implies (Sinn 2004). There is currently no transparency to enable end consumers to access information on, for example, the CO_2 intensity of products and services. The following aspects are to the fore when considering global economies in the context of greenhouse gas emissions:

- Both the outsourcing of production and the increased international trade are classical examples of the externalization of production costs;
- Industrial production often moves to countries that are unable to enforce strict environmental standards. It can be assumed that the use of cheap energy sources and the lack of environmental law enforcement contribute to the competitiveness of countries of the global South.
- The increasing global expansion of production networks leads to higher transport volumes without necessarily creating value.
- A share of the greenhouse gas reductions in countries of the North must be attributed to the relocation of industries to other countries.

The following development of strategies (Part II) takes these aspects of international trade into account. The locality in which greenhouse gases are emitted is insignificant in the main. Both greenhouse gas emissions and their effects are global and reductions from, in particular, emerging economies would be important. Countries of the global South often use the need for economic development in their countries as the reason for abstaining from strong greenhouse gas reduction obligations. However, it could be argued that economic development in recent years has only regionally led to sustained economic development (see for example discussions in Altvater, Mahnkopf 1996; Annan 2002; Cavanagh et. al. 2002; Chasek 2000 und Sachs 2002). Therefore, the contention that international trade must be expanded in any case in order to promote economic development in countries of the global South cannot, therefore, be regarded as valid.

On the contrary, one indicator of today's economic globalization is that the value added to exports from the North by far exceeds the value of exports from the global South. The increase in exports from the global South has therefore contributed less to a technology transfer and to economic growth. "In fact, the increased import content of domestic production and consumption brought about by rapid trade liberalization, (...) implies that such increases in the manufacturing exports of developing countries may have taken place without commensurate increases in income and value added“ (UNCTAD 2002, p. 77).

Development and technology transfer to the global South might specifically not happen under a 'business as usual' scenario. The important question to ask is how global economic space could be managed in such a way that environmental and climate protection would have priority and at the same time the global South would profit from international trade. A greenhouse gas reduction regime and the connected CDM measures might offer opportunities for internalizing production costs and promoting sustained economic development in the global South.

Conclusion:

- The increased global trade indicates the externalization of production costs of today.
- Over proportional increases in the greenhouse gas emissions from freight transport are a direct result of spatially expanding international production networks.
- While these expansions contribute to greenhouse gas reductions in the North, it has led to insufficient economic development of the global South.
- Over proportionally increasing global trade is a greenhouse gas flight that should be limited as long as this flight “promote[s] a supportive and open international economic system that would lead to sustainable economic growth and development in all Parties" (UNFCCC Article 3).
- A greenhouse gas regime in a positive sense should internalize the environmental costs, should make them visible to the users and consumers and should promote economic development, including the transfer of technology and infrastructure, especially in the global South.

In this context, it is also important to highlight the overall marginal costs of transport with regard to the prices of goods. According to the International Chamber of Shipping, the costs for transport have increased by 70% in the last 50 years and those of consumer goods by over 700% in the same time period (data based on the USA). This means that the relative costs of transport are approximately ¼ that of the transport costs 50 years ago. Several examples of different cargo and goods will make the marginal share of transport in the final prices apparent (Table 1). Therefore, even a significant increase in transport costs is likely to have no or only scant damping effect on international trade.

Table 1: Marine transportation costs in comparison with the value of goods

Cargo	Unit or value of cargo	Cost of marine transport in US $
Gasoline in the USA from Middle East crude oil	1 Liter ~ $0,80	<$0,01
1 tonne steel from Australia to Europe		$ 10
Television	$ 700	$ 10
DVD/CD player	$ 200	$ 1,50
Vacuum cleaner	$ 150	$ 1,00
1 bottle of whisky	$ 50	$ 0,15
1 kg of coffee	$ 15	$ 0,15
1 can of beer	$ 1,00	$ 0,01

Source: MISS (2005)

Higher transport costs do not seem to be of concern with regard to the shipping industry, as long as the conditions that lead to higher costs would apply to everyone, producing a level playing field.[18] From this perspective, the industry viewpoint that environmental regulations must be introduced by the IMO makes sense. The low transport costs in relation to the costs of goods also emphasizes that price increases are not likely to have a damping effect on the global economy. However, it should be noted that some corrective measures in the direction of a more balanced global economy could be have a stabilizing effect on the global market (see for example the German journal "Kapital" of 26 November 2006). Moreover, the balancing of trade would be also beneficial for the transportation industry, because the utilization of ships would increase.

5. Potentials for Reducing Greenhouse Gas Emissions from Ships

International ocean shipping is - in comparison with other modes of transport - a relatively energy efficient mode of transport, based on freight unit-distance. The level of greenhouse gas emissions is nonetheless similar to the emissions of countries such as France. Freight transport will, more importantly, continue to grow as a result of the increasing globalization of production networks and represents the externalization of environmental costs.

The goal of this section is to examine some key aspects of the fuel consumption in international ocean transport that may provide insights into how greenhouse gas emissions from ships could be reduced.

5.1 Engineering and Technical Measures

5.1.1 Conflicts of goals and interests

Ship engines are optimized for energy efficiency. This feature originates in the oil crisis of the 1970s and the lack of air emission regulations before the MARPOL Annex VI entered into force in 2000. The development of ship engines focused on high extraction efficiency of energy from the qualitatively poor marine bunker fuels [19]

The marine bunker fuels are divided into secondary fuels (residual fuels) and primary fuels (distillate fuels). The residual fraction accumulates pollutants from crude oil, which are unwanted in the distillate fraction. For example, the increasing demand of low-sulphur distillate fuels leads to an increase of sulphur content in the residual fraction. Ship engine emissions therefore contain a relatively large amount of pollutants, from diesel particles, acids (e.g. nitrogen oxides, sulphur oxides), and heavy metals to toxic aromatic compounds. The high concentration of pollutants causes high emission

[18] Shipping companies see themselves more and more under public pressure (for example on the California south coast; see also different CSR reports) and have reacted with voluntary initiatives. (see for example Wallenius Wilhelmsen in the case of cleaner burning fuels) Those voluntary initiatives have indeed the potential to harm the competitiveness of corporations.

[19] The past couple of years have indicated a reversal of this trend to some degree. However, to date ship engine manufactures continue to describe their customer demands as mostly related to fuel efficiency.

levels, especially in port cities and specific regions, for example in southern California and the Baltic Region. Many regions are now considering more stringent regulations and financial instruments in order to promote engine after treatment technologies and cleaner burning fuels. Applying emission control technologies often lead to a reduction in fuel efficiency, because a share of the energy is used to clean the exhaust gases. [20]

This contradiction should not result in abstaining from greenhouse gas emission reductions. However, often too little attention is paid to this potential conflict of interest. If, due to welcome regulations of emissions from ships, the energy efficiency of ships were to decline, the measures to reduce greenhouse gas emissions would become more important.

5.1.2 Engines: technologies and engineering visions

The dominant engine in large ocean going vessels is the diesel engine. Some ships are propelled by steam turbines and gas turbines.[21] The study on greenhouse gas emissions from ships, published by the IMO in 2000, represents the basis to data and provides important data for technology assessments (IMO 2000). The measures described in this report shall not be repeated in great detail. Table 2 provides an overview of the presented measures and their potentials to reduce greenhouse gases.

Table 2: Emission reduction measures and their potential for greenhouse gas reductions. Source IMO (2000)

Measure	**Percent reduction in terms of fuel consumption**
Improvement of hull design at new ships	5 – 20 %
Improved propellers	5 – 10 %
Hull maintenance, in particular 'anti-fouling'	3 – 5 %
Propeller maintenance	1 – 3 %
Efficiency optimization at new engines	10 – 12 %
Innovative propulsion systems	5 %
Electronic injection	2 – 3 %
Switch from HFO to MDO bunker fuels	4 – 5 %
High pressure fuel injection	1 – 2 %
Improved turbo charger	5 – 7 %

Some of these measures can only be implemented with newly built ships. This makes their introduction a slow proposition due to the regular life time of ships being between

[20] This is not the case with regard to the use of distillate versus residual fuels. Distillate fuels are more energy efficient because of their higher energy density and they burn cleaner, in particular in regard to particulate matter.

[21] Diesel electric propulsion systems are becoming more prevalent in the category of cruise ships. Military vessels may run on nuclear fuels.

20 and 30 years. Other measures can be implemented as retrofits on existing ships or represent ongoing management-related measures.

The list published by the IMO is an optimistic assessment of the potentials for greenhouse gas reductions. The necessary reduction of other pollutants may lead to an increase in fuel consumption. Furthermore, many of the measures described above are already in place for business reasons (see for example Hanjin 2005, K-Line 2006, Maersk Line 2006, NYK Line 2006).

However, in the area of innovative technologies, there are some promising technologies that have mostly not been put on the market due to their high costs. These technology innovations include innovative ruder and propeller systems (such as the Azipod propulsion system), diesel-electric systems, co-shaft-generators[22], wind power support (for example SkySail) and other alternative energy sources. The car carrier logistics company Wallenius Wilhelmsen presented a concept study to the public that would operate without fossil fuels once realized at the world exhibit in Tokyo in 2005. The vessel, which is intended to carry 10,000 cars, is supposed to be powered by a combination of solar, wind, and wave power, although hydrogen will be used as an energy storage. The engines will be electric propulsion systems (Wallenius-Wilhelmsen 2005).

The partially high investment costs of those innovative technologies in light of the low marine bunker prices prevent their economic introduction. Marine residual fuels are sold well below the price for crude oil. Even if the introduction of such technologies could be easily absorbed by consumer prices, the price difference to conventional fuels would make their introduction on any voluntary basis nearly impossible. Environmental measures that will result in significant increases in service prices must be implemented in a mandatory fashion, applicable to all, or large homogenous groups.

5.2 Operative measures

Operative measures can be categorized in logistics and ship management.

Logistics

Logistics is a logical field in which to search for possible operative improvements in the marine transport chains. Some parameters will highlight this. Marine shipping greenhouse gas emissions stem mostly from the transport of freight, when transporting freight units over a certain distance. As with other modes of transport, the utilization of the vehicle plays a major role in determining the emissions per transported unit-distance. The following figures should highlight a few of the other aspects as to how logistics may influence greenhouse gas emissions:

- Petroleum products have a relatively static demand side. Together with storekeeping this enables the long-term planning of petroleum transport. Thus:
  - Tankers are scheduled on a long-term horizon and travel at relatively slow

[22] Shaft co-generation had been deemed infeasible with an amortization of 5 – 10 years at low fuel costs of the 1990s. The recent fuel price hikes have made this technology likely to be amortized with in a couple of years. Maersk announced in February the implementation of shaft generators in order to reduce the greenhouse gas emissions from their ships (personal communication MAN, Maersk 2007)

speeds.
  - Tankers are mostly empty in one direction.
- Consumer goods are more subject to trends and alternating demands. The demand for them occurs, therefore, on a short-term basis.
  - The movement from design, to production and sales is often only a matter of weeks. A prime example is the clothing industry.
  - Consumer goods manufacturer are using the transport chain as an extended warehouse and expect a just-in-time delivery.
  - Flexible production satisfies specific customer demands and creates stringent time requirements for freight transport.
- There is an imbalance with regard to the trade lanes between Europe, North America, countries in transition and the global South.
  - Ships are not fully utilized on many routes.
  - Refrigerated cargo vessels are often not utilized on return trips in tropical regions.
  - Many bulk carriers (oil, steel, coal etc.) are only filled in one direction.
  - The Asia–USA trade is an extremely unbalanced consumer goods trade.

Therefore, a better utilization is an efficient measure for reducing greenhouse gas emissions based on transport demand. Increases in utilization can mean CO_2 reductions of percentages of several dozen (see example below). The emission reduction will only occur if the transport activities are being reduced.

Example 1: Emission reduction through better utilization

Container ship Asia – Europe, 80% real utilization;
Europe – Asia, 40% real utilization

*CO_2 emissions = 100 units/(transport km*nominal freight)*
Import (Asia – Europe) = 125 units
Export (Europe – Asia) = 250 units
Combined = 167 units
If the export route achieves a utilization of 80%, the CO_2 emissions would be reduced by 50%, or by 25% when taking the return trip into account.

The logistics industry and the international marine transport industry has been an international business for a long time, which is subject to strong price pressures. As described above, low transport costs together with open boundaries and improved communications lead in the main to the expansion of production networks and thus to the externalization of environmental costs. The freight purchasers are therefore causally integrated in today's situation and the increasing transport demands in the shipping and aviation freight sector.

Ship management

The study by the IMO (2000) also provides a good overview of measures in the field of ship management. *Table 3* summarizes these measures and their reduction potentials.

Similarly to the technical measures, this view must be described as optimistic, because many of those practices are also already in place (see Hanjin 2005, K-Line 2006, Maersk Line 2006, NYK Line 2006).

The ship velocity and the ship size are the most important parameters for improving the ship performance per transport work, besides ship utilization. The container shipping industry tends towards larger ships that generally have a better energy usage per transport unit. On the other hand, increases in speed, another trend in the container industry, affects the fuel consumption in a negative cubic relationship. The trend to larger ships is furthermore limited by infrastructure and large ships may increasingly lead to rather energy inefficient hub and spoke systems.

Table 3: Emission reduction potentials of operative ship measures

Measure	**Percent reduction in terms of fuel consumption**
Improved fleet planning and utilization	5 – 40 %
"just in time" route planning	1 – 5 %
Weather routing	2 – 4 %
Constant engine return per minutes	0 – 2 %
Optimum trim and minimum ballast	0 – 2 %
Optimum propeller and rudder positions	0 – 2,3 %
Reduced time in ports, better cargo handling	1 – 7 %

Source: IMO (2000)

The degree to which velocity influences greenhouse gas emissions indicates the comparison between tanker and container ships (Table 4*).*

Table 4: Technical data of tankers and container ships

Ship type	Petroleum Tanker	Container ship
Relationship of total versus empty weight	~ 6	~ 2.5 – 3
Mean operational speed	12 – 16 knots	14 – 26 knots
Engine power per dead weight ton (freight plus crew and support)	~0.3 – 0.1 kW/dwt	~0.6 – 0.5 kW/dwt

Sources: MAN (2001); Vinnova 2004

The engine power of tankers is thus less than one half of the engine power of container ships, while the corresponding speed is only 15% - 35% less. This increase in fuel consumption in a cubic manner is caused by hydro-dynamic forces, because when the speed increases, so does the share of energy lost in wave energy (MAN 2001). The necessary energy input for a certain speed is described in the following formula (PANYNJ 2003).

$$\text{Energy input}_V = 0.1 + (0.7 * (\text{velocity } V / \text{nominal cruise speed } VR)^3) * \text{nominal engine power MCR}$$

The assumption is that a 10% engine power is the minimum power for safety and that the regular cruise speed is usually reached at about 80% maximum engine rating.

However, it is important that transportation be viewed as a system. If it were assumed that only as many ships travelled today in the oceans as would be necessary to fulfil the transport demand, additional ships would need to be engaged if today’s ships were to slow down. Large emission reductions can only be achieved if cargo handling and transport on land to the end consumers is made more effective and quicker, with regard to the whole transport chain from point A to point B. Then the transport speed of ships could be reduced by keeping the same transport capacity of the entire chain. Otherwise, the possible emission reduction gain using slow speed shipping is merely 10%, because of the reduction of transport capacity. An energetically optimum engine load is between about 30% – 50% of the maximum engine rating, which corresponds to about 65% - 83% of the maximum speed. This might, however, not be the optimum engine load in regard to other pollutants, such as diesel particulates and nitrogen oxides.

Other measures under ship management, including weather routing, ship monitoring in real time, constant engine monitoring and management and others are described elsewhere (IMO 2000). Many of those measures are already industry standard in companies which have good environmental management practices.

Conclusion:

- The absolute greenhouse gas emissions are relevant for combating climate change. Some measures in the ocean shipping industry focus on energy efficiency, thus relative emission reductions.
- Short term and real emission reductions through technical and operational measures are very limited and often current practice. Technology innovations take a long introductory time due to the long lifetime of ships.
- High cost short-term options, such as switching from HFO to MDO, can only be mandated industry wide.
- The largest potential of relative greenhouse gas reductions stems from logistics measures, in particular better utilizations and slower speeds.
- Far reaching technical greenhouse gas emission reductions are possible but only on a long-term basis. Those technical options include better hull design, engine optimizations, and the use of alternative energies such as wind energy in combination with hydrogen energy storage. The introduction of these technologies can be fostered through mandatory emission limits.