All at sea

A paper by the Institute for European Environmental Policy

for

Friends of the Earth

1 September 2006

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1 INTRODUCTION

This paper has been prepared by the Institute for European Environmental Policy (IEEP) for Friends of the Earth. It is intended to inform their response to the Department for Transport's ongoing Ports Review process.

The rationale for the work is the perceived lack of consideration given to the impact of expanding ports capacity on greenhouse gas emissions from shipping, and the associated landside traffic that it will generate. Also of concern is the lack of attention given to addressing greenhouse gas emissions from the shipping sector at the present time. The scope of this paper is therefore to provide:

- A review of the current policy framework for ports and shipping policy to set the context of the ports review and the consideration of shipping as part of wider government policy on climate change;

- An assessment of the scale and relative importance, currently and in future years, of the trends in shipping traffic and corresponding carbon dioxide (CO_2) emissions from the shipping sector; and

- An indication of the technical, operational and policy measures available that could be used to reduce CO_2 emissions from the sector and the likely scale of reductions feasible.

2 MARINE TRANSPORT: POLICY FRAMEWORK AND THE PORTS REVIEW

2.1 Policy Overview

2.1.1 UK Policy

Ports and shipping policy has traditionally been of the laissez-faire school owing largely to the fact that UK ports and the shipping industry are owned for the most part by the private sector. The trend during the latter part of the last century was of deregulation of ports industries, with the intention that they would become responsive to the market. The most recent major policy initiative in the UK came in 2000 when the Government launched the white paper '*Modern ports: A UK policy*'. The aim of the white paper was to take a more coordinated approach to ports policy ensuring approaches to regulation, standards and training were coordinated nationally. In addition it emphasised the need:

> "to maintain a balanced policy on development which aims to make the best use of existing and former operational land, secures high environmental standards, but supports sustainable projects for which there is a clear need."

Ports development is largely where government has its greatest influence on the industry, be that at national, regional or local levels in terms of planning strategies; the management and provision of connecting infrastructure (road and rail) and through grant programmes.

2.1.2 EU Policy

At the EU level, three strands of policy have developed in terms of shipping; the first concerns the regulation of fuel quality standards for sulphur content, the second is the promotion of the use of shipping as a transport mode within the single market and the third relates to marine pollution and the transport of dangerous goods by ships.

The entry into force of Directive 2005/33/EC last year sets limits for the sulphur content of marine fuel sold within the EU. This is currently in the process of being transposed in the UK. This is a first step in cleaning up ship emissions, which have hitherto been largely unregulated. Currently shipping represents a significant source of sulphur dioxide and nitrogen oxides and can cause significant local air quality problems. There are further options to tackle these which have so far been taken up in some other EU countries. The European Commission has so far taken relatively little action in relation to greenhouse gases, although recently studies have been commissioned to examine allocation of greenhouse gas emissions from shipping to individual Member States (Entec, 2005).

The identification and promotion of the Trans European Transport Networks (Ten-Ts) and the Motorways of the Sea are intended to facilitate trade between countries in the EU, acting as key transport infrastructure corridors. A number of ports and shipping routes have been identified and prioritised with funding available to facilitate their development. In addition, attempts are being made at EU level to promote the development of short sea shipping as a more environmentally friendly mode for freight than land based transport.

In terms of marine pollution and the transport of dangerous goods by shipping, action is focused on international collaboration and planning to prevent and deal with pollution incidents such as oil spills. Following the Erika disaster in 1999, the EU adopted a series of new measures in the area including Directives on inspection and enforcement of ship standards; a Regulation on double hulled tankers; and a Regulation establishing the European Maritime Safety Agency, whose goal is to provide technical and scientific assistance in the implementation of maritime safety and pollution legislation. Action in the area has been further supplemented following the Prestige disaster in 2002.

2.1.3 Global Policy

At the global level, the main actor in maritime affairs is the International Maritime Organisation (IMO), a UN body. The remit of the IMO covers three broad areas; marine safety, marine environmental protection and technical measures.

The environmental protection policy is largely related the International Convention for the Prevention of Pollution from Ships widely known as MARPOL. The convention finally entered into force in 2005 (after reaching the required 15 signatories) and covers air pollution from shipping, the transport of noxious or harmful substances by sea, oil and the disposal of waste from ships. To date, the focus of air pollution emissions has been on sulphur oxides, nitrogen oxides and particulates. Historically, the fuel used by marine bunkers has been of a low quality and the health and wider environmental impacts of these emissions has been increasingly documented and addressed by land based sources. While the agreement on emissions standards as part of the MARPOL process is a clear achievement of the IMO, the method and powers of enforcement of these standards has been called into question (Bode et al., 2002).

From the perspective of climate change issues, the IMO has been designated the responsibility in the realm of international shipping emissions by the United Nations Framework Convention on Climate Change (UNFCCC) - by analogy to the way that ICAO has been given responsibility for dealing with international aviation. In the IMO, the main focus of activity in response to this has been through a review of technical measures and in reaching agreement on the use of indexing measures to quantify and incentivise emissions reductions on a voluntary basis.

In 2000 the IMO published a key document that reviewed technical and operational measures to reduce greenhouse gas emissions (principally CO_2) from ships (IMO, 2000). The document also identified and assessed a number of potential policy instruments in terms of their potential application to incentivising emissions reductions. The detailed policy options proposed are considered further in section 4.3 below. The report proposed the following strategy for the IMO on the implementation of policy to reduce greenhouse gas emissions:

- To explore interest in entering voluntary agreements; including between the IMO and ship owners, or in using environmental indexing;
- Start work on the design of emissions standards for new and possibly existing vessels;
- Pursue the potential of trading credits earned from additional abatement measures implemented on new and/or existing vessels.

Subsequently agreement has been reached by the IMO Marine Environment Protection Committee (MEPC) to pursue the use of environmental indexing and to continue further work on the development of emissions standards and linking ship emissions to carbon trading through the use of the Clean Development Mechanism (CDM) under the Kyoto Protocol (CE Delft, 2004). The basic premise of the use of indexing is that it can be designed to describe the CO_2 emissions from a ship based on a standard metric, for example CO_2 per tonne cargo per nautical mile, thereby allowing the comparison of the performance of individual vessels.

However, as is noted by Bode et al. (2000), the focus of this strategy is interesting given the conclusions that the IMO (2000) main report, which casts considerable doubt on the effectiveness of voluntary agreements and environmental indexing. A recent CE Delft (2004) study on shipping emissions further highlights the fact that indexing requires significant amounts of data monitoring, measurement and verification. It also suggests that “there is major variation in the fuel efficiency of similar ships, which is not well understood” (CE Delft, 2004). These issues are taken up in Section 4.3 below.

2.2 Background to the Ports Review

The context of the Ports Review is the Department for Transport's recent white paper on *'The Future of Transport'* published in 2004. This is based on the three central themes of sustained investment, improvements in transport management and planning ahead. The intention is to update the 2000 Ports white paper to take account of recent developments in international trade, structural changes within the UK transport system and to align the policy with the principles of the overarching Future of Transport white paper looking forward to 2030. The intention is to ensure that the long term framework for ports "encourages the future development of a port sector which has the capacity to support growth." Provision of capacity to meet future demand is the clear influence over the document, which then attempts to set this in the context of ensuring the market response reflects the objectives of sustainable development and how far national policy should reflect regional development objectives.

The main focus of the review centres on the four main issues of:

- The future need for port capacity;
- The planning dimension: specifically the correct decision-making structure at national, regional and local level to ensure timely and appropriate decisions including;
    - Consideration of positive and negative externalities of market decisions;
    - How far government should intervene to influence port development;
    - Whether the planning system should be improved in respect of ports
- Inland access: how to provide the right conditions for infrastructure provision taking account of congestion and environmental consequences and whether current landside priorities take account of the needs of the ports industry;
- Local ports: obtaining the best from smaller trust and municipal ports

In terms of the environment, ports policy currently deals essentially with making port operators aware of the relevant regulations. A stated goal of the review is the "development of the ports sector that is compatible with the Government's social and environmental objectives." Clearly, this deals with both the development of ports capacity and the impact of ongoing operations, although the latter appears to be the focus of this section of the review. The section addresses noise, local air pollution, waste and global emissions.

In terms of global emissions, however, the reference is very much in passing, in terms of the fact that emissions from shipping are currently not included in Annex I of the Kyoto Protocol and referring to the emissions indexing work of the IMO. It effectively implies that this is currently at the stage of quantifying emissions and thereby the climate change impacts, rather than the pursuit of any kind of mitigation policy. Arguably this is unsurprising, given the limited ambition of the paper with respect to environmental requirements generally in combination with the lack of effective international measures on greenhouse gases; but it is a weak approach to a significant problem.

The review also contains a section which addresses the issue of inland connections to ports and the provision of this landside infrastructure. Increasingly the issue of funding for transport infrastructure is coming to the fore in respect of new developments of all kinds. The likely introduction of the planning gain supplement and increase in developer contributions are viewed as clear options for provision for infrastructure in the onward transport of goods delivered to the ports. The sustainability of this infrastructure provision is however perhaps open to question in terms of the framework of development of road versus rail development:

Road	Rail
"The Highways Agency establishes what triggers the need for road improvements or expanding road infrastructure capacity, and then seeks full cost recovery from whoever is responsible, through developer contributions."	"Where expansion of rail freight, including through ports, generates a demand for capital works which would not otherwise be commercially viable for the network provider (Network Rail), the freight users collectively will be expected to pay for such additional works 'up front'. This can, however, raise difficult questions for subsequent open access to the network."

Source: DfT (2006)

This suggests that the framework for land side infrastructure provision clearly favours the development of roads over rail, with the complexity of the deregulated rail industry a potential barrier to sustainable development of freight logistics. Interestingly, the Ports Review also appears to argue that:

> "To some extent it means that developer contributions reflect externalities, including congestion and environmental pollution, though the process is indirect."

There is no mention however, of how developer contributions can be calculated to accurately reflect this assertion of internalising externalities or that they have been designed with this in mind. On the contrary, given that it appears to be only direct infrastructure costs that are sought to be recovered, it is difficult to see how the externalities are included to any significant extent.

In general the focus of the review is not on global issues but addressing concerns on a regional and local basis. In terms of providing capacity it seems clear that the DfT are happy to leave it to the private sector and only intervene should it become a critical issue. This is a less pro-active stance than the one taken on aviation where the government makes clear its ambitions for development of capacity. The review in fact goes so far as to state that they will not use a "crude model of Government predicting demand and then providing capacity", that it acknowledges the Department has been accused of in the past.

2.3 Other Government policy relating to shipping and climate change

The political prominence of climate change and the need to address greenhouse gas emissions has become increasingly important across the political spectrum in the UK in recent years. In addition, the rising cost of oil and energy security issues in relation to increasing imports are beginning to necessitate political action in sectors heavily dependent on fossil fuel.

Alongside the Kyoto Protocol and domestic commitments, the UK has advanced itself as a leader on the climate change front at the global level. Both the recent G8 and EU Presidencies have been used to raise the issue of climate change. The UK delegation also took an active role in achieving a continuation of discussions of future climate change agreements at last year's Conference of the Parties to the UNFCCC in Montreal. This was widely heralded as a success.

The transport sector in general is already the Achilles' heel in this bid for global leadership, as it represents the sector in the UK with the fastest growing emissions (Defra, 2006). The vast majority of this is from road transport, with growth in road freight movement a significant contributor. As indicated previously, emissions from international shipping are not currently covered by national commitments under the Kyoto Protocol, as in a similar way to aviation; there has been no agreement on the allocation of emissions to individual countries. It is perhaps therefore not surprising that the greenhouse gas emissions from the shipping and ports sector in general have had relatively little attention from the policy perspective in the UK.

The UK Climate Change Programme (CCP) Review (DEFRA, 2006a) published earlier in 2006 suggests that the UK is "playing an active role in reducing emissions from shipping". Having stated this however, the actual policy substance behind it appears to be lacking. Principally, this action is through participation in the IMO process where the UK has made a significant contribution in the negotiations on the adoption of Interim Guidelines for Voluntary Ship CO_2 Emission Indexing for Use in Trials. UK flagged ships are now being encouraged to participate in the scheme on a voluntary basis. As the indexing system is still at the early stages of establishing the index, it is unclear how this is resulting in an actual reduction of emissions from ships.

The 2003 Energy white paper *'Our Energy Future: creating a low carbon economy'* was intended to set the UK on a path to a 60 per cent carbon emissions reduction by 2050. Shipping was again referred to in terms of the UK's support for the IMO process (see section 2.1.3) and the potential use of shipping as a lower carbon alternative for freight movement. This latter lower carbon mode option was not actually considered in the recent UK CCP Review, however (Environmental Audit Committee, 2006). Interestingly, the more recent update to the Energy white paper did not cover energy use in shipping.

3 UK PORTS: CURRENT USAGE AND FUTURE PROJECTIONS

3.1 Shipping Trends

The use of ports and shipping world wide is primarily dependent on developments in international trade with 90 to 95 per cent of goods being transported by sea (Michaelowa and Krause, 2000; European Commission, 2004). World trade has shown strong growth in recent years, largely as a result of the integration of China into the world economy and generally strong economic growth. Talks between China and the WTO have been positive, suggesting that this is a trend which is likely to continue. Asia as whole is also expected to show continued economic growth with China, India and South Korea being particularly to the fore (European Commission, 2004). This will continue to stimulate global trade and therefore increase the need for international shipping. In the case of China, oil imports alone increased by 30 per cent per annum for the three years prior to 2004, but are expected to reduce to a rate of increase of between 15 to 20 per cent in future years. In 2003, Chinese imports increased by 40 per cent and exports by 35 per cent in nominal dollar terms. In general, the net flow of trade is from developing nations to the more developed. Developed countries account for 60.3 per cent of seaborne imports with developing countries making up just 31.4 per cent. In contrast developing nations account for 49.4 per cent of exports with developed countries making up just 40.4 per cent (European Commission, 2004).

The worldwide increase in trade has been reflected in Europe where in 2003 there was an increase in throughput of 10.5 per cent on 2002. The increasingly large volumes of containerised trade (primarily carrying manufactured goods between East Asia and Europe) have led to the development of larger vessels. On the main Far East to Europe and Pacific routes the largest container vessels (>8000 TEU) made up 5 per cent of the fleet in 2005 with this being forecast to rise to 14 per cent by 2008 (MDS Transmodal, 2006).

The stimulation of world trade through the development of the Asian economies is also reflected in the UK ports which have also experienced an increase in the volume of containerised freight with origins from outside Europe. Between 1970 and 2004 the amount of trade from foreign ports increased from 66 per cent to 73 per cent. Of this 73 per cent, around a third was from Europe and the Mediterranean (National Statistics and DfT, 2006). The increase in trade from Asia and other regions outside Europe is demonstrated by Table 1 below, where between 1990 and 2004 the amount of containerised traffic from short sea routes, i.e. Europe, increased by 47 per cent whilst the amount from deep sea vessels i.e. from North America, East Asia, Australasia etc. doubled. In terms of the deep sea vessels the largest increases were from East Asia (207 per cent) and Indian Ocean and the Gulf (149 per cent). This increasing emphasis on long-distance traffic also implies growing fuel consumption per tonne delivered, and hence also increases in greenhouse gas emissions (National Statistics and DfT, 2006).

Table 1 Origin of UK containerised freight by region (1000 units)

Region	*1990*	*2004*	*% Increase*
All short sea i.e. Europe	1,291	1,900	47.17
All deep sea i.e. North America, Far East etc.	1,315	2,636	100.46
Deep sea by region			
North America	407	432	6.14
Far East	492	1513	207.52
Africa	117	154	31.62
Indian Ocean and the Gulf	124	309	149.19
Australasia	86	82	-4.65
Other deep sea	88	144	63.64

Source: Based on National Statistics and DfT (2006)

Due to the nature of the British economy and its industries, the demand for sea borne cargo is largely import-driven. Our demand for imports is dependent on a wide range of factors the most important being economic activity, trade barriers, conditions in exporting nations and changes to manufacturing techniques, service provision and consumption patterns. UK ports handle 95 per cent of UK trade by weight so therefore the throughput of ports will be directly related to the amount of trade, assuming there are no major constraints to port capacity development. The UK economy is currently showing steady growth. It is predicted to grow till 2010 at a rate of around 2.5 per cent per annum. The demand for trade is also predicted to grow at about this rate (HM Treasury, 2006).

As part of the Ports review process the DfT commissioned a study by the MDS Transmodal to forecast demand for the major cargo sectors to 2030. This study found that the whole UK cargo sector is predicted to increase at an average annual growth rate of 1.2 per cent to 2030, a figure lower than the GDP growth likely for the same period. However, whilst average growth is lower than GDP, the unitised cargo sector is expected to increase (3 per cent) at a higher rate than non-unitised (0.3 per cent) (MDS Transmodal, 2006). Although there has been an increase in containerised traffic, there has also been a decrease in the loading of containers with the percentage of empty containers going from 21 per cent in 1985 to 28 per cent in 2004 (National Statistics and DfT, 2006).

The distribution of this growth, especially in the unitised sector is likely to be in the South East, which showed a 99 per cent increase in the period 1992-2004 compared with 25 per cent for all the other ports (Department for Transport, 2006). This will have significant implications for inland transport provision in the area and will be key to a sustainable ports policy.

In the OECD, the registered tonnage declined from 51 per cent of world fleet in 1980 to 28 per cent in 1995 (Michaelowa and Krause, 2000). This is largely accountable to the introduction of open registrations which allows the ‘flagging out’ by operators to streamline costs. Flagging out is the when operators register vessels in states with more permissive regulatory enforcement which allows them to cut costs by avoiding national regulation (Michaelowa and Krause, 2000). This has lead to a general increase in the age of the world fleet, which has serious implications for the marine environment and global climate.

3.2 Energy use and CO_2 emissions

When comparing transport modes in terms of the amount of energy used or the CO_2 emitted, then sea borne transport is the least energy intensive and produces the least emissions compared to all the other modes per tonne kilometre (tkm) (see Table 2) (Michaelowa and Krause, 2000).

Table 2 Energy use and CO_2 emissions per tkm for various modes

Mode of transport	*Energy use/tkm (MJ)*	*CO_2 emissions/tkm (g)*
Air	7.0-15.0	501 - 1073
Road	1.8 – 4.5	133 – 333
Rail	0.4 - 1	30 - 74
Sea	**0.1 – 0.4**	**7.7 - 31**
oil products	0.1	7.7
dry bulk goods	0.1	3.9
crude oil	0.0	3.5

Source: Michaelowa and Krause (2000)

Despite this relatively good performance, in 1990 CO_2 emissions from shipping accounted for 7 per cent of worldwide transport emissions and 2 per cent of total emissions (Michaelowa and Krause, 2000). On one level, this does represent good performance in terms of specific emissions when considering the high volumes and increasingly long distances that goods are shipped, it is clearly however a non trivial amount. The actual radiative forcing caused by these emissions has been calculated at 1.8% of total emissions. This figure relates solely to CO_2 and does not include the effects of other greenhouse gas emissions (IMO, 2000).

Emissions from shipping are also forecast to increase; CO_2 emissions from traffic between EU ports are set to increase from 165,412 Kte/annum in 2006 to 172,791 Kte/annum in 2010 (Entec, 2002). In 2004, the net emissions from international marine bunkers in the UK were equivalent to 5.8 million tons of CO_2 compared with 128.4 million tons for all land based modes (equivalent to 3.5 per cent) (DEFRA, 2004). In the period 1990-2004 the emissions of CO_2 from international marine bunkers in the UK actually fell by an eighth. However this figure is based on ships refuelling in UK ports, and as many UK operators refill abroad then this figure may not reflect the true development in emissions from shipping (DEFRA, 2006b).

3.3 Inland Shipment

With 95 per cent of trade by weight entering the UK via our ports the development of the surrounding transport infrastructure will be crucial to the sustainability of the ports and wider society (Department for Transport, 2006). Note that the proportion will be lower in terms of value, as lightweight, high-value goods tend to be shipped by air. The unitised lorry traffic arising from ports alone accounted for 25 billion tkm in 2004, 16 per cent of the total UK lorry freight tkm. Part of the explanation for this is that containerised lorry freight on average travels twice as far (Department for Transport, 2006). In line with increases in the amount of unitised freight entering the UK, this share is expected to increase to 24 per cent of tkm made by lorries by 2030. This figure also assumes an increase in the amount of unitised freight taken by rail. In 2004, bulk freight from ports also accounted for 25 billion tkm transported by lorries on UK roads (Department for Transport, 2006).

Due to changes in the types of freight entering UK, i.e. a decrease in cargo categories for which rail has a larger market share there is predicted to be an increase of 21 per cent in the road tkm made and a decrease of 7 per cent for rail tkm by 2030. This prediction assumes that the relative cost and the distance of rail and HGV journeys for transporting bulk cargo from ports remains constant in the future (Department for Transport, 2006). Also in general, road traffic is on the increase in Britain with LGVs and HGVs showing the greatest growth (5 per cent and 2.9 per cent respectively in 2004 (Freight on Rail, 2006). This increase in the amount of freight transported by road has far reaching consequences. Lorries cause significant damage to the road network with a five-axle 40 tonne lorry causing 10,000 times more damage to the road than a car. Road transport is also less energy efficient than rail in the transportation of cargo. Per tonne carried, rail produces 10 per cent of the CO_2 than the equivalent on road (Freight on Rail, 2006). HGVs also contribute significantly to congestion, local air pollution and global greenhouse gas emissions. For these reasons it is key that the DfT's policy delivers an integrated transport network that encourages the use of energy efficient and socially sustainable modes.

4 REDUCING GREENHOUSE GAS EMISSIONS FROM MARINE TRANSPORT

Action to reduce greenhouse gas emissions from shipping has been slow, largely due to the perceived complexities of the political competency and lack of any kind of framework for global enforcement. The reality is however, that savings in the shipping sector can be easily achieved through both technical and operational measures. Much of the work on mitigation measures stems from a seminal work done for the IMO by a consortium led by Marintek in 2000, the "*Study of Greenhouse Gas Emissions from Ships*", included detailed consideration of technical, operational and policy measures. This section provides an overview of the main technical and operational measures for emissions reductions and some potential policy options which could be used to create the right incentives for their introduction.

4.1 Technical Measures

The introduction of technical measures in shipping can generally be classified in terms of timescales, with short to medium term initiatives possible with current technologies and longer term options involving significant alterations to fuels, power trains and vessel design. It is also important to differentiate between measures that can be introduced in existing ships and those that would be used on new ships. Clearly, this has implications for the 'lead-in' time for changes, as ships tend to have relatively long life spans (around 20 years (IMO, 2000)) and maintenance periods, and thus inertia will exist in the system before emissions reductions are likely to register.

4.1.1 *Short to medium term measures*

Many technical measures are available today for further improving the fuel efficiency and consequentially reducing the CO_2 emissions from ships. These range from measures that relate to the design of the overall vessel to those connected to the efficiency of the propulsion system and the type of fuel used. Table 3 below provides a summary of individual measures and their reduction potential that could be applied to existing ships. Table 4 provides an indication of the combined reduction potential of packages of technical measures and the potential total reduction that could be possible if all technical measures were to be implemented.

Table 3 Individual technical measures and their reduction potential for existing ships

Measures	***Description***	***Fuel/ CO_2 Saving potential***
Optimal hull maintenance	Use of self polishing paint, improved practice during maintenance and re-blasting the hull	3 to 5%
Propeller maintenance	Reduce propeller roughness through polishing	1 to 3%
Fuel injection	Modification so that the amount of fuel is injected over a shorter period of time	1 to 2%
Fuel (HFO to MDO)	Change from heavy fuel oil to marine diesel oil reduces emissions due to the lower carbon/hydrogen ratio	4 to 5%
Efficiency rating	Engine upgrade including increased compression ratio and changes to fuel injection	3 to 5%
Efficiency rating and TC upgrade	Engine upgrade including increased compression ratio and changes to fuel injection combined with a turbo charger upgrade	5 to 7%

Table 4 Reduction potential for packages of technical measures and all technical measures for existing ships

Package	***Combined Fuel/ CO_2 Saving potential (estimate)***	***Total Fuel/ CO_2 Saving potential – All Measures (estimate)***
Hull and Propeller Maintenance	4 to 8%	4 to 20%
Fuel injection and Fuel (HFO to MDO)	5 to 7%	
Effieciency rating and Fuel (HFO to MDO)	7 to 10%	
Efficiency rating, TC upgrade and Fuel (HFO to MDO)	9 to 12%	

Source: Adapted from IMO (2000)

For new vessels, there is even greater technical potential for emissions reductions, as there is a greater scope for engine and vessel redesign (as opposed to modification on existing ships). Table 5 and Table 6 below summarises the technical measures and reduction potential for new ships, again considering the overall vessel and design of the propulsion system on an individual, package and total basis.

Table 5 Individual technical measures and their reduction potential for new ships

Measures	*Description*	*Fuel/ CO_2 Saving potential*
Optimised hull shape	Changes to the shape of the vessel hull design with the objective of optimising fuel consumption	5 to 20%
Choice of propeller	Optimising the propeller type to suit the function of the vessel	5 to 10%
Efficiency optimised	Combined set of measures, particularly increased compression ratio and redesign of fuel injection (higher fuel nozzle opening pressure and injection pressure)	10 to 12% (state of the art technique in medium speed engines) 2 to 5% (slow speed engines when trade off with emissions of nitrogen oxides (NOx) accepted)
Fuel (HFO to MDO)	Change from heavy fuel oil to marine diesel oil reduces emissions due to the lower carbon/hydrogen ratio	4 to 5%
Plant Concepts	For some vessels alternatives to the conventional drive train through for example diesel-electric propulsion allows it to run with a more optimal fuel consumption	4 to 6%
Machinery monitoring	Incorporating more regular use of systems for monitoring machinery efficiency and planning related maintenance and adjustments based on an optimum time interval	0.5 to 1%

Table 6 Reduction potential for packages of technical measures and all technical measures for new ships

Package	*Combined Fuel/ CO_2 Saving potential (estimate)*	*Total Fuel/ CO_2 Saving potential – All Measures (estimate)*
Optimised hull and choice of propeller	5 to 30%	5 to 30%

Efficiency optimised and Fuel (HFO to MDO)	14 to 17% (state of the art technique in medium speed engines) 6 to 10% (slow speed engines when trade off with NOx accepted)	
Plant Concepts and Fuel (HFO to MDO)	8 to 11%	
Machinery Monitoring	0.5 to 1%	

Source: Adapted from IMO (2000)

Thus it is clear that there are a number of feasible technical measures over the short term that could be used to improve the fuel efficiency of ships. Many of these appear to be fairly simple and are not likely to be prohibitively costly. Indeed, with oil prices appearing likely to remain high, many such measures may be increasingly cost-effective, but do not appear to be being actively pursued. While the range of improvement does vary between individual measures, a combination of measures could overall offer potentially substantial CO_2 savings.

4.1.2 Longer Term Measures

Over the long term, further improvements are likely to become feasible both from a technical and cost perspective. The IMO (2000) study also examined the potential for new or improved technical measures which are likely to include:

- Improved and more sophisticated injection systems;
- Better charge-air systems;
- Better utilisation of the exhaust waste heat;
- Improved NOx reduction methods
- Improved engine reliability
- Different kinds of propulsion trains (based on electrical power distribution), gas turbines, overall efficiency improvements to diesel incorporating energy optimisation, fully integrated power plant packages (for example combining gas and steam turbines)
- Development of fuel cells (although there is a need to overcome low power density and hydrogen logistics)

In addition to these measures, a project developed by the North Sea Foundation in collaboration with a number of maritime specialists, recently identified a number of technical improvements that could be made to ships in order to improve their environmental performance. Leemans and Luiten (2005) suggest among others these technical measures to improve shipping are through:

- Propulsion –
  - POD propulsion in combination with improved hydrodynamic hull shape results in a drastic improvement
  - Wind energy – developments in Skysails technology
- Clean Engine –

  - Biofuels
  - Hybrid engines
  - Fuel cells
- Air lubrication
  - Reducing friction through the water through the introduction of millions of tiny air bubbles underneath the ship

It must be stressed however that technical feasibility will not necessarily result in widespread market take-up, without the correct incentives for shipping companies and owners to change. Bunker fuels are not taxed, and are generally notoriously dirty fuels, so the price paid does not reflect the significant external costs. Hence the objectives for ship and cargo owners may not necessarily be compatible with that of improved environmental performance, and the introduction of policy measures may be necessary to correct market failures.

4.2 Operational Measures

Operational measures largely concern the practices undertaken by shipping companies, individual vessels and crew. Effectively they reflect how the ship is used and in a number of cases offer significant potential for reducing CO_2 emissions at what is likely to be a very low cost. The IMO study examined and quantified reduction potential for a number of measures (Table 7), of which the combination of improved operational planning and speed reduction offer the greatest scope for reducing emissions and saving money for the fleet overall (Table 8).

Table 7 Individual operational measures to reduce CO_2 emissions

Measure	*Description*	*Fuel/ CO_2 saving potential*
Operational planning/ Speed selection		
Improved fleet planning	Increased fleet utilisation	5 to 40%
"just in time" routing	Operation at a reduced speed	1 to 5%
Weather routing	Weather, current and depth conditions affect ship speed. Optimisation is possible based on weather and vessel data to reduce fuel consumption	2 to 4%
Miscellaneous Measures		
Constant RPM	Steady power throughout the voyage can be used to minimise total fuel consumption	0 to 2%
Optimal trim	Maximum speed at a given mean draft and engine power	0 to 1%
Minimum ballast	Decrease ballast and extra bunker fuel to a minimum	0 to 1%
Optimal propeller pitch	Manual or automatic adjustment to the propeller based on draft, speed and weather conditions	0 to 2%
Optimal rudder	Steady rudder or minimum rudder angle variations can reduce fuel consumption	0 to 0.3%
Reduced time in port		
Optimal cargo handling	Can be used to reduce ship speed at sea. Use of special planning tools, more efficient procedures and development of new technology	1 to 5%
Optimal berthing, mooring and anchoring	Also can reduce ship speed at sea. For example through use of low emission tug boats rather than use of large ship engines	1 to 2%

Table 8 Packages of operational measures to reduce CO_2 emissions

Package	*Combined Fuel/ CO_2 Saving potential (estimate)*	*Total Fuel/ CO_2 Saving potential – All Measures (estimate)*
Operational Planning/ Speed Selection	1 to 40%	1 to 40%
Miscellaneous Measures	0 to 5%	
Reduced Time in Port	1 to 7%	

Source: Adapted from IMO (2000)

Examining these measures in more detail, it is clear that many are simple and yet very effective. Additionally, in terms of cost, it is likely that most operational measures could be introduced at a relatively low cost and would also represent a future cost saving to the operator as overall fleet efficiency would improve (a so called win-win). Nonetheless, it appears that these measures are not being pursued in a systematic way.

4.3 Policy Options

It has been argued that investment in improving environmental performance in shipping lacks any real incentives and in fact that non compliance with environmental standards reduces operating costs (Bode et al., 2002). In terms of the use of policy instruments to improve the environmental performance of shipping, particularly that of CO_2 emissions, the focus has been how emissions from shipping can be addressed through the United Nations Framework Convention on Climate Change (UNFCCC). The IMO (2000) study examined a number of policy instruments that could be used to incentivise CO_2 emissions reductions. The instrument and conclusions reached by the study is summarised in Table 9 below.

Table 9 Policy instruments to incentivise emissions reductions

Policy Instrument	***Description***	***Viable option?***
Carbon charge on bunker fuel	Increasing fuel costs by imposing an additional cost on fuel to reflect its carbon content	Not at a regional level due to the huge scope for evasion – requires global agreement
Voluntary agreements programme	Agreement on a voluntary basis to: adopt emission or efficiency standards; or adopt of certain approved practices; or report on emissions or efficiency levels and actions being taken to improve them	Not found to be a viable approach for significant reductions on a global scale
Environmental indexing	Use environmental criteria to give vessels an index indicating the environmental performance of the ship. This can be used to differentiate taxes, port dues and charges, insurance rates and financial conditions	Not seen as a very efficient tool to reduce emissions even if some reductions could be achieved on a voluntary basis
Emissions trading	The inclusion of the shipping sector within an emissions trading system - allocating emissions allowances to owners – difficulty in allocation and setting of cap levels	Allocation of allowances to ship owners was not viable.
Emissions credits sales	Through a system for creating emissions credits, for example through the use of CDM. A baseline would need to be established in order to judge the improvement level and therefore the number of allowances allocated	A system for creating emissions credits may be a way to include shipping in a general trading system

Energy or emission efficiency standards	Setting a minimum standard for existing ships and basing a standard for new ships on ship design parameters. It should relate to function and not technology.	These are feasible, although it is questionable as to whether they are cost effective

Source: Adapted from IMO (2000)

As indicated in section 2.1.3 above, the IMO has chosen to initially concentrate its efforts on the introduction of environmental indexing of CO_2 emissions. This appears to contradict the findings of its own study that concluded indexing was not a very efficient tool to reduce emissions. At a broader level, the conclusions of the IMO study on some of the policy options as presented in the table above appear unduly negative, and could also be revisited in our current climate of high oil prices. For example, the questioning of the use of emissions standards (which has proved particularly successful in the regulation of local air quality pollutants in the automotive industry) on cost efficiency grounds could be more easily dismissed currently, with oil prices of $70 per barrel (versus $30 per barrel in 2000 (BP, 2006)).

It must be recognised however that regulation of the shipping sector for greenhouse gas emissions is likely to be particularly difficult, owing to a range of issues (Bode et al., 2002):

- Martime transport is provided by a global industry and it takes place beyond national borders;
- Transport is an accelerator of economic growth, increasingly on a global scale;
- Decentralised and mobile sources of emissions make them difficult to quantify and regulate;
- Almost all energy intensive industries operating in international markets are fully exempt or pay reduced emissions or energy taxes; and
- Local and regional air quality issues will continue to be the main driver of policy.

In addition, the nature of the global industry means that applying measures such as fuel tax on a regional level will simply result in tax evasion. Bunker fuel used for shipping is often ‘tankered’ long distances in the vessel before being used and therefore refuelling would switch to a low tax bunker source. Another significant barrier to regulation is the increasing use of open registers and of ‘flagging out’. Ship owners can cut costs through registering their vessel in open registers or by using the OECD flagging-out option. However, this can reduce the traceability of vessels and the accountability of owners to maintain high standards, and is considered to be promoting a ‘race to the bottom’ towards substandard shipping (Michaelowa and Krause, 2000).

5 DISCUSSION

5.1 Is the policy framework adequate?

- Ports and shipping policy are not part of an integrated and effectively linked transport system. Although the Ports review considers the need for provision of landside infrastructure, it is not clear how the anticipated growth would be accommodated on the already congested road and rail networks in the UK.
- Ports and shipping policy does not seriously consider the issue of global emissions, particularly CO_2.
- The current policy framework is likely to prioritise land connections through road development rather than rail, which is less sustainable and risks further increases in CO_2.
- Although the review makes an attempt to distance itself from the predict and provide paradigm, it appears this new approach merely allows the market to predict the capacity for the government to then provide it.
- Are we making best use of what we have?

5.2 What is the scale of emissions from shipping and its relative importance?

- Shipping offers a substantially lower CO_2 emission per tonne/km than any other motorised mode.
- However, lack of attention to the sector means that not only are local air pollutants an issue but also the poor quality of the fuel means that it has a higher carbon ratio than could be the case, and the technologies used do not place great emphasis on improving fuel efficiency.
- Also, the recent large growth and future predicted growth of the shipping sector means that overall emissions are significant and likely to become more so in the future.
- We should be doing more to ensure that utilisation of vessels and ports capacity is maximised.
- Increases in freight volumes from shipping are predicted to contribute to a significant rise in the freight tonne kilometres transported by road.

5.3 What are the alternative future policies?

- The overall technical potential for short term reductions is considered to be 5 to 30 per cent in new ships and 4 to 20 per cent in existing ships.
- For operational measures, the potential for short to medium term reductions are thought to be between 1 and 40 per cent. Clearly the large scope for operational improvements also represents a potential 'win-win' situation whereby reductions in CO_2 emissions are through improved efficiencies within the sector and therefore would also reduce operators' costs.
- Over the long term, the IMO study estimated that the reduction potential of the world fleet could be around 18 per cent in 2010 and 28 per cent by 2020.
- In terms of policy options, the choice of environmental indexing appears to be more of a politically motivated decision than one that reflects the real reduction potential of the measure.

- In contrast, the use of mechanisms such as emissions or efficiency standards could be more viable and more effective, particularly in respect of the high global energy prices.
- In addition, the use of mechanisms such as CDM are favoured by some (Bode et al., 2002) and this could be used as a more 'market based' solution to bring shipping emissions under commitments such as Kyoto.

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