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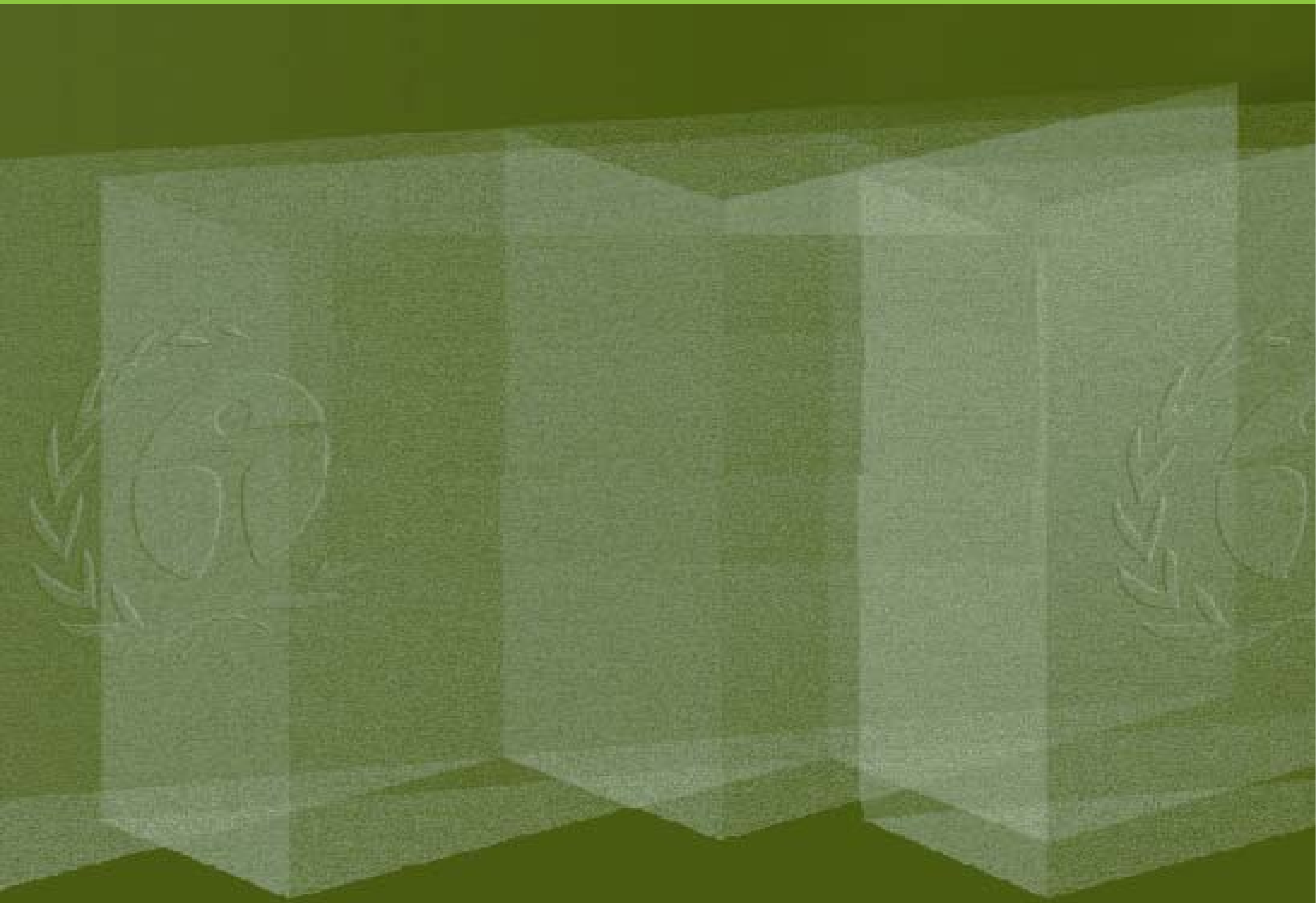

# Market Based Instruments for Abatement of Emissions from Shipping

## A pilot project for the Baltic Sea

Umwelt
Bundes
Amt
Für Mensch und Umwelt

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# Market Based Instruments for Abatement of Emissions from Shipping

A pilot project for the Baltic Sea

by

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<tr><td colspan="3">16. Zusammenfassung: Schiffsemissionen, insbesondere $SO_x$, $NO_x$ und PM, werden in zunehmendem Maße als Gesundheits- und Umweltproblem wahrgenommen. Bestrebungen der Internationalen Schifffahrtsorganisation (IMO), diese Emissionen durch internationale Abkommen zu reduzieren, resultierten in Regelwerken, die nur in sehr begrenztem Maße das Potenzial der derzeitigen technischen Möglichkeiten einbeziehen. Diese Bestrebungen gleichen nicht einmal den erwarteten Zuwachs der Emissionen durch die Zunahme des Seeverkehrs aus. Durch diese Tatsache ergaben sich gute Gründe für die Untersuchung potentieller ökonomischer Anreize, welche zum Ziel haben, eine Motivation zu schaffen, die über die internationalen gesetzlichen Forderungen hinausgeht.<br>Dieses Projekt fasst die Gegebenheiten in der Ostsee hinsichtlich der technischen Standards und Möglichkeiten zusammen, um die schiffsseitigen Emissionen zu vermindern und betrachtet den Zuwachs des Seeverkehrs und dessen Emissionen bis in das Jahr 2020. Weiterhin liefert es eine Analyse der rechtlichen Möglichkeiten zur Inkraftsetzung ökonomischer Anreizinstrumente für die Verminderung von $SO_x$- und $NO_x$-Emissionen in diesem Seegebiet.<br>Basierend auf zwei Wachstumsszenarien für den Seeverkehr in der Ostsee werden die Einflüsse der reduzierenden Maßnahmen für $SO_x$- und $NO_x$-Emissionen berechnet und mit der damit einhergehenden Reduzierung der Gemeinkosten abgeglichen. Die Berechnungen haben ergeben, dass es sinnvoll erscheint, unter sozio-ökonomischer Betrachtungsweise die Emissionen unter das Maß der derzeitigen gesetzlichen Vorgaben zu reduzieren. Jedoch müssen diese Maßnahmen bald greifen und erheblich sein, um mindestens die Emissionen durch die erwartete Zunahme des Seeverkehrs auszugleichen.<br>Letztendlich wird ein Vorschlag unterbreitet, wie die Umsetzung der ökonomischen Anreizsysteme zur Reduzierung der SOx- und NOx-Emissionen in der Ostsee begonnen werden kann.</td></tr>
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<tr><td colspan="4">16. Abstract: Emissions from shipping, especially $SO_x$, $NO_x$, and PM, are perceived increasingly as a problem for human health and the environment. Efforts by the International Maritime Organisation to reduce these emissions by international agreements have not resulted in legislation that takes account of more than a very limited part of the existing technological potential. These efforts will not even offset the expected increase in emissions due to traffic growth. This seemed a good reason to start investigating potential marked-based incentives aimed at motivating action beyond internationally legally required measures.<br><br>This project summarises the situation for the Baltic Sea with regard to technical standards and opportunities to reduce ship emissions, and looks at the expected growth in traffic and emissions up to 2020. It then provides an analysis of the legal enforceability and feasibility of market based instruments for the reduction of $SO_x$ and $NO_x$ emissions in the area.<br><br>Based on two scenarios for traffic growth in the Baltic Sea, effect of the implementing different measures for the reduction of $SO_x$ and $NO_x$ emissions is calculated and compared with the reduction of social costs. The calculation shows that under socio-economic cost/benefit considerations it is reasonable to expect that emissions can be reduced to below what can be achieved under current rules. However, the additional measures have to start soon and be substantial in order to at least offset the expected increase in ship emissions.<br><br>Finally, a proposal is made on how to begin implementing market based instruments for the reduction of $SO_x$ and $NO_x$ emissions in the Baltic Sea.</td></tr>
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## Abbreviations

| | |
|---|---|
| AIS | Automatic Identification System |
| AMRIE | Alliance of Maritime Regional Interests in Europe |
| BAU | Business-As-Usual |
| BLG | Balk Liquids and Gases |
| CAFÉ | Clean Air For Europe |
| CARB | California Air Resources Board |
| CCB | Coalition Clean Baltic |
| CDM | Clean Development Mechanism |
| CFCA | Community Fisheries Control Agency |
| $CO_2$ | Carbon Dioxide |
| CONCAWE | Conservation of Clean Air and Water in Europe |
| DWI | Direct Water Injection |
| EAS | Emission Abatement Scenario |
| EC | European Commission |
| EEB | European Environmental Bureau |
| EEZ | Exclusive Economic Zone |
| EMSA | European Maritime Safety Agency |
| EPA | Environment Protection Agency |
| EU | European Union |
| FC | Ferry/Cruise |
| FSA | Formal Safety Assessment |
| GAUSS | Gesellschaft für Angewandten Umweltschutz und Sicherheit im Seeverkehr |
| GHG | Green House Gas Emission |
| GPS | Global Positioning System |
| GT | Gross Tonnes |
| GWh | Giga Watt hour(s) |
| HAM | Humid Air Motor |
| HFO | Heavy Fuel Oil |
| IAPP | International Air Pollution Prevention Certificate |
| IEM | Internal Engine Measures |
| IIASA | International Institute for Applied Systems Analysis |
| IMO | International Maritime Organisation |
| IPPC | Integrated Pollution Prevention and Control Directive |
| ISL | Institut für Seeverkehrswirtschaft und Logistik |
| JI | Joint Implementation |
| LCPD | Large Combustion Plant Directive |
| LSF | Low Sulphur Fuel |
| MACC | Marginal Abatement Cost Curve(s) |
| MARPOL | International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78) |
| MDO | Marine Diesel Oil |
| MEPC | Maritime Environment Protection Committee |
| Mio | Million |

| | |
|---|---|
| MWh | Mega Watt hour(s) |
| NEC | National Emissions Ceiling Directive |
| NERA | Naval Enlisted Reserve Association |
| $NO_x$ | Nitrogen Oxides |
| NT | Net Tonnes |
| OPA 90 | Oil Pollution Act 1990 |
| PM | Particulate Matter |
| RECLAIM | Regional Clean Air Incentives Market |
| SCAQMD | South Coast Air Quality Management District |
| SCR | Selected Catalytic Reduction |
| SECA | Sulphur Emission Control Area |
| SEK | Swedish Krona |
| SMA | Swedish Maritime Administration |
| SOLAS | Safety Of Life At Sea |
| $SO_x$ | Sulphur Oxides |
| T&E | European Federation for Transport and Environment |
| TBT | Tetrabutytin |
| TWh | Terra Watt hour(s) |
| UNCLOS | United Nations Convention on the Law of the Sea |
| UNFCCC | United Nations' Framework Convention on Climate Change |
| VMS | Vessel Monitoring System |
| VOC | Volatile Organic Compound |
| WHO | World Health Organization |
| WWF | World Wildlife Fund for Nature |

# 1 Introduction

Projections, prepared for the European Commission's Clean Air For Europe (CAFE) programme, show that emissions of nitrogen oxides ($NO_x$) from international shipping are expected to increase by two thirds between 2000 and 2020, and those of sulphur oxides ($SO_x$) by nearly half, and this even after the implementation of Annex VI of the International Maritime Organisation's MARPOL Convention on air pollution by ships and the new EU directive on sulphur in marine fuels (Amann, et al, 2004). According to this estimate, $NO_x$ and $SO_x$ emissions from international shipping in Europe will have surpassed the emissions from all land-based sources in the 25 EU Member States combined by 2020.

A problem in the context of shipping is that efforts by the International Maritime Organisation (IMO) to reduce emissions by international agreements have not resulted in legislation that takes account of more than a very limited part of the existing technological potential. Where $NO_x$ is concerned, MARPOL's Annex VI merely reflects the state of the art of maritime diesel engines at the time when the agreement was negotiated. No account is taken either of new engine technologies or of existing after-treatment opportunities.

Designating the Baltic Sea as a Sulphur Emission Control Area (SECA) made it possible to introduce an upper limit of 1.5 per cent for the sulphur content of marine fuels used in the area. However, the resulting reduction will within a few years be offset by the increase in emissions resulting from the fast growth in ship movements.

The Baltic Sea is highly sensitive to eutrophication and most of its drainage area suffers from acidification. Furthermore, many cities in the region have difficulties attaining the Community's air quality standards for $NO_x$ and Particulate Matter ($PM_{10}$). The situation is aggravated by the fact that maritime shipping in the area is expected to double in the next 15-20 years. In order to prevent economic growth from having adverse effects on the natural environment and human health, further measures to reduce emissions are urgently needed. As most of the inexpensive measures aimed at emissions from land-based sources have already been used, shipping is increasingly urged to do more than is required by globally agreed regulations.

Low-cost techniques for reducing considerably the emissions of $NO_x$ and sulphur from shipping are available. Studies for the European Commission show that in relative terms it is now very cost-effective to reduce emissions from shipping. The 2005 impact assessment for the Clean Air for Europe programme found that reducing ship emissions could deliver the same environmental and health benefits to EU citizens for €325 million less than reducing emissions from land-based sources by the same amount. Therefore, the real challenge is rather of a legal and political nature than technical.

In 1995, the Commission published a Green Paper (COM(95)691) on fair and efficient pricing in transport, and three years later a White Paper, Fair Payment for Infrastructure Use, that underlines the importance of marginal cost pricing in all modes of transport. The latter paper was followed by reports from a High Level Group containing suggestions on ways of estimating marginal costs and proposed options for charging users directly for transport infrastructure and associated social costs. However, the Commission has not yet come forward with any proposal for how to charge shipping for the marginal damage costs caused by its emissions.

Emissions of greenhouse gases (GHG) from shipping are a growing concern. However, fuels used in international shipping are only to a small extent burnt in the territorial waters of the country where the fuel was purchased. The Parties to the United Nations' Framework Convention on Climate Change (UNFCCC) therefore decided to exclude emissions from such fuels from the national emission inventories. Instead, IMO was instructed to analyse ways to reduce GHG emissions from maritime transport. So far IMO has failed to come up with concrete proposals.

The aim of this paper is to assess potential market-based instruments for reducing emissions from shipping, and to design a scheme that can be used in a pilot project for providing incentives to shipowners to improve the environmental performance of vessels operating in the Baltic Sea. The first phase of such a pilot program would focus on $SO_x$ and $NO_x$, but in principle the same market based instruments should be feasible for the abatement of particulate matter and other airborne pollutants.

Being a vulnerable brackish water ecosystem makes the Baltic Sea a suitable candidate for a pilot project. The Baltic is also an ideal area for a trial with market-based instruments as its boundaries are well-defined and competition with ports in other areas is relatively small.

However, where carbon dioxide is concerned, a larger geographical area than the Baltic might be needed for an implementation that does not distort competition. The fact that carbon dioxide ($CO_2$) is a greenhouse gas that affects the global atmosphere also argues in favour of a more international perspective. $SO_x$ and $NO_x$, on the other hand, predominately cause local and regional damage.

Introducing charges or emissions trading for the abatement of $CO_2$ is an important supplement to similar market based instruments for $NO_x$, as in diesel engines it is difficult to simultaneously reduce both. Energy-efficient slow speed diesel engines produce a lot of $NO_x$, while more energy-consuming high-speed diesels and gas turbines emit much less $NO_x$. Thus introducing charges on $NO_x$ might in the absence of similar charges on $CO_2$ make shipowners choose less energy-efficient engines.

Market-based instruments for use in the shipping sector must be designed in a manner that does not violate the United Nations Convention on the Law of the Sea (UNCLOS) or distort trade and competition. As congestion is expected to become worse in land-based modes of transport, it is essential to develop short-sea shipping in an environmentally benign way and make best possible use of the 'motorways of the sea'.

## 1.1 Structure

After a short introduction on the environmental impacts of shipping emissions and current regulations, this report goes on to assess potential technologies and market-based instruments for the abatement of $NO_x$ and $SO_x$. The analysis departs from an assessment of two recent reports issued by NERA, whose recommendations are carefully examined as a baseline for further steps. A proposal for the design of a pilot scheme for the Baltic Sea is presented, and its legal feasibility, administrational structure and cost-effectiveness are discussed.

## 1.2 Delimitations

The study covers commercial ships larger than 400 GT in the Baltic Sea Area. Fishing vessels, military and leisure craft are excluded regardless of size. The study mainly addresses $SO_x$ and $NO_x$. However, a similar approach could in future be used on emissions of $PM_{10}$.

$CO_2$ is covered by a separate report (Per Kågeson, *Linking $CO_2$ emissions from International Shipping to the EU ETS* (UBA 2 July 2007)).

## 2 The environmental and health impacts of shipping

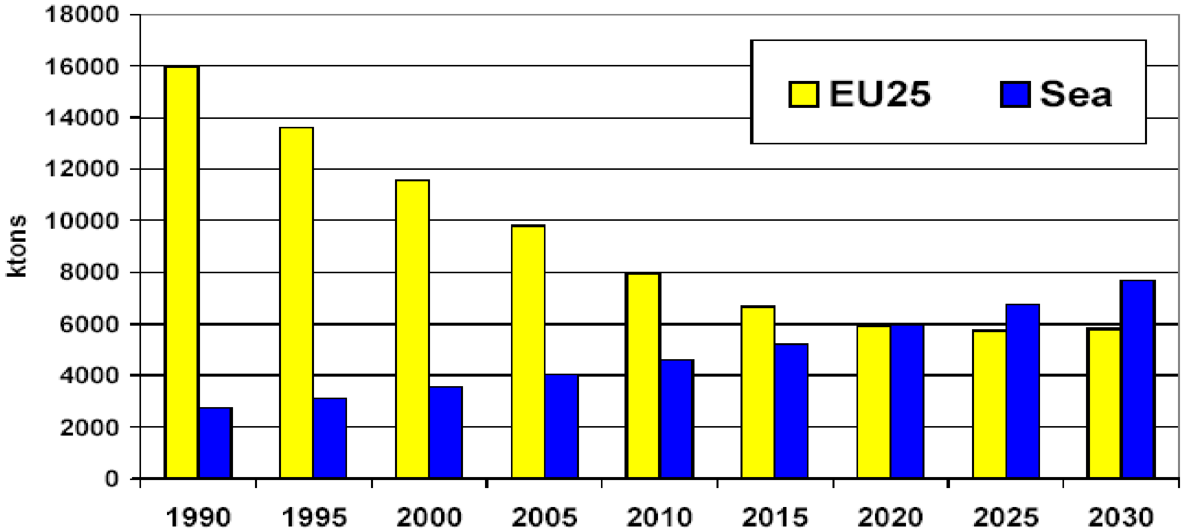
Emissions of $NO_x$, $SO_x$ and PM are threatening human health and the environment in numerous ways. The main object of this paper is not to provide a detailed analysis of the environmental impact of shipping emissions, which has been done elsewhere, but to assess various options for their abatement. Nevertheless, a short summary of the environmental effects might be useful as a background to the assessment of policy instruments that follow in later chapters.

### 2.1 Nitrogen oxides emissions

Nitrogen is an inert gas that makes up approximately 78 per cent of the volume of the lower layers of the earth's atmosphere. In the combustion of fuels, nitrogen reacts with oxygen to form oxides of nitrogen ($NO_x$). Initially in this process mostly nitric oxide (NO) is formed. Later, during the expansion process, and in the exhaust, some of this NO will convert to nitrogen dioxide ($NO_2$) and nitrous oxide ($N_2O$), typically 5 and 1 per cent respectively of the original NO. The mix of oxides of nitrogen is called $NO_x$. These emissions have residence times of 1 to 3 days, which mean they can be transported up to 1,200 km.

Worldwide, ship $NO_x$ emissions have been estimated at about 10 million tonnes per annum, equivalent to about 15 per cent of the total global $NO_x$ emissions from fossil fuels (Corbett and Eyring, 2007). In 2000, the emissions from ships engaged in international trade in the seas surrounding Europe were estimated to have been 3.6 million metric tonnes of nitrogen oxides. As mentioned in the previous chapter, the share of emissions from shipping is constantly rising. Table 1 shows the trends for $NO_x$ in EU25 and the surrounding seas.

**Table 1: Emissions of $NO_x$ 1990–2030 (ktons)**




Source: Main baseline scenario developed by IIASA for the Commission's CAFE program. http://www.iiasa.ac.at/rains/cafe.html (October 2004)

Although great amounts of $NO_x$ emitted from ships in international trade are deposited at sea, shipping is a large source of acid deposition in many countries in Europe. Especially in sensitive coastal regions, ship emissions contribute notably to overstepping the critical loads of acidification (Committee on the Environment, Public Health and Consumer Policy, 2003).

$NO_x$ also causes eutrophication, affecting biodiversity both on land and in coastal waters. In 2000, the depositions of nitrogen exceeded the critical loads for eutrophication on 800,000 square kilometres, representing about 60 per cent of the sensitive terrestrial ecosystems in EU25 (Amann et al, 2004). $NO_x$ from shipping also contributes significantly to the severe eutrophication of the Baltic Sea.

Nitrogen oxides also contribute to the formation of ozone, a major health hazard in many regions of Europe and a cause of vegetation damage and reduced crop yields. Around three quarters of the urban population in southern Europe, and 40 per cent of that in northern Europe live in cities where levels exceed the EU air quality standard for ozone. The exposure to high levels of ozone and $PM_{2.5}$ (see below) results in 370 000 annual cases of premature death in Europe (European Commission, 2005a and 2005b). Under current trends the number of fatalities is likely to stay high even in 2020, and by then maritime shipping may have become the most important source in Europe of the main precursor, $NO_x$. Shipping emissions already contribute considerably to the formation of ozone, especially in the Mediterranean region (Jonson et al, 2000).

Ozone is also a greenhouse gas, contributing to global warming. According to a study commissioned by the IMO's environment committee (MEPC), the radiative forcing resulting from increased levels of ground-level ozone due to $NO_x$ from international shipping is "highly likely to produce positive forcing effects that will contribute to global warming and that could be in the same range as (or larger than) direct forcing from $CO_2$" (Committee on the Environment, Public Health and Consumer Policy, 2003).

## 2.2 Sulphur emissions

Emissions of $SO_x$ are a function of the sulphur content of the fuel oil. The sulphur content of fuels can vary from less than 0.1 per cent to more than 5 per cent (50,000 ppm). On average, distillate diesel fuel contains 0.3-0.5 per cent sulphur and residual fuel oil around 2.3-3.0 per cent. According to IMO (2006), the average sulphur content worldwide is 2.7 per cent[1].

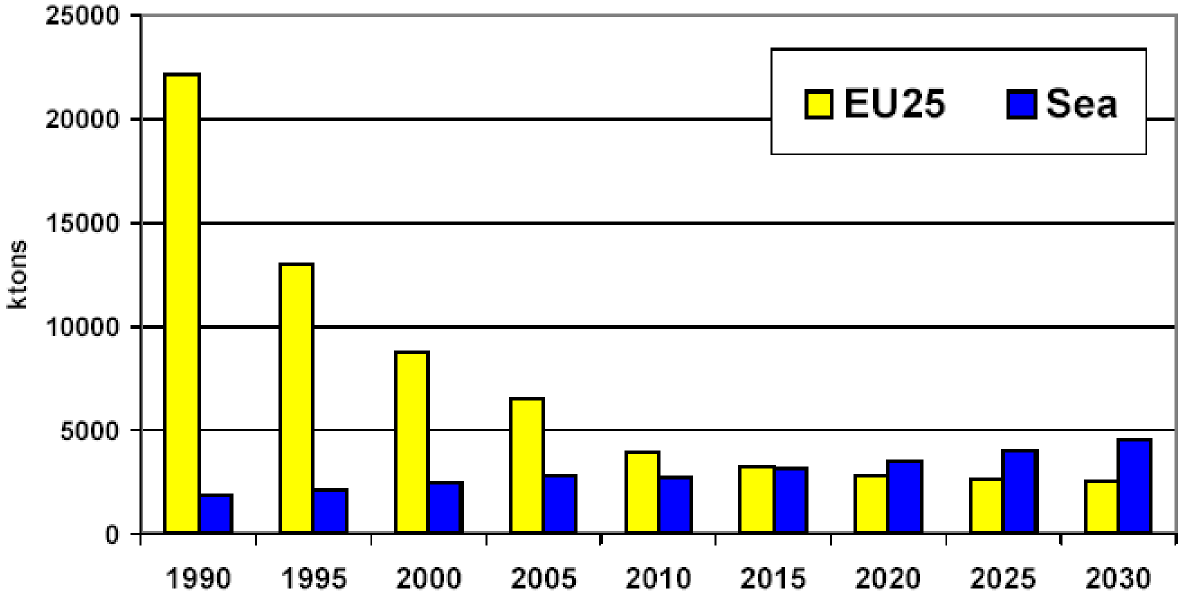
By the burning process in the cylinder, sulphur contained in the fuel oil is oxidised into sulphur dioxide ($SO_2$). Thereby mainly $SO_2$ and 2-3 per cent $SO_3$ (diesel engine) are produced. Sulphate ($SO_4$) may also be emitted in small amounts combined with metals. The amount of sulphur oxides emitted is proportional to the sulphur content of the fuel and fuel consumption. Approximately 95 per cent of the sulphur from the fuel appears in the exhaust gases, the rest remains in the lubricating oil and the sludge (Groß, 2000).

$SO_2$ has higher residence time in the atmosphere than most other pollutants. This allows $SO_2$ to be transported over long distances and deposited far from the point of origin. $SO_x$ compounds typically remain in the air for 4-7 days, but can stay airborne for up to several years (EPA, 2002). This means $SO_2$ can frequently travel up to several hundred kilometres and $SO_2$-related problems are not confined to areas where the gas is emitted but may also appear in faraway regions (Bakewell et al, 2004).

[1] IMO MEPC 55/4/1, 55th session, Agenda item 4, Sulphur monitoring 2005, Submitted by the Netherlands, 2 June 2006

Sulphur emissions from shipping are estimated at 4.5 to 6.5 million tonnes per year, which corresponds to about 4 per cent of total global sulphur emissions. In 2000, the emissions from ships engaged in international trade in the seas surrounding Europe were estimated to have been 2.6 million metric tonnes of $SO_2$ (Amann et al, 2004). As mentioned in the introduction, the share of emissions from shipping is constantly rising. Table 2 shows the trends for EU25 and the surrounding seas for $SO_2$.

**Table 2: Emissions of $SO_2$ 1990–2030 (ktons)**




Source: Main baseline scenario developed by IIASA for the Commission's CAFE program. http://www.iiasa.ac.at/rains/cafe.html (October 2004).

Emissions over open seas are spread out and the effects are moderate, but emissions close to land create considerable environmental problems.

In high concentrations $SO_x$ causes irritation to eyes and the respiratory system. $SO_x$ is a pre-cursor to the formation of fine particulate matter. Sulphate particles contribute to increased levels of haze, thereby reducing visibility.

The emission of $SO_x$ is a major cause of acid rain and the acidification of soil, groundwater and lakes. Sulphuric acid ($H_2SO_4$), which is formed from $SO_x$, converts lime in building bricks and finery into gypsum, which has a larger volume and – compared to lime – is more easily water-soluble and thus vulnerable to damage by corrosion.

$SO_x$ reacts with water vapour in the stratosphere to form a dense optically bright haze layer that reduces the atmospheric transmission of some of the sun's incoming radiation. $SO_2$ thus has a negative radiative forcing.

## 2.3 Particulate matter emissions

Particulate Matter (PM) is a term for a mixture of large and small airborne particles. The causal factors within this complex mixture are difficult to define and have not yet been totally identified. Particle size distribution of PM from marine engines is not well known, but the vast majority in number of particles is said to be smaller than 2.5 micrometres whereas the total mass is comparatively low. Considering the residual fuel used, it is assumed that the exhausts contain more large particles compared to particulate matter emitted from on-road diesel vehicles using distilled low-sulphur fuels.

$PM_{10}$ refers to particles with a diameter of less than 10 micrometres and includes the 'coarse' fraction. $PM_{2.5}$ refers to those with a diameter of less than 2.5 micrometres, comprising the 'fine' fraction. 'Ultra-fine' particles have a diameter smaller than 0.1 micrometres and make up most of the PM emissions from diesel engines running on distillate fuels (WHO, 2005).

Primary particulates are emitted directly into the atmosphere from combustion processes. Secondary particulates are formed in the exhausts or in the atmosphere in chemical reactions with sulphur dioxide, nitrogen oxides and ammonia ($NH_3$). The ambient residence time of particles varies with their size. In general, coarse particles tend to settle rapidly. The travel distance of such particles could be from one to tens of kilometres. By contrast, fine particles remain suspended longer in the atmosphere, and tend to be transported hundreds to thousands of kilometres. PM is the main source of haze that reduces visibility. It often takes hours or days for $PM_{10}$ to settle on the ground or sea.

Primary particles emitted from shipping in European waters have been estimated at 210,000 tonnes in 2000, and are expected to rise to 330,000 tonnes in 2020 (European Commission, 2005b). In addition shipping is estimated to contribute between 20 and 30 per cent to the ambient concentrations of secondary inorganic particles in most coastal areas (European Commission, 2002).

There is evidence from several studies that short and long term exposure to $PM_{10}$ and $PM_{2.5}$ cause human health problems, especially when originated by motor vehicles. Fine particles ($PM_{2.5}$) are strongly correlated with harmful effects on human health as they can penetrate deep into the lungs whereas larger particles tend to be removed by respiratory clearance mechanisms. "Long-term exposure to elevated $PM_{2.5}$ is associated with mortality from cardiopulmonary diseases and lung cancer, and … the development of chronic respiratory disease" (IMO/BLG 12, 2007). There is insufficient evidence to determine a safe level of human exposure to particles and in practical terms all emissions of PM should be regarded as harmful.

Various components of airborne fine particles ($PM_{2.5}$) have climate-forcing impacts, either contributing to or offsetting the effects of greenhouse gases. In particular, black carbon particulate matter has been identified as an important contributor to radiative heating. Sulphate and nitric particles, on the other hand, may have a negative radiative forcing as they reflect sunlight.

Although not as intensively investigated as the development of sulphur and nitrogen emissions PM emissions from shipping are assumed to cause 62.000 to 64.000 premature deaths per year (3 – 8 per cent of all deaths from global outdoor fine PM pollution) with an expected increase of 40% by 2012 (IMO/BLG 12, 2007) due to an increase in shipping traffic.

# 3 Existing regulations of emissions from shipping

## 3.1 Sulphur oxides

MARPOL Annex VI regulates $SO_x$ emissions from ships by a worldwide limit on the sulphur content in marine fuels of 4.5 per cent (45,000 ppm). Special '$SO_x$ Emission Control Areas' (SECAs) are allowed to be established in which more stringent control of sulphur emissions operate. In these areas, the sulphur content of fuel oil used on board ships must not exceed 1.5 per cent. Alternatively, ships may fit an exhaust gas cleaning system or use any other technological method to limit $SO_x$ emissions to less than 6 g/kWh in the exhaust gas.

The Baltic Sea was designated a SECA with effect from 19 May 2006 by IMO. According to EU-law operators of passenger vessels on regular services to or from any Community port must comply with the 1.5 per cent limit while they are in EU territorial seas, the exclusive economic zones, and pollution control areas, including the North Sea and the Channel since 11 August 2006.

For the North Sea and Channel SECA, the same limit entered into force on 21 November 2006, with full implementation 12 months later.

The European Commission has developed a strategy to reduce air pollution from ships. As part of that strategy, the European Parliament and Council have adopted the Sulphur Directive (2005/33/EC[2]) requiring the use of low-sulphur fuel by certain ships operating in European waters, specifically including:

- A 1.5 per cent sulphur limit for fuels used by passenger vessels on regular service between EU ports, effective in 2006; and
- A 0.1 per cent sulphur limit for fuels used by inland vessels and seagoing ships with berths in EU ports, effective in 2010.

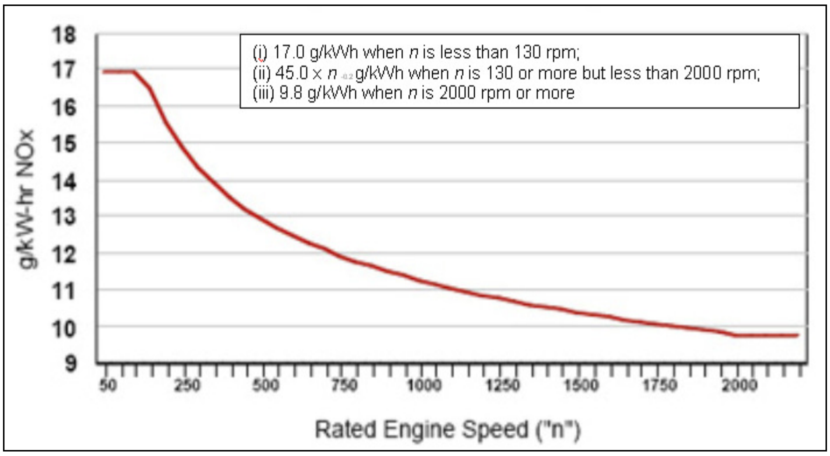
## 3.2 Nitrogen oxides

The Technical Code of MARPOL Annex VI regulates $NO_x$ emissions from diesel engines with a power output greater than 130 kW installed on a ship constructed after January 2000. The specified $NO_x$ limit represents only a small reduction in emissions compared to unregulated engines.

The $NO_x$ emission requirements of MARPOL's Technical Code, shown in Figure 1, relate to engine revolutions. The permissible emission of $NO_x$ is a function of the engine's rpm and varies from 17.0 g/kWh, when the rated engine speed is less than 130 rpm, to 9.8 g/kWh, when the engine speed is equal to or above 2000 rpm. The lower the engine's revolutions, the more polluting it is thus permitted to be.

[2] DIRECTIVE 2005/33/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL, 6 July 2005, amending Directive 1999/32/EC

**Figure 1: Emission requirements for Nitrogen Oxides ($NO_x$)[3]**




Source: MARPOL Annex VI, Technical Code

## 3.3 Particulate matter

MARPOL Annex VI currently provides no limits for emissions of particulate matter.

## 3.4 The revision of MARPOL Annex VI

At its meeting in July 2005 the Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) agreed to initiate a process to revise international standards for emissions of $SO_x$ and $NO_x$ from shipping and to consider regulating emissions of particulates as well as volatile organic compounds emitted from cargoes. Limits on existing engines will also be considered. The MEPC's action came after a group of seven European nations officially proposed the commencement of a process to consider stronger air pollution standards. The review of Annex VI is being carried out by the Sub-committee on Bulk Liquids and Gases (BLG), and should be ready by 2008.

[3] Maximum allowable NOx emissions for marine diesel engines (MARPOL Annex VI, Regulation 13, NOx curve)

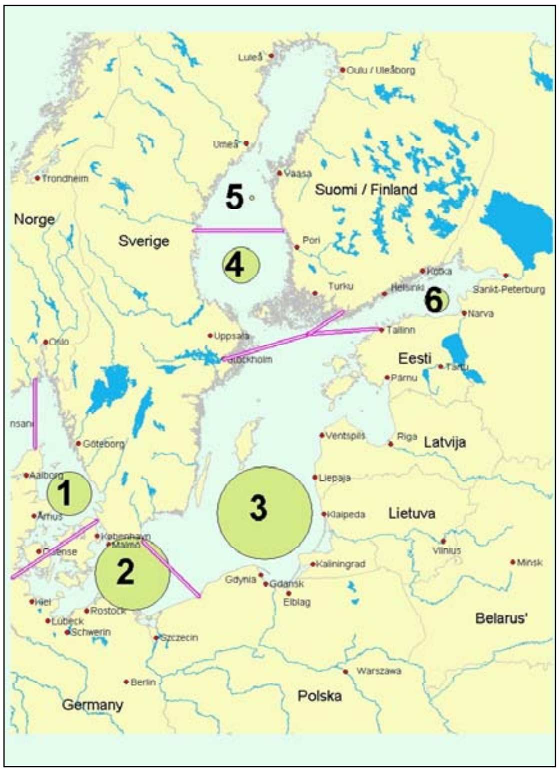
# 4 Emissions from ships in the Baltic Sea

A primary objective of this report is to present a proposal for market based instruments to be used in a pilot scheme for reducing emissions from maritime transport in the Baltic Sea. This chapter defines the test area, provides figures on current traffic and emissions and gives a forecast for traffic and emissions until 2020.

## 4.1 Definition of the regions for classification of the traffic in the Baltic

There are several good reasons for making the Baltic Sea a test region for market-based instruments:

**Figure 2: Regions of the Baltic Sea[4]**




- The Baltic is a sensitive area because of its nature environment and the population density of the area surrounding its basin.
- The IMO has recognized the sensitivity of the Baltic by awarding it the SECA status.
- Surrounded by highly developed industrial countries, the Baltic Sea is used for intensive sea transport, which is expected to increase dramatically over the next decade.
- Coastal states have shown interest in sustainable shipping by making several attempts to support the move towards more environmentally benign maritime transport.
- The availability of data is better than in most other regions.
- With the exception of a few miles of Russian coast, the Baltic Sea is entirely surrounded by EU countries, which should offer more opportunities to introduce high environmental standards.
- In order to include the ferry traffic from Copenhagen and Kiel to Oslo the borderline between the North Sea and the Baltic Sea is defined by a line which connects Cape Skagen with Oslo. This sector merely considers the traffic to and from the Baltic.

## 4.2 Current traffic

The aim of this chapter is to describe the sources of air pollution. Therefore, traffic is analysed according to ship types, ship sizes, routes and frequency. Knowledge of ships, their en-

[4] The separation of the Baltic Sea into six regions was made for calculation purposes.

gines and routes allow one to estimate the total amount of installed engine power[5] and the time the engines are running and producing emissions.

In the future the AIS[6] will provide more complete information on individual ship movements. For this study the potential sources of reliable data were the ship movement data of Lloyd's and statistics published by countries and ports. However, as Lloyd's excludes many regular services like ferry lines the data for the analysis was compiled generally on the following main sources:

- Schedules of cruise ships regularly using the Baltic Sea;
- Schedules of ferry services according to "Statistics" from ShipPax Information;
- Schedules of RoRo ships according to ShipPax Information and sailing lists of ports;
- Official statistics of the Kiel Canal authority;
- Daily reports of vessels passing through the Kiel Canal;
- Reports on the traffic through the Great Belt and Sound (Öresund);
- Sailing lists, traffic statistics and turnover statistics of all the major ports in the Baltic Sea.

### 4.2.1 Ship types

The ship movements considered belong to the following types of traffic:

- Cruise shipping
- Extra Baltic tramp traffic
- Extra Baltic liner traffic including feeder traffic
- Intra-Baltic short sea traffic with subdivisions
    - Ferry
    - Roro
    - Regular forest products trades
    - Multi-purpose (coasters)
    - Bulk shipping
- Local ferry services

Finally they were aggregated into the following groups:

- FC (Ferry, Cruise)
- RoRo (RoRo-Shipping (no passenger)
- Container (Container incl. combined Container, Feeder, Reefer)

[5] Auxiliary engines were not considered – in the case of diesel-electric ship 85% of total engine capacity was used

[6] AIS, Automated Identification System: AIS is compulsory for all passenger ships and all cargo ships of 300 GT and more engaged in international voyages.

- General (Cargo: Dry cargo, Heavy lift)
- Others (Bulker, Crude Oil-, Chem.-, Prod.- and Gas Tanker and Miscellaneous)

### 4.2.2 Definitions and traffic data

#### *4.2.2.1 Cruise shipping*

Cruise shipping is defined as pure passenger shipping without any cargo transport. The minimum duration is one overnight stay on board, which makes cruises clearly discernable from day excursions. The season is from June to September, but many ships make alternative trips to Baltic ports and to Norway. Therefore, the average number of Baltic Sea round trips per ship in one season is 8 to 10.

#### *4.2.2.2 Extra-Baltic traffic*

Extra Baltic traffic is generated by ships entering and leaving the Baltic Sea via the Kiel Canal, the Great Belt or the Sound (Öresund), and the Kattegatt.

#### *4.2.2.3 Traffic through the Kiel Canal*

The *roro traffic* that uses the canal is around 900 vessels per year per direction or 17 ships per week. It can be assumed that most of these vessels make weekly round trips from and to North Sea ports in Belgium, the UK and Germany. A few more make longer trips to the Iberian Peninsula. In the Baltic Sea most roro ships call at Finnish ports or at ports in northern Sweden. The average GT of the roro vessels is 9,700.

The *feeder traffic* passing through the canal consists of approximately 2,300 container vessels per year per direction or 45 ships per week. Most of these vessels make weekly round trips from and to Hamburg and Bremerhaven. Only a few travel to Rotterdam, Antwerp and UK ports. The most important ports for the feeder traffic in the Baltic Sea are in the north-eastern part such as St. Petersburg and Helsinki. The container fleets are much more homogenous than the general cargo or tanker fleets. Most ships belong to standard types delivered by J.J. Sietas Shipyard of Hamburg or by Hegemann Rolandwerft. They have typical capacities of 508, 658, 822 TEU and corresponding gross tonnage. These ship sizes were partly outdated in 2006. Because of the rapidly increasing container turnover in St. Petersburg the operators have already introduced 1200 TEU vessels.

About 1,600 *chemicals/oil tankers* per year pass through the canal from East to West and about 1,400 in the other direction. Westwards there is an average of 31 ships per week. This figure is backed up by data from selected week in September 2004. The figures for the average size of 5,000 and 4,600 GT respectively and a maximum size below 20,000 dwt prove that the majority of tankers in the Kiel Canal carry chemicals, oil products, bunker oil or vegetable oils. Larger tankers use the Great Belt.

The *general cargo traffic* amounts to around 9,000 movements per year in each direction or on average 176 per week. The mean size is 2,800 GT and observations show that most are between 1,000 and 5,000 GT. In this size group the multi-purpose single-decker is the standard ship.

#### 4.2.2.4 *Great Belt and Sound*

Danmarks Statistik publishes figures on the ships passing through Danmark's natural approaches in its statistical yearbook. The figures for 1994, 2003 and 2004 are displayed in table 3.

**Table 3: Number of ship passages in the Great Belt and Öresund.**

| Passage | | 1994 | 2003 | 2004 |
|---|---|---|---|---|
| Öresund | northward | 14,366 | 17,916 | 16,717 |
| | southward | 16,249 | 19,245 | 18,659 |
| Gr. Belt | northward | 9,035 | 9,559 | 10,111 |
| | southward | 8,420 | 7,845 | 7,959 |
| Total | northward | 23,401 | 27,475 | 26,828 |
| | southward | 24,669 | 27,090 | 26,588 |
| | grand total | 48,070 | 54,565 | 53,416 |

Source: Danmarks Statistik: Statistik Aarbog 2005, Tab. 374, based on Soevaernets Operative Kommando

#### 4.2.2.5 *Intra-Baltic short sea traffic*

Data on ferry traffic have been collected from "Statistics" by "ShipPax" of Sweden, and a number of other sources, including ferry ports. Port data have also been used for estimating the duration and length of trips by other types of ship. However, the ports of origin and destination are only known for ferries and a large percentage of roro and container ships. For general cargo ships and others, the destination, have been estimated. The reason for this is not only lack of information but also the large data volume, which requires some generalisation.

#### 4.2.2.6 *Local ferry services*

Where ferries are concerned, most national shipping statistics do not include the local ferry routes. Sometimes they are included in a lump sum, but detailed data are lacking. Such services are negligible in Germany, Poland, Lithuania or Latvia but more interesting in Estonia, Finland and Sweden, and, above all, in Denmark. While the statistics of international and major national routes in Denmark include 80,000 ferry arrivals, the total figure for this ship type is 516,000 per year. Such a huge figure includes small shuttle-type services, small ships on routes of various distances, but also more important routes with ferries of more than 1,000 GT. These local routes contribute significantly to on-shore problems on shore because of the proximity to land and the short distances, which result in longer port stays than sailing times.

### 4.2.3 Results on traffic flows

Subtracting the transits from the total number of movements (598,000 incl. transit), the number of trips in the Baltic Sea is 433,000 (counting both directions). They consist of 85,880 extra-Baltic and 347,000 intra-Baltic movements. The internal traffic consists mostly of ferry traffic for which the quality of data is good. For other ship types like general cargo and bulk carriers or tankers the routes and the number of ships have partly been estimated. Since more than 50 per cent of the trips are made by ferries, the reliability of data and the results are thus considered to be satisfactory.

The results of the traffic analysis have been divided into the six main regions of the Baltic Sea in the chart above.

- Region 1: The Kattegat and Denmark
- Region 2: Southern Baltic Sea including Bornholm
- Region 3: Baltic Sea between Bornholm and Stockholm
- Region 4: The Aaland Sea
- Region 5: Gulf of Bothnia
- Region 6: Gulf of Finland

After the separation of the Baltic Sea into the regions above the traffic was classified. Table 4 shows an example for the classification of the traffic for different relations.

**Table 4: Examples for the classification of different relations to regions**

| Trip | | Region | | |
|---|---|---|---|---|
| From | To | 2 | 3 | 6 |
| Rostock | Malmö | Intra | - | - |
| Rostock | Klaipeda | From/To | From/To | - |
| Rostock | St. Petersburg | From/To | Transit | From/To |

Source: GAUSS, 2007

For each region figures have been calculated that indicate the number of ships, the aggregated GT figure, the aggregated kW figure and the hours this output has been used. This leads to easily comparable figures of billion kWh per region (TWh). The results are presented in Table 5. Please note that the figures for energy reflect the energy transferred to the propellers. To arrive at the fuel used for moving the ships one would have to consider the engine efficiency rate. If it is assumed to be 45 per cent, the fuel consumption for the entire region would be 66 TWh.

**Table 5: Ship movements, transits and energy used divided by region (both directions)**

| Region | Total movements | Ships transits (thereof) | Number of trips | Energy (TWh) |
|---|---|---|---|---|
| Region 1 | 221,000 | 38,800 | 182,200 | 4.5 |
| Region 2 | 166,500 | 64,900 | 101,600 | 7.8 |
| Region 3 | 97,000 | 50,600 | 46,400 | 10.3 |
| Region 4 | 49,500 | 10,300 | 39,200 | 3.9 |
| Region 5 | 13,500 | - | 13,500 | 0.5 |
| Region 6 | 50,400 | - | 50,400 | 2.6 |
| Regions 1-6 | 597,900 | 164,600 | 433,300 | 29.6 |

Source: GAUSS, 2007

In Table 5 in column 2 "Total ship movements" are listed and in column 3 "transits thereof". Both figures are mentioned because the transits are only legs of longer trips and the total movements minus transits results in the total number of trips in the Baltic Sea.

Assuming that ferries, cruise ships and the small general cargo ships (coasters) are equipped with medium-speed diesel engines and the others - mostly tankers and bulkers - with slow-speed engines, the emissions can be roughly calculated. However, when calculating the emissions a value of 85 per cent of the installed of the total kW was used.

## 4.3 Current emissions

According to the calculations based on the assumptions above the situation with ship emissions in 2004 in the Baltic Sea is as follows.

### 4.3.1 $SO_2$ emissions

In the following table the results of the calculation of the emissions for 2004 in the Baltic are shown. SECA was not yet in force, however due to certain circumstances e.g. *Swedish Differentiated Fairway Dues,* marketing concepts etc. the assumptions were set lower compared to the world wide average of 2.7 per cent. The average for the calculation was estimated in a range between 1.3 and 2.5 per cent depending on ship types as well as regional aspects and extra Baltic traffic. Ship type specific emission rates for the calculation are based on ENTEC.

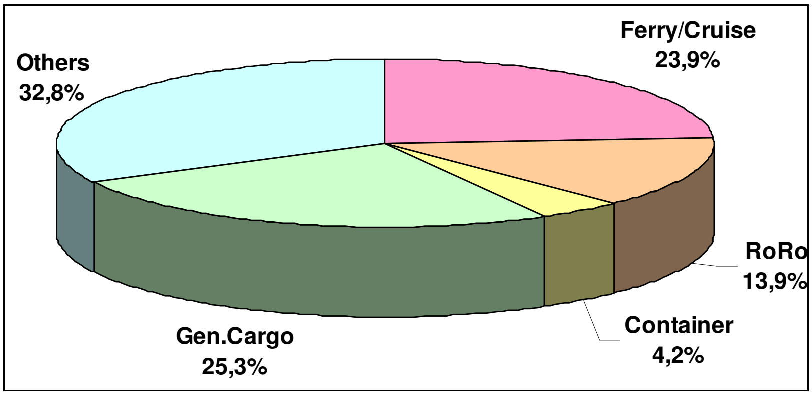
**Table 6: Emissions of $SO_2$ in tons in 2004 (based on used GWh)**

| Region | Ferry/Cruise | RoRo | Container | Gen.Cargo | Others | *Total* |
|---|---|---|---|---|---|---|
| 1 | 9,159 | 876 | 1,432 | 7,628 | 10,320 | 29,415 |
| 2 | 13,165 | 7,855 | 2,020 | 10,522 | 16,362 | 49,924 |
| 3 | 9,151 | 13,513 | 3,471 | 20,823 | 24,486 | 71,443 |
| 4 | 10,401 | 2,834 | 500 | 3,580 | 4,921 | 22,235 |
| 5 | 113 | 115 | 20 | 1,154 | 2,898 | 4,301 |
| 6 | 4,459 | 1,743 | 622 | 5,420 | 4,736 | 16,981 |
| Total | 46,448 | 26,936 | 8,065 | 49,126 | 63,723 | 194,299 |

Source: GAUSS, 2007

The distribution of $SO_2$ emissions among different ship types is as follows:

**Figure 3: $SO_2$ emissions in the Baltic Sea by ship type in 2004**




Source: GAUSS, 2007

The distribution of $SO_2$ emissions shows the high proportion of others (Tanker, Bulker etc.) and General Cargo due to the assumed high sulphur content in fuel oil and Ferry and Cruise shipping due to the large traffic volume.

### 4.3.2 $NO_x$ emissions

In the following table the results of the calculation of the $NO_x$ emissions for 2004 in the Baltic are shown. Ship type specific emission rates for the calculation are based on the $NO_x$ limits of MARPOL Annex VI. Ship type specific emission rates for the calculation are based on EN-TEC.

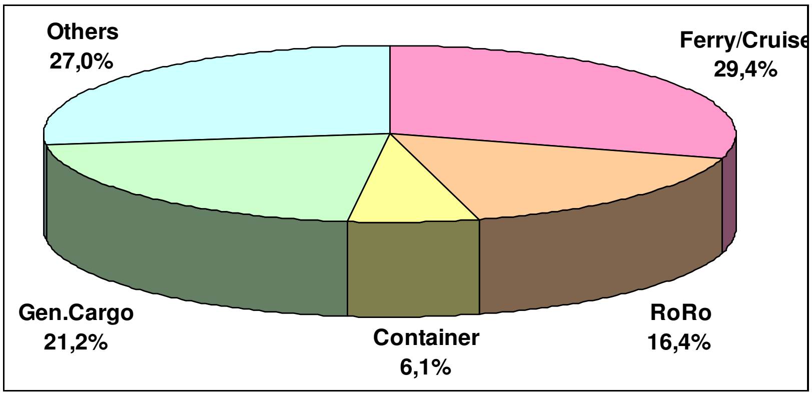
**Figure 4: Emissions of $NO_x$ in tons in 2004 (based on used GWh)**

| Region | Ferry/Cruise | RoRo | Feeder | Gen.Cargo | Others | Total |
|---|---|---|---|---|---|---|
| 1 | 21,986 | 2,016 | 4,177 | 12,636 | 16,781 | 57,595 |
| 2 | 32,440 | 18,565 | 5,891 | 17,430 | 26,605 | 100,930 |
| 3 | 21,138 | 31,410 | 10,124 | 34,493 | 39,814 | 136,979 |
| 4 | 25,967 | 6,631 | 1,458 | 5,930 | 8,001 | 47,987 |
| 5 | 284 | 265 | 60 | 1,912 | 4,712 | 7,232 |
| 6 | 11,054 | 4,116 | 1,815 | 8,978 | 7,701 | 33,664 |
| Total | 112,869 | 63,003 | 23,523 | 81,378 | 103,615 | 384,388 |

Source: GAUSS, 2007

Based on the figures above the distribution of $NO_x$ emissions among different ship types is as follows:

**Figure 5: $NO_x$ emissions in the Baltic Sea by ship type in 2004**




Source: GAUSS, 2007

### 4.3.3 PM emissions

The following table shows the calculation of the PM emissions for 2004 in the Baltic Sea. SECA was not jet in force therefore the range of 1.3 and 2.5 per cent sulphur content (shown in 4.3.1) was considered as the basis for the calculation of PM emissions. Ship-type-specific emission rates for the calculation are based on ENTEC.

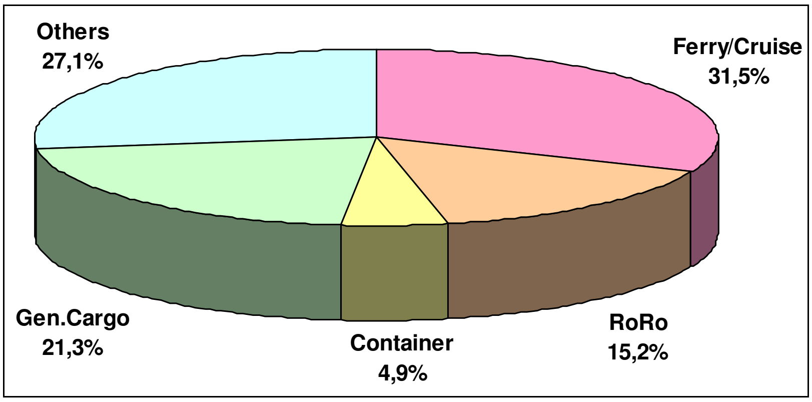
**Table 7: Emissions of PM in tons in 2004 (based on used GWh)**

| Region | Ferry/Cruise | RoRo | Container | Gen.Cargo | Others | Total |
|---|---|---|---|---|---|---|
| Total | 12,157 | 5,872 | 1,882 | 8,217 | 10,435 | *38,563* |

Source: GAUSS, 2007

As PM emissions are partly correlated[7] with the sulphur content of fuel oil, the distribution is similar to this. The allocation of PM emissions among different ship types is thus as follows:

**Figure 6: PM emissions in the Baltic Sea by ship type in 2004**




Source: GAUSS, 2007

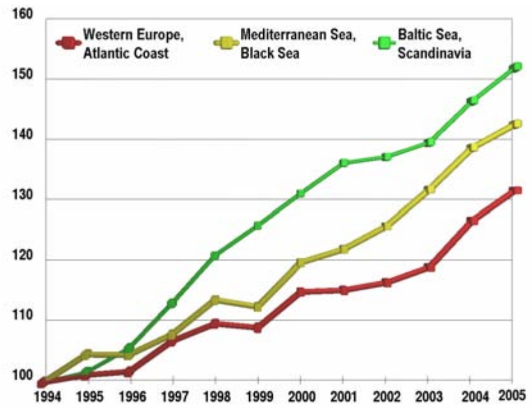
[7] Chapter 11.3, Fn. 26

## 4.4 Forecast for emissions until 2020

For the calculation of emissions, the results of different studies were considered (see references), among others the most recent IIASA Report from 2007 (IIASA, 2007) as it analyses $SO_x$ and $NO_x$ as well. However, due to different assumptions the results of the IIASA Report and this report cannot be easily compared. Apart from different methodology, different data sets and base year, the expected growth rates for the scenarios are different. Furthermore IIASA based their analysis on the assumption for the distribution of fuel oil by 90 per cent HFO with 2.7 per cent sulphur content and 10 per cent MDO with 0.2 per cent sulphur content for European waters in general.

Under IIASA's scenarios, growth rates from 2.5 per cent (cargo) and 3.9 per cent (passenger) for all European sea regions are expected. This is, according to the report, at the "low end" compared to other studies, e.g. Corbett 2007, assuming 4.1 per cent annual growth. For the separated growth in the Baltic Sea region, only a higher increase is expected by different sources (see Fig 7), partly due to the fact that a comparable high proportion belongs to "Ferries".

**Figure 7: Total cargo traffic of European ports by region 1994 - 2005 (Index 1994 = 100)**




Source: ISL, Shipping Statistics and Market Review Nov/Dec. 2006

For our calculations we expect above-average growth for the period from 2004 to 2020 as well. In order to address the possibility of different traffic growth rates in the Baltic Sea, two scenarios are provided (the aggregated results shown in Table 8).

The overall average growth rates for the calculations are different by ship-type and sea areas in the Baltic, and intra/extra Baltic traffic, as well as over the time line.

**Table 8: Assumed energy growth rates in the Baltic Sea**

| Period: | 2004-2010 | 2011-2015 | 2016-2020 | Overall average |
|---|---|---|---|---|
| Growth rate Scenario I | 6.6 % | 5.9 % | 4.9 % | 5.9 % |
| Growth rate Scenario II | 4.7 % | 4.3 % | 3.8 % | 4.3 % |

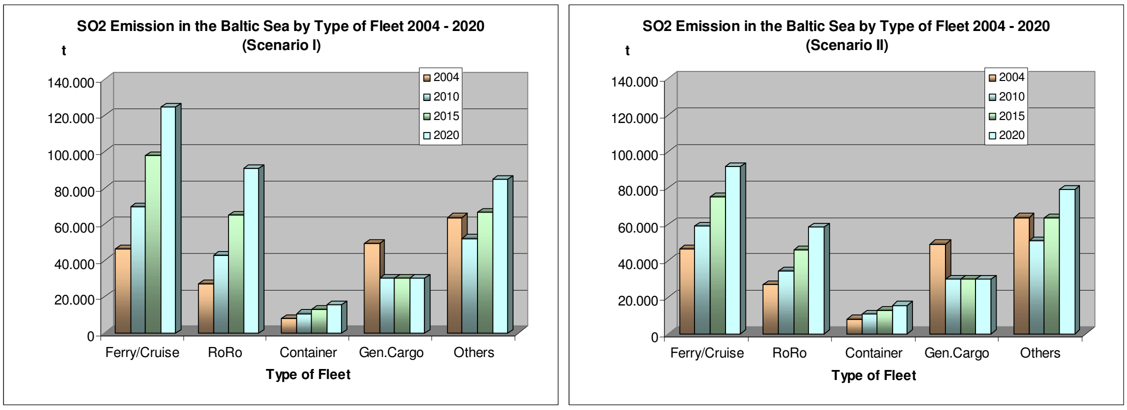
Source: GAUSS, 2007

The effects on traffic caused by the implementation of IMO's Marpol Annex VI – with regard to the $NO_x$ curve and the development of $SO_x$ emissions due to the recognition of the Baltic Sea as a SECA – are reflected in the 2010 figures. According to the assumption made in this study, total ship traffic would increase annually by an average of 5.9 (4.3) per cent as shown in Table 8. The total growth in used kWh from 2004 to 2020 would thus be approximately 148 per cent in Scenario I and 96 per cent in Scenario II.

### 4.4.1 $SO_2$ Emissions

Under the BAU scenario a sulphur content in fuel oil of 1.5 per cent until 2020 was assumed. Those modes of shipping with a higher proportion of external traffic (General Cargo, Others) using fuel with a sulphur content above 1.5 per cent will experience an initial decrease in emissions after the implementation of SECA followed by an increase due to traffic growth.

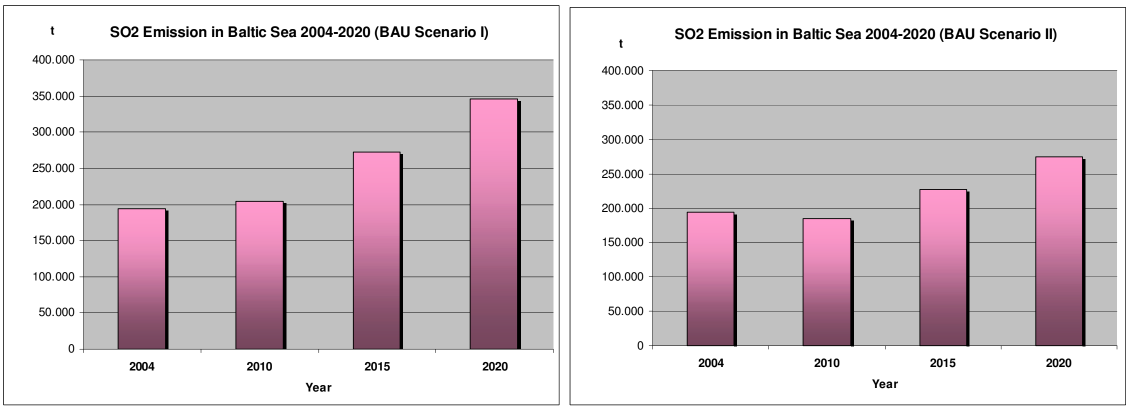
**Figure 8: $SO_2$ emissions by type of ship in tons 2004 – 2020, scenarios I and II**




Source: GAUSS, 2007

As the assumption is that there will be no growth in general cargo (transported mainly by Roro) and the $SO_x$ level is assumed to remain constant the emissions also remain constant. Especially in Ferry/Cruise and Roro, emissions are constantly rising as here internal traffic prevails and the sulphur content is expected to start from a comparatively low level. The expected further growth and shift from other ship-types to this sector will add to the rapid increase in emissions.

**Figure 9: $SO_2$ emissions in tons 2004 – 2020, scenarios I and II**



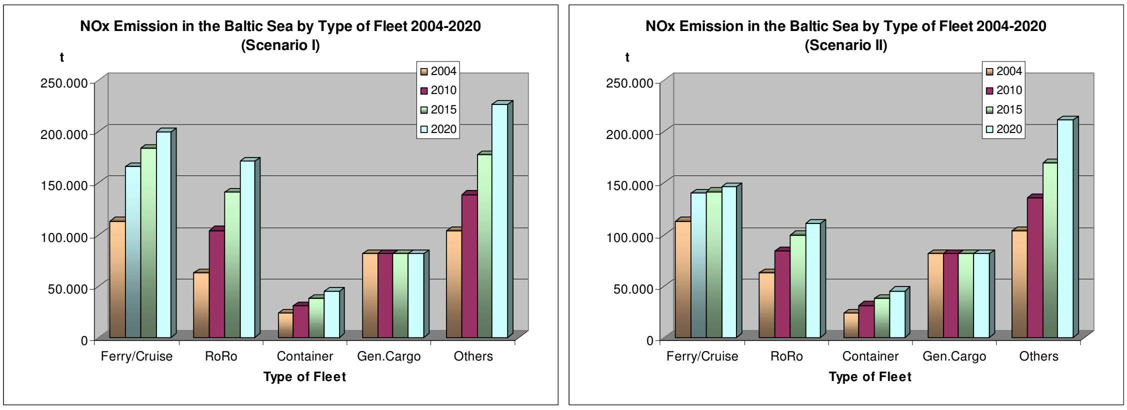

Source: GAUSS, 2007

As can be seen from the figures in Scenario I, sulphur emissions are rising despite the fact that SECA was implemented in 2006. In Scenario II, with lower traffic growth rates (Table 8), emissions are back to 2004 levels in 2011 despite the implementation of SECA.

### 4.4.2 $NO_x$ Emissions

Based on the assumed growth rates (Table 8), $NO_x$ emissions were calculated after taking into account different reduction technologies (SCR, DIW and HAM)[8] and their allocation to different fleet segments. New-builds were considered to have higher installation rates compared to existing vessels. Figure 10 shows the results of this calculation of $NO_x$ emissions by ship type over the periods until 2020.

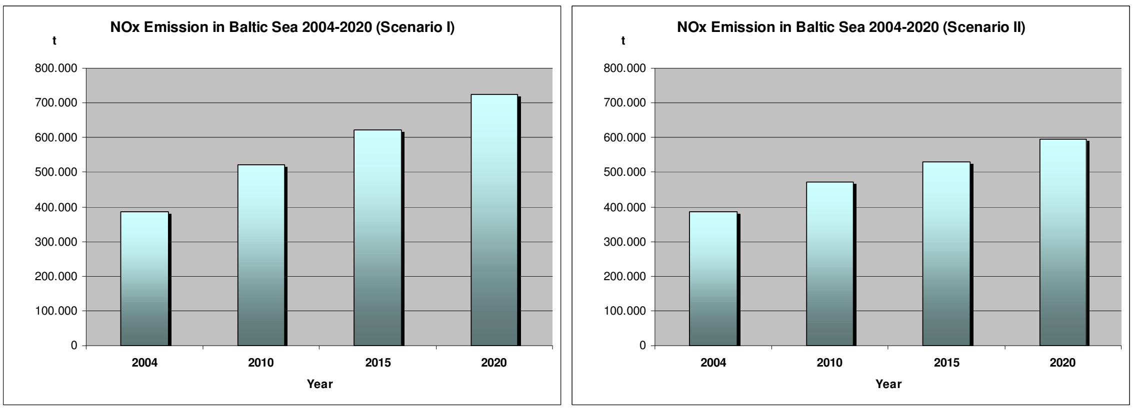
**Figure 10: $NO_x$ emissions by type of ship in tons 2004 – 2020, scenarios I and II**




Source: GAUSS, 2007

The aggregation of the above specific ship type $NO_x$ emissions (Figure 10) are shown over the periods until 2020 by years (Figure 11).

**Figure 11: $NO_x$ emissions in tons 2004 – 2020, scenarios I and II**



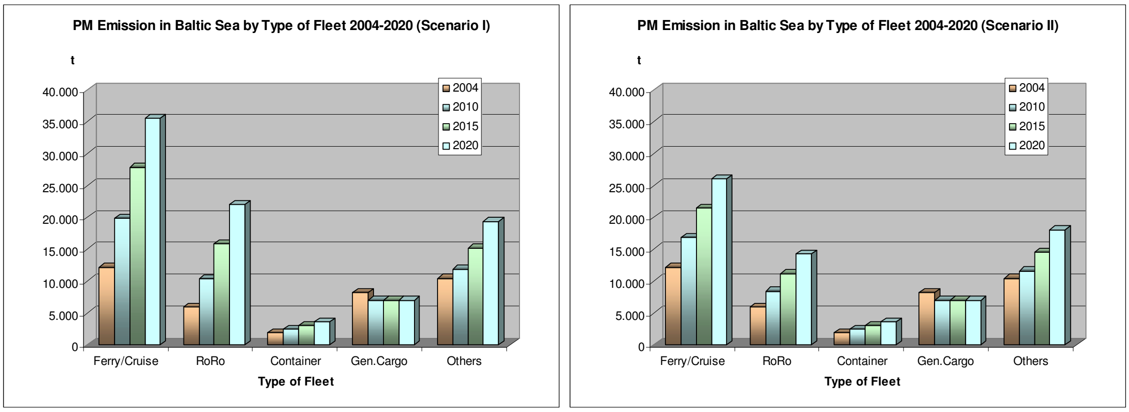

Source: GAUSS, 2007

[8] SCR with 90 per cent, DWI with 55 per cent and HAM with 77.5 per cent (chapter 11.1)

### 4.4.3 PM Emissions

The focus of the study is primarily on $SO_2$ and $NO_x$. However, as there may be significant changes in PM emissions due to change in the use of fuel oil it is important to evaluate and give an overview on the development of these emissions as well.

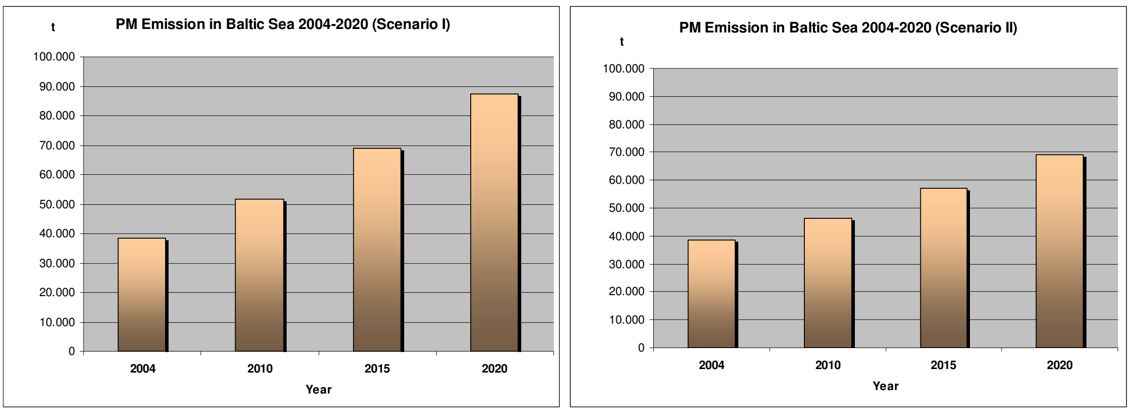
**Figure 12: PM emissions by type of ship in tons 2004 – 2020, scenarios I and II**




Source: GAUSS, 2007

In the calculations, the emissions of PM are partly correlated with the sulphur content of fuel oil, thus the development is linked to the development of sulphur dioxide; however it is not linear. A change to low-sulphur fuel (LSF) in order to abate sulphur emissions shows a positive effect on the reduction of PM emissions as well, which is getting comparably smaller with lower sulphur values.

**Figure 13: PM emissions by type of traffic in tons 2004 – 2020, scenarios I and II**




Source: GAUSS, 2007

## 4.5 Emissions in a business-as-usual scenario

The focus in this chapter has been to evaluate the development of emissions in the Baltic Sea. Based on the analysis of the existing traffic flows and expected growth rates up to 2020, combined with assumptions on the building of new ships and retrofitting of new-builds and existing ships with abatement technologies, the BAU calculations provided in chapter 4.4 were worked out. From these, it is clear that there will still be a considerable increase in emissions.

In the following table the aggregated emission figures for all traffic in the Baltic Sea are provided.

**Table 9: Total of Emissions in 2004, 2010, 2015 and 2020 (1,000 t), scenarios I and II**

| \Year Scenario Emission | 2004 | | 2010 | | 2015 | | 2020 | | % change 2004-2020 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | I | II | I | II | I | II | I | II | I | II |
| $SO_2$ | 194 | 194 | 205 | 185 | 272 | 228 | 345 | 275 | 78 | 41 |
| $NO_x$ | 384 | 384 | 521 | 473 | 621 | 530 | 723 | 595 | 88 | 55 |
| PM | 39 | 39 | 52 | 46 | 69 | 57 | 86 | 69 | 127 | 79 |

Source: GAUSS, 2007

Table 9 shows that total $SO_2$ emissions in the period until 2020 increase by approximately 78 per cent (41 per cent), $NO_x$ emissions by about 88 per cent (55 per cent) and PM emissions by 127 per cent (79 per cent) – the PM emissions take into account the lower reduction potential for PM in the case of better fuel quality depending on the scenario.

However, in order to assess the results accurately, it should be noted that there are a number of imponderables inherent in the calculated figures. First the distribution of internal/external traffic is not trivial minor matter; and it is subject to constant changes by new political and economic basic conditions in the affected states or regions, which (may) trigger new services and ship types etc. Second, the engines and equipment on board (abatement technologies) and fuel consumption of ships are very often not known in detail. And last but not least, the assessment of the sulphur content in fuel oil used by ships has an element of uncertainty.

# 5 Abatement measures and costs

The marine diesel engine is the dominant method of propulsion of merchant ships. Most ships have several diesel engines, including auxiliary engines for onboard electricity production. Among ships with two-stroke, low-speed engines, 95 per cent use heavy fuel oil (HFO) and the remaining 5 per cent are powered by marine distillate oil. Around 70 per cent of ships propelled by medium-speed engines use HFO, with the remainder burning either marine distillate oil or marine gas oil. High-speed engines operate on distillate oil or gas oil, and gas turbines use gas oil (Corbett, 2006).

## 5.1 Sulphur dioxide emissions

Sulphur emissions from sea vessels are almost proportional to the sulphur content of the fuel. The average global sulphur content of today's bunker oils is around 2.7 per cent. However, in SECAs such as the Baltic Sea, the highest permissible sulphur content is 1.5 per cent.

Shifting to a low-sulphur bunker oil requires few engine modifications. On the contrary the higher quality of the low-sulphur bunker oil leads to smoother running and less risk of operating problems. Several ferries operating in the Baltic have for some years used bunker oils with a content of less than 0.5 per cent sulphur. Environmental demands from major customers and environmentally differentiated fairway and harbour dues in Sweden have contributed to a rapid increase in cargo vessels operating on low-sulphur oil. Currently approximately 1,000 ships calling at Swedish ports run on low-sulphur bunker oils (generally with a sulphur content between 0.5 and 0.9 per cent).

### 5.1.1 A possible shift to marine distillate oil

The International Association of Independent Tank Owners (Intertanko) is an organisation with 250 members owning more than 2,500 tankers, which comprise 70 per cent of the world's independent tanker fleet. In October 2006, Intertanko in a submission to IMO proposed the establishing of a global sulphur cap of 1.0 per cent from 2010, to be lowered to 0.5 per cent in 2015. The latter limit is to apply to new ship engines only, i.e. those installed as from 2015. It was moreover proposed that as from 2010 all ships would use only one type of fuel, namely distillate fuel (Intertanko, 2006).

However, the current trend in fuel quality is negative from an environmental view. In 2005 residual oil made up 60 and 88 per cent respectively of bunker fuel used in domestic and international European shipping. The use of residual oil grew by 35 and 65 per cent respectively between 1990 and 2005, while demand for gas and diesel remained unchanged domestically and declined by 10 per cent in international shipping.

According to Intertanko, this proposal would result in large reductions in $SO_2$ and PM emissions, as well as reductions in $NO_x$ and $CO_2$ emissions from ships, with no other investment than a higher price for the fuel. It would eliminate the need for bunker treatment plants currently onboard ships, and also reduce the amount of generated fuel waste that needs to be stored, handled and treated onboard.

The use of distillate fuel only would mean that ships around the world would use a single, well-defined type of fuel, which would simplify the monitoring and control of fuel quality compliance as well as enhancing safety. It would also facilitate the use of advanced flue gas emission control devices.

The petroleum industry claims that a switch to distillate fuels would result in a net increase in $CO_2$ emissions equivalent to around 15 per cent of current refinery emissions and says that the shift would take more than 10 years to achieve because of the scale of construction required and the limited capacity of the engineering and construction industry (IPIECA, 2007). Sweden (2007), on the other hand, argues that the switch would reduce onboard fuel consumption by 5 per cent and result in a substantial reduction in the cleaning and maintenance work on all fuel-related systems and components. Sweden therefore proposes that the relevant IMO subcommittee should initiate a Life Cycle Analysis that provides a comparison between current practice and a shift to distillate fuels.

Growing demand for low-sulphur bunker oils and marine distillate oil will make it more difficult for refineries to use maritime transport as a way of disposing of residuals. An increase in the cost of low-sulphur fuel oils resulting from rising demand might trigger a shift to high-sulphur residual oils among land-based users such as electric utilities, who may find it cheaper to invest in flue gas desulphurisation to be able to use oil with a high sulphur content. Power stations would then become the new sink for residual oils. A second option is for refineries to invest in capacity to produce a higher share of distillate oil. A third might be to invest in gasification of the heavy residual oil.

### 5.1.2 Seawater scrubbing

An alternative to low-sulphur bunker oil and marine distillate oil could be to use a seawater scrubber to remove sulphur from the exhaust gas. The operation relies on hot exhaust gases mixing in a turbulent cascade with seawater, whereupon $SO_2$ in the exhaust is transferred to the seawater. The seawater is re-circulated, and sulphur and solid particles that were removed from the exhaust are trapped and collected for disposal.

A few trials with prototype scrubbers have been carried out in the last 15 years but currently only one vessel is equipped with a scrubber. The technique is said to be able to reduce the exhausts of $SO_x$ by up to 90 per cent when the ship is running on HFO. Entec (2005) assumes in its cost calculations that an average removal of 75 per cent is feasible and that the scrubber in addition removes 25 per cent of the ship's emission of particulate matter (PM). For fuel with 2.7 per cent sulphur content, a 75 per cent removal rate would result in remaining airborne emissions equal to 0.68 per cent of the fuel used.

Due to lack of trials there is only limited experience on how sensitive scrubbers are to various operational parameters, the most important being the alkalinity of the sea water. In non-marine waters and freshwater-dominated waters there may be an insufficient alkaline reserve to neutralise acid compounds by seawater scrubbing. In general all European waters except the Baltic Sea have normal marine alkalinity (as the alkalinity is proportional to salinity). Field tests suggest that the seawater consumption needed for 90 per cent $SO_x$ removal is substantial, and that in fresh and brackish waters the amount would have to be significantly increased to ensure the same reduction efficiency (CE Delft et al, 2006).

An additional problem connected to the use of HFO and seawater scrubbers is that when HFO is burned a small part of the sulphur is oxidised to $SO_3$. In the seawater scrubber any $SO_3$ formed will rapidly react with water vapour to form $H_2SO_4$ (sulphuric acid) vapour when the temperature falls below the dew point for the acid. CE Delft et al (2006) conclude that acid mist can potentially be formed in all scrubbers, especially if they are operated with low $SO_x$

cleaning efficiency and designed without taking the problem into account. Entec (2005) considers the problem to be insignificant in the open sea but potentially more problematic in port.

The acidic effluent from the seawater scrubber may contain a significant content of toxic particles (hydrocarbons and heavy metals), that should not be released in ports nor in brackish waters (Ives and Klokk, 1993). The water treatment produces an oily sludge which needs disposal. However, the acidity of the sludge might cause additional disposal problems and costs, which require further investigation to be better understood (Entec, 2005).

CE Delft et al (2006) recommend that seawater scrubbers should not be operated in waters where there is insufficient ability to absorb $SO_x$ and transform it into $SO_4$. They believe that the difficulties in using seawater scrubbing to achieve an efficient reduction of $SO_x$ might require ships operating in SECAs to have a control system that would ensure the scrubber is not used in areas with alkalinity levels that it was not designed for. Problems of this kind may appear not only in the Baltic Sea, where the salinity differs greatly between the Sound and the Gulf of Botnia, but also in entering river-based ports (e.g. the Port of Hamburg).

### 5.1.3 Costs of removing $SO_x$

The cost of $SO_x$ abatement is difficult to assess as the premium on distillate oil and low-sulphur heavy fuel oil depends on the balance between supply and demand in the oil market and on the development of crude oil prices. However, over the last five years there has been a tendency towards an increasing difference in cost between high- and low-sulphur heavy oils. Currently (February 2007) the premium for 1.0 per cent sulphur over 1.5 per cent is approximately $20 per tonne (+8%).

Entec (2005) considered two options for fuel switching – from the current average of 2.7 per cent sulphur residual oil down to 1.5, and to 0.5 per cent sulphur residual oil. There is a wide range of estimates for the additional cost of low-sulphur fuels, and Entec uses figures from two sources. According to these, switching to 1.5 per cent sulphur fuel would cost 1,230 or 2,053 euros per tonne of reduced $SO_2$, and for switching to 0.5 per cent sulphur fuel the cost would be 1,439 or 1,690 euros per tonne. IIASA et al (2006) say that switching from 2.7 per cent to 1.0 and 0.5 per cent would cost respectively 783 and 879 euros per tonne based on estimates by CONCAWE (2006) but add that an approximate 50 per cent uncertainty range should be observed.

For shipping in the Baltic Sea SECA, it is the difference between the cost of 1.5 per cent sulphur and 0.5 per cent that is relevant. Based on Entec's figures, the incremental cost of going from 1.5 to 0.5 per cent appears to fall in the range of 209 and 363 euros per tonne of $SO_x$ abated. Based on IIASA et al and CONCAWE's 2006 prices, the additional cost is only about 100 euros per tonne abated. The total cost, however, is substantial as 0.5 per cent sulphur equals a total reduction of 81 per cent from 2.7 per cent sulphur compared to only 44 per cent reduction for a shift from 2.7 to 1.5 per cent.

When considering the incremental cost of shifting to low sulphur heavy fuel oil or marine distillates, one needs to consider the positive effects on shipowners of reduced maintenance and prolonged engine life. Another positive side-effect is that PM emissions will fall by more than 60 per cent (Entec, 2005 with reference to US EPA).

The cost of removing $SO_x$ by seawater scrubbers for new ships has been estimated by Entec (2005) to be 13-16 euros per tonne of fuel depending on the size of the ship. For retrofits the equivalent cost was estimated to be 21-24 euros per tonne of fuel. These figures are equal to 320-390 and 504-576 euros per tonne of $SO_2$ removed for, respectively, new ships and retrofits. All figures, however, are based on very limited experience, and in the case of the Baltic Sea, one would have to add the costs for achieving an efficient reduction of $SO_x$ when using brackish water, and possibly also the costs of more far-reaching waste water treatment and waste disposal than required in the high seas.

The cost of reducing $SO_x$ by scrubber technology should not be compared with the incremental cost of shifting from 1.5 per cent sulphur oil in SECAs to fuel containing 1.0 or 0.5 per cent sulphur. It should rather be compared with moving from 2.7 to 0.5 per cent as the scrubber provides an opportunity to burn high sulphur oils in the SECA. The cost of switching from 2.7 to 0.5 per cent was calculated by Entec to be 64 euros per tonne of fuel in 2005. This is around three times the cost of retrofitting an existing ship with scrubbers. However, per tonne of $SO_2$ removed, the difference is somewhat smaller as the scrubber may not reduce the emission by quite as much.

## 5.2 Emissions of nitrogen oxides

Nitrogen oxides are formed in the combustion chamber of the engine when some of the nitrogen in the combustion air is oxidised due to high temperature and pressure. In the past decades the maximum combustion pressure and temperature in marine diesels have been markedly increased as a result of successful efforts to improve the energy efficiency (by as much as 20 per cent). However, increased emissions of $NO_x$ have been a negative side-effect. There are in principle two different ways of reducing $NO_x$ emissions:

- Modifications of the engine and/or media to the engine
- After-treatment of the exhaust gas

Combinations of the two methods are feasible.

### 5.2.1 Modifications of the engine and/or media to the engine

#### *5.2.1.1 Basic internal engine modifications*

The most widespread basic internal engine modification is the replacement of conventional fuel valves by low- $NO_x$ slide valves, a method that is currently applicable only to slow-speed two-stroke engines. Most new engines of this type have these valves fitted as standard, as a means of meeting the IMO $NO_x$ standard. Retrofitting is considered easy. In 2005 more than 500 commercial installations of basic IEM had already taken place (Entec, 2005).

#### *5.2.1.2 Advanced internal engine modifications*

Advanced IEM involves combinations of a number of techniques – such as retarded injection, higher compression ratio, increased turbo efficiency and common rail injection – optimised for particular engine types.

#### *5.2.1.3 Direct Water Injection (DWI)*

Injecting water to cool the combustion chamber is a way of reducing $NO_x$-formation by up to 60 per cent. The method requires rebuilding the engine and bunkering fresh water on board, which is either injected directly with separate nozzles or sprayed into the combustion air at the inlet to the cylinder. The system is technically fairly complicated. The heat consumed in the evaporation of the water is lost with the exhaust gas. Typical ratios of water to fuel consumption are 40-70 per cent. By 2005, 23 ships had installed DWI on approximately 50 engines (Entec, 2005).

#### *5.2.1.4 Exhaust Gas Recirculation (EGR)*

Part of the exhaust gases are filtered, cooled and redirected into the engine intake air, thus reducing the combustion temperature. This technique is used in road vehicles and may be best suited to engines running on high-grade low-sulphur fuels. The reduction in efficiency in ships is estimated to be around 35 per cent.

#### *5.2.1.5 Humid Air Motor (HAM)*

HAM is a technique for preventing $NO_x$-formation during combustion by adding water vapour to the engine's combustion air. The compressed and heated turbo air passes through a specially designed cell that humidifies and chills the hot air from the turbo charger by taking up moisture from the warm cooling water until saturation of the intake air is achieved. Saline seawater heated by thermal losses from the engine's jacket cooling and the turbo charger is utilised in the HAM process for humidifying the intake air. The salt brine from the process is rejected back into the sea. This means there is no need for fresh water. The system makes the inter-cooler superfluous as the HAM system constitutes a replacement.

HAM makes the combustion smoother, the combustion temperature more uniform and prevents so called "hot spots". The method is independent of the bunker oil quality and the engine's workload. Fuel consumption does not increase, and HAM has the advantage over Selective Catalytic Reduction (SCR) of somewhat reducing operating costs instead of increasing them. This means that with HAM there is no risk of tampering. The HAM method is able to reduce $NO_x$ by around 75 per cent. However, there is as yet only one commercial vessel, the Viking Line's ferry Mariella, that has installed HAM on its Pielstick engines (starting in 1999).

The Mariella has been certified by the Swedish Maritime Administration (2007) as having reduced its $NO_x$ emissions from 15 to 4.4 g/kWh (-71%). The Viking Line reports that installation of HAM reduced lube oil consumption by about 30 per cent and that the engine life has been extended. The engines run cleaner, fuel consumption is down by an average of 5 per cent and operating and maintenance costs have been reduced (Hagström, 2005).

An initial problem to overcome for a more widespread application of the HAM technology is that additional space is required, and research and trials may be necessary before installation is possible on engines other than those produced by Pielstick.

Other means of reducing $NO_x$ include using gas turbines or gas engines with low-$NO_x$ burners. Such engines, however, have thermal efficiencies well below those of slow- and medium-speed diesel engines, as shown in table 10. There is thus an inherent trade-off between fuel efficiency and $NO_x$ abatement.

**Table 10: Energy efficiency and $NO_x$ emission levels of selected marine engines.**

| Engine type | Efficiency (%) | $NO_x$ emission (g/kWh) |
|---|---|---|
| Slow-speed diesel (60-250 rpm) | 48-54 | 11-21 |
| Medium-speed diesel (250-1000 rpm) | 43-50 | 8-12 |
| High-speed diesel (1000 rpm) | 40-43 | 6-8 |
| Gas turbine  10 MW | 32-39 | 0.5-2 |
| Gas diesel engine, medium speed | 43-50 | 4 |
| Gas Otto engine, medium speed | 46-47 | 1 |
| Gas Otto engine, high speed | 37-40 | 1-2 |

Source: Oftedal et al (1996).

### 5.2.2 After-treatment of the exhaust gas

#### *5.2.2.1 Selective Catalytic Reduction (SCR)*

SCR is a system for after-treatment of exhaust gases and reduces the emissions of nitrogen oxides by up to 95 per cent. The method is suitable for both new vessels and retrofit installations. SCR requires low-sulphur bunker oil of good quality and an exhaust temperature above 300°C. NO and $NO_2$ are reduced to N2 and H2O by mixing a water solution of urea into the exhaust gas before it passes through a catalytic converter. This reaction takes place in a satisfactory manner only within a certain "temperature window". The exhaust temperature of medium-speed four-stroke engines is normally within this window, but often only at full engine load with large slow-speed two-stroke diesel engines. In the latter case, the catalytic converter must be placed between the engine cylinder and the turbocharger where the temperature is high enough. This is sometimes a handicap when retrofitting existing vessels as it requires more space in the engine room. The urea consumed amounts to 2-3 per cent of the fuel consumption. By 2005 and worldwide, around 350 engines on 80 ships were equipped with SCR (Entec, 2005).

### 5.2.3 Assumptions on costs and efficiencies

According to Entec the costs per tonne $NO_x$ abated for various technologies including the modification of the engines and/or media to the engine are as summarised in table 11.

**Table 11: Emissions reduction efficiencies and estimated costs**

| Technology | Ship type | Euro per tonne $NO_x$ abated | | |
|---|---|---|---|---|
| | | Vessel size | | |
| | | Small | Medium | Large |
| Basic IEM | New | 12 | 9 | 9 |
| Basic IEM | Retrofit | 12-60 | 9-24 | 9-15 |
| Advanced IEM | New | 98 | 33 | 19 |
| DWI | New | 411 | 360 | 345 |
| HAM | New | 268 | 230 | 198 |
| HAM | Retrofit | 306 | 282 | 263 |
| SCR inside SECA | New | 543 | 424 | 398 |
| SCR inside SECA | Retrofit | 613 | 473 | 443 |
| SCR, ships using MDO | New | 413 | 332 | 313 |
| SCR, ships using MDO | Retrofit | 483 | 381 | 358 |

Source: Entec (2005)

For further calculations the reduction assumptions of the following studies have been considered (Table 12). As the projections are calculated until 2020 and techniques in this period probably will improve the values for the study at hand are rather at the upper end of the average of the different sources.

**Table 12: $NO_x$ reduction potential of different technologies**

| Measure | Ref. 1[9] | Ref. 2 | Ref. 3 | Used value |
|---|---|---|---|---|
| | $NO_x$ - Reduction (%) | | | |
| **DWI** | 50 | 50-60 | 50-60 | 55 |
| **HAM** | 70 | 40-80 | 70-85 | 77.5 |
| **SCR** | 90 | 80-90 | 90 | 90 |

Source: GAUSS, 2007

Exhaust gas re-circulation is not included in the table as no installations have yet been made in commercial ships, and because the ship would for technical reasons have to switch from heavy residual oil to marine distillates. None of the technologies affect the specific fuel consumption significantly (Entec, 2005). However, the Viking Line claims a 5 per cent reduction for HAM (see above).

[9] Ref. 1: Entec 2005 a: Assignment, Abatement and Market-based Instruments, August 2005
Ref. 2: Bailey, Plenys, Solomon, et. al.: HARBORING POLLUTION - Strategies to Clean Up U.S. Ports:, August 2004
Ref. 3: G.Lövblad and E.Fridell: Experiences from use of some techniques to reduce emissions from ships, 2006

# 6 Existing Market-Based Instruments in Shipping

## 6.1 Differentiated Fairway Dues (Sweden)

Recognising the need for abatement measures at sea, the Swedish Maritime Administration, the Swedish Port and Stevedores Association and the Swedish Shipowners' Association in 1996 arrived at a Tripartite Agreement to use differentiated fairway and port dues to reduce emissions of $NO_x$ and $SO_x$ by 75 per cent by the end of the first decade of the new millennium. The parties concluded that vessels engaged in dedicated trade and other frequent vessel traffic involving Swedish ports, regardless of flag, should reduce emissions of $NO_x$ by installing SCR or other cost-effective $NO_x$-abatement techniques. Shifting to low sulphur bunker fuels was to reduce sulphur emissions.

### 6.1.1 Fairway dues

Fairway Dues constitute the main part of the economic foundation of the Swedish Maritime Administration (SMA) that enables provision of services to shipping, infrastructure investments, dredging, lighthouse and fairway maintenance, icebreaking, hydrological surveys, etc. The SMA is funded by fairway dues on shipping and not by the government.

The Swedish fairway dues consist of two parts, one related to the gross tonnage (GT) of the ship and one based on the amount of cargo carried. It is only the former that is differentiated according to environmental criteria. In 1998, when the new system was introduced, the basic levels were raised to make room for substantial deductions for ships that emit less sulphur and nitrogen oxides. This means that the scheme is revenue-neutral.

From 1 January 2005 the basic rate is SEK 1.80 per GT for passenger ships, SEK 2.20 for oil tankers and SEK 2.05 for other types of ship[10]. Cruise ships were included in 2006 (SEK 0.50). On top of this rate, vessels are charged an additional SEK 0.60 per GT unless they use fuels containing less than a certain percentage of sulphur.

The $NO_x$ -related reduction of the due is based on the emissions measured in grams per kWh. If the emissions at 75 per cent engine load are above 10 g/kWh, no $NO_x$ discount is given. Below this level the discount increases continuously down to a level of 0.5 grams per kWh, where the discount amounts to SEK 1.20 per GT (€ 0.13).

Shipowners who state and verify their continuous operation of ships on bunker oils with a low sulphur content qualify for discounts. Ferries that use fuels with less than 0.5 per cent sulphur (by weight), and other ships using fuels with less than 1.0 per cent, get a discount of SEK 0.20-0.60 per GT. The exact discount depends on the extent to which the sulphur content falls below these limits.

A passenger ferry that runs on 0.5 per cent sulphur bunker oil and uses SCR for reducing $NO_x$ emissions to a level of 0.8 g/kWh would, for instance, enjoy a total discount of SEK 1.40 per GT. Subsequently the remaining fee is SEK 1.00. A general cargo vessel running on fuel containing 1.0 per cent sulphur and using an equally effective SCR would pay SEK 1.40 per GT, whereas a similar vessel that uses high-sulphur bunker oil and emits $NO_x$ above 10 g/kWh would pay SEK 2.65. The maximum total discount is 67 per cent for ferries, 64 per cent for oil tankers and 66 per cent for other cargo vessels.

[10] SEK 1 is equal to € 0.109 (December 2006)

The number of calls that are subject to fairway dues is limited to five per calendar month for passenger vessels and two per month for other vessels.

By December 2006 1,006 ships had been granted a discount for low-sulphur bunker fuel. These vessels represent around 75 per cent of the annual ferry tonnage and more than 45 per cent of the cargo tonnage calling at Swedish ports (Stefan Lemieszewski, SMA, personal communication). However, the number of ships has declined by 11 per cent since November 2005. The reduction is largely explained by the fact that the premium on low-sulphur fuel has increased.

By December 2006, 47 ships had been certified for a $NO_x$-related discount of the fairway due. Among them 42 have installed SCR, two apply water injection, one has installed HAM, one is a cargo vessel that has relatively low emissions (7-8 g/kWh) without having installed SCR, and four are high speed craft moved by low-$NO_x$-emitting gas turbine engines. Some vessels apply different abatement technologies to the main engine and the auxiliary engines, which explains why the total number of installations by type exceeds 47. The National Maritime Administration estimates that the scheme reduces $NO_x$ emissions from ships calling at Swedish ports by around 48,000 tonnes per year.

One reason why $NO_x$ abatement measures take longer to introduce is that shipowners have to invest in new technology. This involves a certain degree of risk-taking compared with shifting to low-sulphur bunker oils, as the investments in most cases will have to be written off over a period of approximately 10 years. The response would, presumably, have been swifter had other North European countries provided a similar incentive.

For $NO_x$ emissions below 2 grams $NO_x$/kWh there is a multiple factor for the ship's total installed engine power. The reason for this is to provide an economic incentive to shipowners to apply $NO_x$ reduction technology on auxiliary engines.

To overcome initial problems and encourage the installation of SCR technologies, the Swedish Maritime Administration (SMA) offered shipowners partial subsidies for installations made during the first five years following 1 January 1998. Installations made in 1999 and 2000 qualified for a reimbursement of 40 per cent of the investment cost. Thereafter the maximum level was 30 per cent until the end of 2003 when the scheme was discontinued. The offer is applied to all vessels calling at Swedish ports regardless of flag and was designed as restitution of paid fairway dues. When introduced, the scheme did not apply to abatement techniques other than SCR. It thus had the disadvantage of not promoting new and potentially more cost-effective techniques such as HAM. The Maritime Administration therefore decided to open the reimbursement scheme to installations other than SCR that reduce $NO_x$ by a similar amount (i.e. the HAM technique). Of the 36 ships currently enjoying reduced fairway dues because of low $NO_x$ emissions, 13 received an investment subsidy from the SMA for the abatement equipment.

### 6.1.2 Differentiation of Swedish port dues

Close to 30 ports, representing more than 90 per cent of the traffic in Sweden's 52 ports, differentiate their dues for the sulphur content of the fuel used and the $NO_x$ emitted by calling vessels. They apply a differentiation of their port dues, based on data of qualified ships from the SMA, but their systems are outside the influence of the SMA.

Each port is an autonomous body, which in competition with other ports has to cover its costs. This makes the situation of ports different from that of the Maritime Administration. The challenge lies in differentiating the port due in a way that provides an incentive additional to that of the fairway due without risking a loss of customers or revenue. Such difficulties explain why the port dues are much less differentiated than the fairway dues. Table 11 provides information on the sulphur differentiation of selected major Swedish ports. The border between low- and high-sulphur content is set at 0.5 per cent for ferries and 1.0 per cent for other ships. Some ports apply discounts on the nominal tariff for low-emitting vessels, while others enforce surcharges on ships with emissions above the threshold. For ferries, however, the Port of Stockholm applies a surcharge on vessels using bunkering fuel with more than 0.2 per cent sulphur.

**Table 13: Discounts for low-sulphur bunker oils and penalties on high-sulphur fuels in selected Swedish ports in 2005. SEK per GT (SEK 1 = € 0.109).**

| Port | Discount | Surcharge |
|---|---|---|
| Port of Gothenburg | | 0.2 |
| Port of Helsingborg | 0.1 | |
| Port of Malmö | 0.1 | |
| Port of Stockholm * | | 0.2 |

Source: Kageson, 2007

* For ferries with less than 0.5 per cent sulphur but more than 0.2 per cent the charge is limited to SEK 0.1.

By November 2005, close to 20 Swedish ports had introduced discounts for low emissions of nitrogen oxides. Table 12 shows the current rates in the most important Swedish harbours.

**Table 14: Discounts for $NO_x$ emissions in selected Swedish ports in 2005. SEK per GT (SEK 1 = € 0.109)**

| Port | g $NO_x$/kWh | Discount (SEK/GT) |
|---|---|---|
| Port of Gothenburg | ≤ 12<br>≤ 6<br>≤ 2 | 0.05<br>0.10<br>0.20 |
| Port of Helsingborg | ≤ 12 | 0.01 |
| Port of Malmö | ≤ 6 | 0.15 |
| Port of Stockholm | ≤ 10<br>≤ 5<br>≤ 1 | 0.15<br>0.25<br>0.30 |

Source: Kageson, 2007

The discounts are small compared to the nominated rates. For instance, in the case of Stockholm the nominated tariff is € 0.27 per GT with a lower fee of € 0.16 for scheduled service vessels (at least four calls per week). The port fee is supplemented by cargo and passenger fees. The cargo fee depends on the type of cargo and the amount loaded or unloaded. It should also be kept in mind that substantial rebates may occur as a result of bargaining.

### 6.1.3 The effects of port and fairway discounts in Sweden

When assessing the Swedish schemes, one obvious observation is that the discounts do not reflect real emissions. Even if there might in most circumstances be a relatively accurate relationship between GT and engine output, neither the fairway due itself nor the discount take into account the distance travelled. The environmental differentiation of the Swedish port dues suffers from the same disadvantage. The fact that the fairway due is limited to a certain number of port calls per month is another deviation from making ships pay for real emissions (or from granting them a discount for reducing them).

However, even a scheme that does not truly reflect real emissions may provide sufficient incentives to shipowners to clean up their operations.

The discounts provided for low-sulphur fuel appear to be high enough to make most frequent visitors choose blends that are less sulphur-rich than the maximum permissible level in the Baltic and North Seas, and this in a situation where most of them do not gain from any discounts on port dues in neighbouring countries. However, many of the vessels, in particular ferries, did use low-sulphur bunker oil or middle distillates prior to the differentiation of the Swedish port and fairway dues.

Where decisions to maintain the use of low-sulphur fuel are concerned, one should keep in mind that the price difference between low- and high-sulphur bunker oil has increased in recent years. In October 1999, the premium for 0.5 per cent over high-sulphur oil was US$ 30 per tonne (Kågeson, 1999). In November 2005, the premium had increased to nearly 100 US$ per tonne. The total price for bunker fuel containing 0.5 per cent sulphur increased from 130 to 330 dollars per tonne between 1999 and 2005.

As already mentioned, the $NO_x$ discounts have contributed to investments in SCR in 34 ships. It may be of interest to see to what extent the current discounts balance these investments and the additional running cost associated with the use of urea. As an example we will use a ferry of 60,000 GT with a total engine capacity of 40 MW, sailing on a daily basis between Stockholm and a port in a neighbouring country. Her owner would pay Swedish fairway dues for 60 entries and port dues to the Port of Stockholm for approximately 360 calls per year.

Retrofitting a ferry of this size with SCR would cost around SEK 18 million[11] and result in emissions below 0.5 g/kWh, which would earn her a discount on the fairway due of SEK 4.3 million per annum. Assuming that the due negotiated with the Port of Stockholm truly reflects the port's nominal discount for low $NO_x$ emissions, the annual reduction would be SEK 6.5 million, based on 360 calls. Thus the total discount on port and fairway dues amount to SEK 10.8 million per year.

The annual operating cost of the SCR system of such a ship is around SEK 4.7 million.[12] Thus SEK 6.1 million of the annual discount is available for writing off the investment. With a presumed interest rate of 4 per cent and 10 years depreciation, the annuity amounts to SEK 2.2 million. The owner thus makes an annual profit of SEK 3.9 million by participating in the programme. This is equal to 21.7 per cent on the investment. It thus appears profitable for a frequent visitor to the Port of Stockholm to install SCR. A higher interest rate, of course, would result in a lower profit.

[11] Information from Per Holmström, Munters Europe AB, based on data from Viking Lines' Cinderella.

[12] Information from Per Holmström, Munters Europe AB, based on data from Viking Lines' Cinderella.

Where the environmental differentiation of port dues is concerned, one should keep in mind that if such a scheme proves very successful, the port would be forced to continuously increase its basic due in order to balance its cash flow. When the most frequent visitors have undertaken the necessary investments to reduce their emissions, all rebates would have to be paid by the infrequent port users. They would in such a case consider calling at an alternative port, which would make it problematic for the first port to maintain its nominal rate of differentiation. In the case of Sweden, much of this problem appears to have been avoided as all major ports decided to follow the recommendation of the Swedish Port and Stevedores Association to participate in the effort by differentiating their port dues. Being situated on a peninsula, Swedish ports may also be less vulnerable to foreign competition than ports that share a coastline with ports of neighbouring countries.

## 6.2 Differentiated port dues in Åland

In January 2000, the Finnish Port of Mariehamn (in Åland) began to differentiate its basic dues with regard to ships' emissions of $NO_x$ and $SO_x$. The port offers vessels emitting less than 10g $NO_x$/kWh a discount of 1 per cent off the port due. The discount increases on a linear scale up to 8 per cent for ships emitting less than 1 gram. Ships using bunker oils with less than 0.5 per cent sulphur receive an additional reduction of 4 per cent. Sulphur content below 0.1 per cent is rewarded with an 8 per cent discount. An additional 8 per cent is available for the combination of low-sulphur fuel (<0.5%) and $NO_x$ emissions below 1.0 g/kWh. Most participating ships are ferries on the route between Finland and Sweden. Most vessels are certified by the Swedish Maritime Administration as they also take advantage of the differentiation of fairway and port dues in Sweden.

## 6.3 Norwegian Ship Environmental Accounting System, tonnage tax and $NO_x$ charge

In 1994, a Nordic committee for environmental control published a report[13] containing ideas about environmental indexing for shipping. The aim was to find solutions for Nordic applications, with possibilities to expand the system globally. The report underlined the importance of introducing a system through the IMO in order to reach a wide international acceptance. The proposal addressed $NO_x$, $SO_x$, VOC and formal safety assessment (FSA).

Parallel with the Nordic committee, the Norwegian Shipowners' Association and the Norwegian Environmental Protection Agency published a report on the same issue. Their system was designed to be the basis for differentiation of, for example, port and canal dues. The proposal includes additional performance parameters such as waste assortment, sewage collection tanks and treatment systems, construction and navigational aids.

In 1999 the Norwegian Parliament decided to introduce the principle of environmental differentiation into the country's tonnage tax. This resulted in environmental taxes on sulphur and $CO_2$-emissions for ships in domestic trade, and provided grants for $NO_x$ measures on existing ships. The tonnage tax is enforced on all vessels above 1,000 net tonnes (NT) subject to taxation in Norway. The tax is a substitute for corporate taxation in the Norwegian shipping sector. The tonnage tax is differentiated for environmental performance on the basis of a Ship Environment Index System (SEIS), which is based on up to seven different environmental

[13] Nordiska ämbetsmannakommittén för miljövård (1994)

parameters, including sulphur and $NO_x$ emissions. Ships that meet all requirements can receive up to 10 environmental points. Abatement of $NO_x$ and $SO_x$ emissions makes up six of the system's 10 maximum points for tankers, general cargo vessels and passenger ships. For "other ships" (including towboats, fishing vessels, research ships, barges and supply and standby ships related to Norwegian off-shore activities) all 10 points relate to emissions of $NO_x$ and sulphur. However, if the $NO_x$ emissions are 80 per cent (or more) lower than the IMO's $NO_x$ curve, the maximum score of 10 is automatically achieved. This means, as shown in table 13, that not all ships get the same credit for an equal reduction of $NO_x$ and $SO_x$.

**Table 15: Points earned for different reductions of $NO_x$ and $SO_x$ in the Norwegian model.**

| Criteria \ Ship type | Tankers | General cargo | Passenger ships | Other ships |
|---|---|---|---|---|
| ***$NO_x$*** | | | | |
| IMO $NO_x$ -curve* | 0.75 | 0.75 | 1.05 | 1.75 |
| (IMO curve) - 15% | 1.50 | 1.50 | 2.10 | 3.50 |
| (IMO curve) - 60% | 3.00 | 3.00 | 4.20 | 7.00 |
| ***$SO_x$*** | | | | |
| 2.5% S | 0.75 | 0.75 | 0.45 | 0.75 |
| 1.5% S | 1.50 | 1.50 | 0.90 | 1.50 |
| 0.5% S | 3.00 | 3.00 | 1.80 | 3.00 |
| Total points for best emission reduction practice | 6.00 | 6.00 | 6.00 | 10.00 |

A full score of 10 environmental points allows for a 25 per cent reduction of the tax. The average score is 2.33, ranging from 8.8 for offshore units to 2.5 for cargo ships and 2.2 for tankers (NERA 2005).

The tonnage tax, however, is very moderate. No tax is paid for ships of less than 1,000 NT. Ships liable to the tax pay only around NOK 3.5 per NT per year which is equal to NOK 2.2/GT. The part of the tax which is open to rebates corresponds to about half of this amount, i.e. little more than NOK 1 per GT per year (€0.12). The maximum reduction for a cargo vessel will then be in the order of NOK 0.6 per GT and year.

From 1 January 2007 Norway introduced a charge on $NO_x$ emissions from ship engines above 750 kW. The rate is NOK 15 per kilo (equivalent to €1840/tonne). However, ships in international traffic are exempt (Toll- og Avgiftsdirektoratet, 2007).

## 6.4 Green Award (Rotterdam)

In 1994 the Green Award Foundation was set up as an initiative of the Rotterdam Municipal Port Authority and the Dutch Ministry of Transport and Water Management. It was established to initiate market incentives to promote quality shipping i.e. to provide cost reductions at contracting ports for tankers that have achieved this award. Since 2000 the foundation is independently organised.

The Green Award Foundation is a pioneer in the field of promoting a maritime, environmental and safety-conscious culture, and has been the inspiration for later similar initiatives including the Qualship 21 initiative of the United States Coast Guard.

In collaboration with the Port of Rotterdam, in 1994 the Green Award launched the Green Award programme, which is designed as an incentive to large vessels to improve safety and environmental protection. Crude oil tankers, product tankers and bulk carriers with a minimum deadweight of 20,000 tonnes may apply for inspection and certification. Worldwide about 1,500 tankers and 1,500 bulk carriers are operational in the categories for which the Green Award is available in principle. Today more than 30 ports in eight different countries offer reduced port dues for tankers and bulk carriers that carry a Green Award Certificate. Most of them offer discounts of 5 or 6 per cent on port dues. Around 180 ships have been certified. Most of these vessels are larger than 50,000 DWT and not used in short-sea shipping.

The certification procedure consists of audits of crew and management procedures and technical provisions. The emphasis is on safe and environmentally friendly management and crew competence. A certificate is valid for three years. In addition the shipowner must demonstrate environmental and safety awareness in a number of areas affecting management and crew competence, as well as technical provisions. They include manning, maintenance systems, tank and hull arrangements, oil leakage prevention, vapour emission control, accidental oil pollution prevention, spill collection, bilge water treatment, waste disposal, tank cleaning and exhaust emissions. For each element a certain minimum score must be obtained in order to be granted a Green Award, and a certain minimum total score for the entire ranking list must also be obtained. Criteria related to air emissions can contribute a maximum of 10 per cent of the total number of ranking points available. Points are awarded for $NO_x$ emissions of no more than 17 g/kWh, the use of low-sulphur fuel or alternatively $SO_2$ emissions below 6 g/kWh. The assessment procedure is carried out in absolute confidentiality, which means third parties are not offered any insight.

## 6.5 Qualship 21 (USA)

The Qualship 21 initiative (Quality Shipping for the 21st century) came into effect in January 2001 and was introduced by the US Coast Guard to eliminate substandard shipping by providing incentives to encourage quality shipping. Before the introduction of Qualship 21 vessels were examined no less than once each year regardless of their performance. This provided no incentives for the well-run quality ship. Therefore the US Coast Guard implemented an initiative to identify high-quality ships of all flags and provide incentives to encourage quality operations. A quality vessel is associated with a well-run company, is classed by an organisation with a quality track record, registered with a flag state with a superior Port State Control record, and has an outstanding Port State Control history in US waters.

For a flag state to be granted eligibility, it must have submitted a self-assessment of flag state performance to the IMO and must have provided a copy to the US Coast Guard. Approximately 10 per cent of the non-US-flagged vessels that call in the USA qualify for this initiative. The eligibility requirements are:

1. The vessel must not have been detained, and determined to be substandard, in US waters within the previous 36 months;
2. The vessel must not have any marine violations, no more than one paid Notice of Violation case (tickets), and no reportable marine casualties, that meet the definition of a serious marine incident or major marine casualty, in US waters within the previous 36 months;

3. The vessel must have completed a successful, US Port State Control examination within 12 months of eligibility determination;
4. The vessel must not be owned or operated by any company that has been associated with a substandard vessel detention in US waters within the previous 24 months.
5. The vessel must not be classed by, nor have its statutory Convention Certificates issued by, a targeted class society. A class society is targeted if points are assigned to it in the Port State Control targeting matrix;
6. The vessel must not be registered with a flag state that has a detention ratio more than 1/3 of the overall US detention ratio, determined on a 3-year rolling average, and the flag state must have at least 10 distinct vessel arrivals in each of the last three years;
7. The vessel's flag state must submit its self-assessment of flag state performance to the IMO, and provide a copy to the Coast Guard; and
8. Though not specifically mentioned in the above criteria, the Coast Guard reserves the right to restrict eligibility in the Qualship 21 initiative to any vessel because of special circumstances, including, but not limited to, significant overseas casualties or detentions, and pending criminal or civil investigations.

Incentives for quality vessels include a Qualship 21 certificate, and vessel names are posted on the US Port State Control website. With a Qualship 21 certificate, a quality freight ship will be subject to fewer Port State Control inspections for a period of two years. For the further development of the scheme, it is intended to include reduced port fees, based on additional attributes of the vessel.

## 6.6 Notations of classification societies

From the mid 1990s several classification societies started to develop approaches to identify and recognise environmentally sound shipping, to be included in their respective notation systems. Some of the approaches were organised to require shipowners to pass certain requirements; others were aimed at compiling and documenting different efforts of the shipowner. The latter do not have to adhere to any particular preference of the classification society.

DNV (Det Norske Veritas) for example has two environmental protection class notations, namely:

1. Clean Design – with ambitious standards, especially for new-buildings; and
2. Clean – prepared primarily for existing ships engaged in deep-sea trading.

Lloyds Register's Environmental Protection notation recognises ships' compliance with Lloyds's provisional rules for Environmental Protection (originally published in 1998). It applies to both new builds and operational vessels.

The Green Star scheme of RINA has both a Clean Sea and a Clean Air element. The Clean Sea notation requires bunker tanks to be installed over double bottoms and to hold tanks for black and grey water, as well as to ensure that garbage is disposed of safely and that ships use TBT-free anti-fouling. The Clean Air notation sets limits on $SO_x$ and $NO_x$ emissions, and enforces requirements on refrigeration gases and controls for incineration plants.

Most of the important classification societies have implemented notation systems to describe the environmental situation on board. However, all of them are different in textual context and requirements.

## 6.7 Conclusions on existing schemes

The Swedish differentiation of port and fairway dues is the only existing scheme of market based instruments with a potential to influence ship owners' decisions on sulphur content and $NO_x$ abatement technologies. The differentiation explains why, world-wide, more than half of the advanced systems for $NO_x$ reduction currently in place are found in vessels that frequently call at Swedish ports. A disadvantage, however, is that the differentiation does not take account of distance. The size and differentiation of the Norwegian tonnage tax are too modest to provide much incentive, and ships in international traffic are exempt from the Norwegian $NO_x$ charge.

The Green Award Foundation promotes an environmental and safety-conscious maritime culture, but the award is limited to large tankers and bulk carriers and not aimed at reducing emissions of sulphur and nitrogen oxides. The American Qualship 21 Certificate ensures that quality freight ships are subject to fewer Port State Control inspections than other ships, but the certificate has not yet been used as a basis for differentiation of port fees.

# 7 Evaluation of the NERA proposals

In 2004 NERA Economic Consulting produced a report for the European Commission's directorate-general for the environment on the feasibility of alternative market-based mechanisms to promote low-emission shipping in European Union sea areas. In September 2005 the Commission released a follow-up study, also by NERA, called Economic Instruments for Reducing Ship Emissions in the European Union, in which the consultants examine in greater detail some of their more promising economic mechanisms from the first report. After briefly presenting NERA's first report, this chapter will discuss the results of the second report.

## 7.1 NERA's 2004 Report

NERA's first report provides information on the feasibility of a broad range of market-based approaches to regulate atmospheric emissions from seagoing ships in European Union waters. The emissions under consideration are primarily $SO_2$ and $NO_x$. However the approaches considered could also be applied to other emissions such as $CO_2$ or PM.

The report evaluates programmes in two broad categories: (1) emissions trading programmes, in which participants trade quantities; and (2) emissions charging programmes, in which participants respond to a charge on emissions or on another quantity, such as sulphur in fuel.

Six market-based programmes (three trading and three charging) were evaluated, selected for their prominence in specific shipping proposals or in previous programmes for land-based sources. Because of the trade-offs along various dimensions, the consultants developed multiple approaches for each of the six programmes. The six programmes and specific approaches considered in NERA's first report for each programme are discussed below.

### 7.1.1 Credit-based trading programme

These programmes provide tradable credits to facilities that voluntarily reduce emissions below their business as usual (BAU) levels. These credits can be traded and counted toward compliance by facilities that would face high costs or other difficulties in meeting their emissions requirements. Credits are generally created through an administrative process in which the credits must be pre-certified and approved before they can be traded. In the shipping context, a credit-based programme would allow ship owners to reduce emissions and sell the emission reduction credits to land-based sources assumed to be subject to a cap-and-trade programme.

NERA elaborates with two varieties of credit-based programmes, the simple credit approach that would allow vessels to generate credits based upon a simple formula for determining BAU levels (e.g. 1.5% sulphur in fuel), and the stringent credit approach. The latter would require shippers to achieve emission rates below BAU levels, in order to provide net emissions reductions, and also provide clear evidence of BAU levels in order to avoid "anyway tonnes", i.e. reductions that would occur anyway without the programme.

### 7.1.2 Benchmark trading

Benchmarking programmes identify a specific emissions rate to apply to covered activities and require that the average emission rate from these activities does not exceed the benchmark level. Sources subject to the programme can trade credits among each other and thereby lower the cost of meeting the emissions rate target. In the shipping context, NERA identifies two approaches to benchmarking: universal benchmarking, which would require all ships in EU waters (above a given size) to participate in the programme, with no geographic differentiation and relatively simple monitoring, and trading consortia, which would allow vessels to “opt in” to a trading consortium.

### 7.1.3 Cap–and-trade programmes

Under a cap-and-trade programme, an aggregate cap on emissions is set by creating a total number of emissions allowances, which initially are distributed among all emitters that are subject to the programme. They provide their owners with the right to emit a unit of emissions. In contrast to benchmarking programmes, cap-and-trade programmes limit total emissions. In the shipping context, a cap-and-trade programme could be set for overall shipping emissions within a region, with individual ships allocated allowances and allowed to trade amongst each other. NERA identifies two approaches that differ only in their treatment of the location of shipping emissions: trading with exchange rates, which would set simple exchange rates for emissions in different seas, and trading with geographic formulas, which would use more detailed location formulas to account for geographic concerns.

### 7.1.4 Taxation

NERA considers three taxation approaches that differ in whether fuel or emissions is taxed and, for the fuel taxes, whether fuel purchases or fuel consumption would be taxed. The fuel taxes would target $SO_2$ emissions while the emissions tax would target both $SO_2$ and $NO_x$ emissions. NERA distinguishes between tax at the pump, which would tax sulphur fuel content in excess of a given level at the point of sale in Europe; fuel-use tax, which would tax the sulphur in fuel used by each ship above a given level; and emissions tax, which would tax emissions from ships, with emissions weighted by sea region and distance from shore.

### 7.1.5 En-route charging

En-route charging has been used for many years in the aviation sector to provide payment for use of the air traffic control infrastructure. Charges are based on the distance travelled within the relevant airspace and the weight of the aircraft. A similar approach could be applied to maritime traffic to charge vessels for emissions en route. NERA studies two approaches that vary in whether or not specific ship movements would be monitored, trip-based charges based on generic shipping travel patterns, and distance-based charges, whereby ships would be charged according to the actual distance travelled, including variations by region and distance from shore. In both cases periodic emissions monitoring would be required.

### 7.1.6 Differentiated dues

A system of differentiated port or fairway dues would take advantage of the fact that most ports and some countries already impose charges on vessels that use their facilities and waterways. Differentiating charges in this context means basing port dues in part on emissions of various pollutants. A revenue-neutral system of this kind has been used in various Swedish ports since 1998 to encourage reductions in $NO_x$ and $SO_2$ emissions. NERA distinguishes between three types of differentiated dues: voluntary differentiated port dues, mandatory differentiated port dues, which would require ports within the EU to adopt a differentiated dues system, and differentiated fairway dues.

### 7.1.7 Results by NERA (2004)

Based on 13 evaluation criteria, divided into four broad categories – environmental criteria, efficiency criteria, distributional criteria, and legal/political feasibility criteria – NERA found that the various market-based approaches share advantages relative to less flexible regulatory approaches. However, the wide mix of programmes also illustrates potential trade-offs among the approaches. According to NERA, perhaps the most fundamental trade-off is between, on the one hand, broad and comprehensive approaches that promise major cost savings and environmental gains, but would require a major shift in legal and political acceptability and substantial administrative costs; and on the other hand more modest approaches that would provide smaller cost savings and environmental gains, but would involve less substantial administrative costs and fewer legal and political obstacles.

In the 2004 report NERA provides a brief assessment of the cost-effectiveness of the six different instruments trying to take into account their respective advantages and drawbacks. Table 14 shows NERA's summary of the most important aspects of the different approaches from an environmental and cost/benefit perspective.

**Table 16: Qualitative assessments of Market-Based Approaches for shipping**

| 0 = Worst Performance<br>5 = Best Performance | Credit | Bench-marking | Cap & Trade | Fuel Tax | En Route | Diff. Dues |
|---|---|---|---|---|---|---|
| Environment: Overall | 0 | 4 | 5 | 3 | 4 | 3 |
| Environment: Geo. Diff. | 1 | 0 | 3 | 1 | 3 | 5 |
| Cost-Effectiveness | 4 | 3 | 5 | 1 | 5 | 3 |

Source: GAUSS, 2007

When considering NERA's assessment it must be kept in mind that the indication-numbers are not meant to be added in order to identify the most suitable approach. They would have to be weighted (which is difficult) in order to become comparable. However, they provide a rough indicator of the qualitative performance of each instrument and indicate that cap-and-trade schemes and en-route charging would be the most favourable.

Given the relative novelty of market-based instruments for the marine sector, NERA (2004) recommends a start with more modest programmes. Although none of them is perfect, NERA sees three approaches as the most promising means of introducing market-based instruments to promote low-emission shipping in EU waters: the stringent credit-based approach, the consortia benchmarking approach, and voluntary port dues differentiation. NERA's reason for not recommending cap-and-trade programmes, taxation or en-route charges is that they may turn out not to be politically and/or legally feasible. However, from NERA's 2005 report it is evident that the credit-based approach and consortia benchmarking could also be affected by problems of this kind.

## 7.2 NERA's 2005 report

The 2005 report by NERA provides a detailed analysis of four economic instruments for reducing emissions from sea transport. It covers the three most promising approaches identified in NERA's 2004 study, and a fourth category, subsidies, to promote clean shipping. In the following sections we will take a closer look at NERA's favoured mechanisms.

### 7.2.1 Credit-based programmes

NERA notes that credit-based programmes have been used in several circumstances, the most well-known being two of the flexible mechanisms under the Kyoto Protocol: the Clean Development Mechanism (CDM) and Joint Implementation (JI) that allow for emission reduction projects in developing countries and countries with quantitative emissions reduction targets respectively.

Another example exists in the Los Angeles Air Basin where the South Coast Air Quality Management District (SCAQMD) runs a marine pilot programme that allows marine vessels that reduce emissions of $NO_x$ to receive credits in the Regional Clean Air Incentives Market (RECLAIM). Under this programme, close to 50 vessels, mostly tug boats and fishing vessels, have had their engine modifications subsidised by SCAQMD; the funds have been acquired from stationary sources which were required to offset their emissions in excess of those allowed under RECLAIM.

NERA believes that credit-based programmes would require more detailed baseline and monitoring procedures that can reduce the likelihood of "anyway credits", and says experience indicates that such additional administrative requirements can substantially increase participation costs. This, according to NERA, reduces the likelihood that entities would participate.

The stringent credit-based approach should, according to NERA, avoid offering credits to reductions that would most likely have taken place anyway. Thus in order to provide a benefit beyond what would have been achieved anyway, credits would only be provided to measures that reduce emissions of $NO_x$ below a certain level substantially below the IMO's $NO_x$ curve. A similar margin would have to be applied to the 1.5 per cent sulphur that is allowed in fuel used in North Sea and Baltic Sea shipping as most ships already run on fuel containing somewhat less than 1.5 per cent, and a number of ferries voluntarily use fuel oil containing substantially less.

NERA recognises that the environmental effects of a tonne of $NO_x$, $SO_x$ or PM emissions emitted at sea are clearly less significant than the effects of the same amount emitted in ports. Therefore there is need for some form of geographic differentiation.

NERA notes that a credit-based system that is designed to allow for interaction between maritime vessels and stationary sources probably requires modifying at least two European Directives: the Large Combustion Plant Directive (LCPD) and the Integrated Pollution Prevention and Control Directive (IPPC).

According to NERA, the stringent credit-based approach would provide some environmental benefits and improve the overall cost-efficiency of abating $SO_2$ and $NO_x$ emissions, provided that the specific transaction costs can be kept at a low level. There is, however, a trade-off between creating incentives high enough to motivate shipowners to participate and the need to introduce appropriate safety margins in order to avoid giving credits to "anyway tonnes" and tonnes with relatively limited impact on terrestrial ecosystems and human health. Implementation would require legal and political action by the Commission as the approach would normally not be feasible without the development of a cap-and-trade scheme for land-based sources of $SO_2$ and $NO_x$.

NERA says that in the absence of a land-based trading programme, a credit-based approach could be implemented via a government subsidy programme. An approach similar to that being pursued in California by the SCAQMD would be legally feasible, as current EU rules on state aid allow Member States to subsidise the development and introduction of low-emission shipping technologies. However, a major challenge would be to obtain the funds required for providing the subsidies.

### 7.2.2 Consortia benchmarking approach

In this approach, vessels would have the option of joining a consortium that would commit itself as a group to achieve a certain average emissions rate. In the design proposed by NERA, ships belonging to the consortium would be free to trade among themselves to achieve the average rate.

NERA notes that a similar system has been in force in the United States since the 1970s, the Corporate Average Fuel Economy (CAFE) act that sets minimum standards of fuel economy that the average vehicle sold by each manufacturer must meet. However, in contrast to NERA's proposal for consortia benchmarking, the American CAFE act does not allow for any trade between companies.

A second example of an existing benchmarking scheme, mentioned by NERA, is the American programmes for flexible emission limit values for $NO_x$ and VOCs from different kinds of mobile source categories. In these cases the US Environmental Protection Agency has designed policies that allow manufacturers the flexibility to trade surpluses and shortfalls relative to regulatory benchmarks. The systems are referred to as ABT programmes as they allow manufacturers to average emissions over all engine types produced by the manufacturer in the same model year, to bank credits to be used for offsetting excess emissions from engines produced in future years, and to trade credits among different manufacturers to offset excess emissions.

NERA also mentions that the California Air Resources Board (CARB) is considering allowing shipping operators to band together in order to achieve as a shipping average a set of new emissions targets for PM and $NO_x$ that entered into force on January 1, 2006 for vessels calling at Californian ports.

NERA says that one possible benchmark value for European waters would be to require the average emission rate for $SO_x$ within SECAs to correspond to a sulphur content in fuel of 1.5 per cent, equivalent to 6 g/kWh of $SO_x$. NERA, however, recognises two problems with using the 6g rate as a benchmark. The directive was not designed to establish a trading average under MARPOL Annex VI, and the 6g average would reduce the environmental benefit achieved by the current scheme. As presently there are already ships using low sulphur fuel for different reasons, the delta to 1.5 per cent could be sold to vessels using fuel with an average sulphur content of 2.7 per cent. The environmental performance of the scheme would thus be reduced. One should consider that the directive already provides for some flexibility of compliance. Operators may also use seawater scrubbing or similar forms of abatement. Scrubbing is expected to reduce emissions to 2 g/kWh, which is significantly below the 6g required by the benchmark. For many vessels, the cost of scrubbing may turn out to be substantially lower than the cost of buying low-sulphur heavy fuel oil. As a consequence, the expected average emission rates in SECAs under the regulation currently in place may be closer to four or five grams of $SO_x$ per kWh. If the current SECA rules were changed to allow ships to run on standard 2.7 per cent sulphur fuel, a consortium's average emission could, according to NERA, be expected to equal the benchmark, provided that its excess emissions were balanced by lower emissions from ships equipped with scrubbers. Thus from the environmental point of view, the benchmark would have to be substantially below the regulatory limit.

The problem associated with an introduction of consortia benchmarking for reducing emissions from vessels in European waters, as recognised by NERA, is that it would require new legislation for $NO_x$ that is more stringent than the values expressed by the IMO's $NO_x$ curve. In addition MARPOL Annex VI would have to be revised in order to allow consortia trading. Where emissions of $SO_x$ are concerned, a benchmarking trading programme appears feasible as an instrument for achieving the current SECA fuel restriction of 1.5 per cent sulphur. It would, however, require revision of MARPOL Annex VI and the European Union's Marine Fuels Sulphur Directive to allow vessels to participate in a consortium and permit some of them to operate within SECAs using fuel with higher sulphur content than would under current legislation be allowed. In addition the benchmark value would have to be set below 6g in order to secure an improvement over the current regulation.

In summary, NERA says allowing consortia of shipowners to band together to reduce the cost of meeting more stringent legal limits would provide gains both to shippers and to the environment. The voluntary nature of the trading part of such a scheme would allow vessels that are able to benefit from emissions trading to do so. This approach, however, would face legal and political challenges, notably the need for changes in both MARPOL Annex VI and the EU's fuels directive.

### 7.2.3 Voluntary port dues differentiation

Voluntary port dues differentiation could, according to NERA, build upon the experience of the Swedish system of integrated port and fairway dues differentiation. The Commission could encourage this development by developing emissions indices and recommended differentiation formulas for ports to use.

However, NERA emphasises the difficulties connected with an introduction of voluntary differentiation of dues in a competitive environment. To preserve revenue neutrality, ports would need to offset any incentive offered to low-polluting ships by higher dues for high-polluting vessels. Thereby they would risk losing the latter category to competitors that do not differentiate their port dues. In general, the more price-sensitive the customers of a port, the more difficult it would be to maintain revenue neutrality. One way of diminishing the risk of losing traffic would, of course, be to depress the degree of environmental differentiation. This, however, would reduce the environmental benefits of the scheme.

Another problem connected with voluntary differentiation of port dues is that many ports offer regular customers negotiated rates that differ from published port dues. These negotiated rates are normally not public information, but NERA says that ports consulted by its researchers indicated that the difference from published rates may be substantial. The port may take into account the environmental performance of ships covered by a negotiated contract, but in the absence of transparency, both ship operators and competing ports will be left in doubt. One result is that shipowners cannot be certain to recoup the costs of emissions abatement measures *ex ante*. NERA finds it hard to see how this issue can be addressed in a commercial setting.

There are also limits to the incentives that can be provided for different kinds of vessels. With reference to a study by GAUSS (2001) of the charging structure in five German ports, NERA says that port and quay dues generally do not constitute more than 20-30 per cent of the overall port costs of most ships, even when the costs of cargo handling are excluded. Payments made to private firms offering different kinds of services in the port usually cannot be expected to be available for environmental differentiation. NERA's conclusion is that in some cases even very large discounts (percentage-wise) off port dues may not be able to offer incentives that match a significant proportion of the ship's expenditure on emission abatement measures.

NERA recognises that the risk of losing customers to competing ports can be diminished if all ports in an area differentiate their dues in a similar manner. According to NERA a likely reason for the success of the Swedish voluntary scheme for port dues differentiation is the participation of a high proportion of Swedish ports, which helps mitigate the risk of loss of business by any port.

NERA concludes that if fear of losing business contracts makes the creation of a voluntary scheme impossible, an alternative might be to make the system asymmetric, i.e. offering lower charges for low-polluting vessels without raising the rates for high-emitting ones. In this case competition between ports would be unaffected but some form of public assistance would be required to close the gap between reduced revenues and full cost recovery. Yet another option would be to base the environmental differentiation entirely on publicly managed mandatory infrastructure charges.

### 7.2.4 Environmental subsidies

A new category of instruments elaborated on in NERA (2005) is subsidies on investments in environmental technologies for reducing emissions at sea.

Subsidies on the introduction of new technologies are used in many countries and for numerous purposes. In the maritime sector, the Swedish government for a few years offered a grant equal to 40 per cent of the cost of installing SCR or HAM equipment on board ships operating in Swedish waters (regardless of flag). It was deemed that the cost of investing in these technologies was too expensive to be fully incentivised by the differentiation of the Swedish fairway and harbour dues that entered into force in 1998.

Another example of environmental subsidies in the shipping sector is a pilot programme carried out in 2000-2002 in the port of Hamburg, where ships meeting certain environmental criteria (low-sulphur bunker oil, having tributylin-free anti-fouling paint, or demonstrating a $NO_x$ emissions rate 15 per cent below the one specified by the IMO $NO_x$ curve) were eligible for a 12 per cent discount on port dues. A discount of 6 per cent was offered to ships holding a Green Award or an ISO 14000 EMS certificate. In both cases the discounts were financed by a government subsidy. The programme has been discontinued, partly because the city found that in the absence of similar programmes in other ports, the incentive was unlikely to be sufficient to promote expensive abatement measures.

NERA believes that an environmental subsidy programme could be incorporated into the existing subsidies provided to EU shipbuilders by making the subsidy contingent on incorporation of air emission control equipment. Current rules authorise European governments to provide a subsidy of up to 14 per cent of the contract value of ships in "protected market segments". To avoid distorting competition among European shipyards, aid above 6 per cent must be approved by the European Commission. NERA says shipbuilding subsidies could be transformed into environmental subsidy programmes in three different ways: (1) part of the subsidy could be targeted for pollution control equipment; (2) the subsidy could be conditioned on installing certain pollution control equipment; or (3) the subsidy could be conditional on the achievement of a given emission rate.

Another alternative brought forward by NERA is to introduce environmental guidelines into the EU's existing Marco Polo and Motorways of the Sea programmes. The former was launched in 2003 and seeks to reduce pollution and relieve congestion on European motorways by funding short-term projects that promote shifts to modes such as rail, inland waterways and short-sea shipping. The first programme expires in 2006 but will be superseded by Marco Polo II (2007-2013), for which a budget of €740 million has been proposed. The Motorways of the Sea is closely linked to the Marco Polo programme. The idea is to make use of inexpensive sea "motorways" rather than investing heavily in infrastructure for land-based modes of transport. NERA, however, does not present any concrete proposals for the greening of these existing programmes.

As mentioned above, NERA also suggests the potential use of subsidies for funding credits (the stringent credit-based approach) or discounts on port dues (environmentally differentiated charges).

European Community law does not prevent state aid being given for environmental measures in the shipping sector. The Community guidelines on state aid for environmental protection (2001/C37/03) allow aid to private firms to achieve levels of protection that are higher than those required by Community standards, or where no such standard exists. Aid can be given for investments intended to reduce pollution so long as the sum does not exceed 30 per cent gross of the eligible investment costs. A special set of guidelines apply to state aid for maritime transport (1997/C205/05), which allow investment aid in certain circumstances for the promotion of clean shipping. Finally, the Commission framework on state aid for shipbuilding (2003/C317/06) allows aid for research and development up to 20 per cent of gross expenditure for innovation.

## 7.3 Calculation of cost/benefit in the study NERA 2005

The calculation of the cost/benefit by NERA is based on results from investigations carried out by Entec (2005a-2005e). In this study the ship movements in Europe were analysed and arranged in different groups according to ships' size, age and capacity of main and auxiliary engines. For the different groups emission rates for $SO_2$ and $NO_x$ were assumed and potential abatement technologies considered. These technologies possess different reduction capabilities and differing investment and operational costs. Based there upon, the costs for the reduction of one tonne of a certain pollutant were calculated. As some of the assumptions are based on very limited experience, e.g. with regard to the costs implied by the installation of scrubber technology, the indicated results are in some cases questionable. The assumed level of cost depends on further technical and legal development.

### 7.3.1 Calculation of Marginal Abatement Cost Curves (MACC)

NERA constructed illustrative Marginal Abatement Cost Curves[14] (MACCs) for a variety of scenarios for $SO_2$ and $NO_x$ reduction measures. A MACC is a depiction of the additional cost

[14] NERA calculated the marginal cost of each abatement measure per tonne of pollutant abated to construct Marginal Abatement Cost Curves (MACCs) for each pollutant. The MACCs show the additional cost of reducing

of incremental or marginal emission reductions that each technology provides, and therefore the costs shown in these figures cannot be matched one-for-one with the average costs shown in the calculated tables.

### 7.3.2 Application of abatement technologies for $NO_x$ reductions

The following figures show the cost per tonne of $NO_x$ reduced for certain measures when the reductions are applied to all vessel emissions occurring in different geographic regions. The costs for the use of shore-side electricity are only shown for in-port emissions. The costs of the different $NO_x$ abatement technologies are shown in table 17.

**Table 17: Cost of $NO_x$ technologies/tonne reduced by ship size and age, by area (€/tonne)[15]**

| | Small | | Medium | | Large | |
|---|---|---|---|---|---|---|
| | New | Young and Old | New | Young and Old | New | Young and Old |
| *All Emissions* | | | | | | |
| Basic IEM | 12 | 60 | 9 | 24 | 9 | 15 |
| Advanced IEM | 98 | N/A | 33 | N/A | 19 | N/A |
| HAM | 268 | 306 | 230 | 282 | 198 | 263 |
| DWI | 411 | N/A | 360 | N/A | 345 | N/A |
| SCR | 740 | 809 | 563 | 612 | 526 | 571 |
| Shore Power | - | - | - | - | - | - |
| *12-Mile Emissions* | | | | | | |
| Basic IEM | 60 | 300 | 46 | 125 | 48 | 77 |
| Advanced IEM | 489 | N/A | 166 | N/A | 96 | N/A |
| HAM | 1,285 | 1,472 | 1,095 | 1,351 | 930 | 1,257 |
| DWI | 920 | N/A | 669 | N/A | 595 | N/A |
| SCR | 1,125 | 1,467 | 838 | 1,086 | 777 | 1,003 |
| Shore Power | - | - | - | - | - | - |
| *In Port Emissions* | | | | | | |
| Basic IEM | 8,220 | 41,100 | 6,362 | 14,929 | 5,725 | 8,723 |
| Advanced IEM | 8,583 | N/A | 3,517 | N/A | 1,942 | N/A |
| HAM | 22,311 | 25,602 | 22,868 | 28,271 | 18,609 | 25,243 |
| DWI | 11,488 | N/A | 8,481 | N/A | 6,651 | N/A |
| SCR | 9,149 | 15,211 | 7,723 | 12,938 | 6,846 | 11,451 |
| Shore Power | 9,662 | 12,086 | 5,371 | 6,631 | 3,847 | 4,704 |

NERA 2005[16]

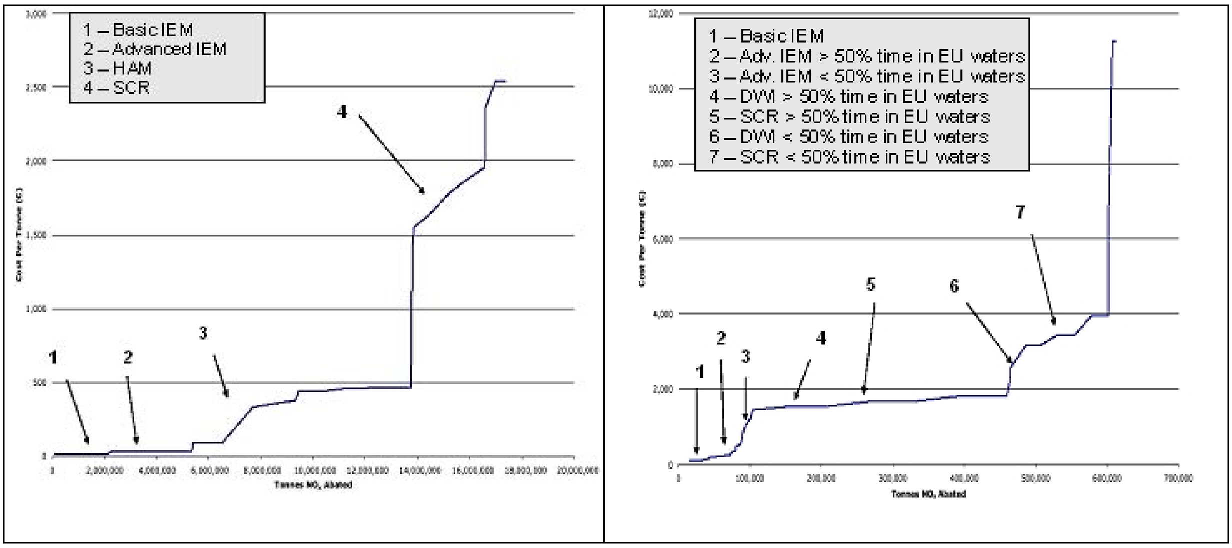
The figures show the additional amount that must be paid to gain additional reductions of $NO_x$ from more effective technology. They illustrate that the marginal cost per tonne of choosing SCR over HAM will be significantly greater than the marginal cost of moving from no control to SCR, because the incremental emissions reduction associated with making a choice to install SCR instead of HAM is much less than the total reduction associated with SCR.

incremental tonnes of pollutant, over and above the cost of the previous (less costly) reductions without monitoring costs (NERA 2005)

[15] Similar to Entec, NERA assumes for costs calculations for each vessel type three ages: new, which were built in the last year; young, built in the last fifteen years; and old, built before 1990.

[16] Note: The cost of basic IEM for young vessels is the same as that for new vessels. Also note that basic IEM becomes less cost-effective at berth because it is less effective on auxiliary engine emissions.

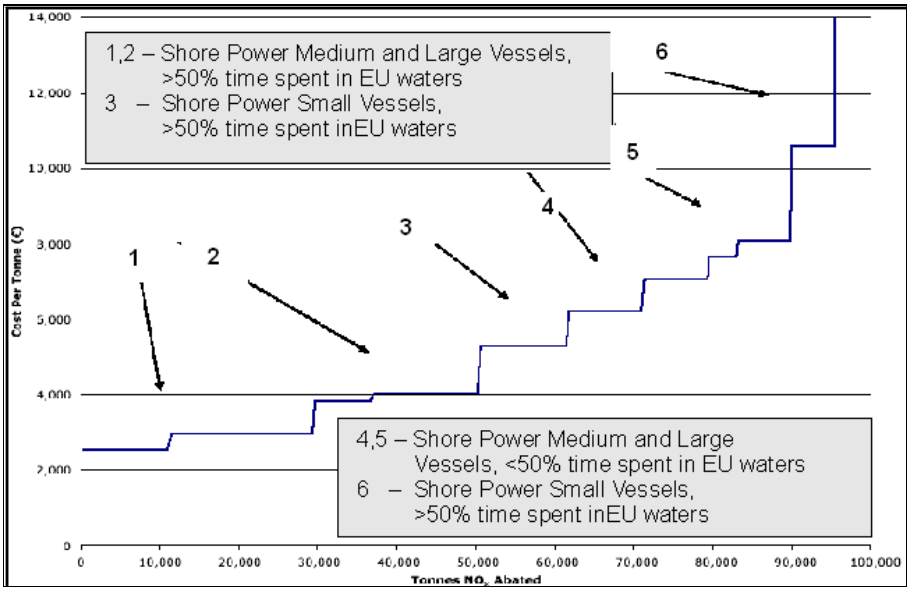
**Figure 14: MACC for $NO_x$, no geog. considerations, MACC for $NO_x$, EU 12-mile zone**




NERA 2005

In figure 12, the first scenario is based on the assumption that all vessels in any one year spend all of their time in the relevant waters. This is clearly unrealistic and is important to correct, because the time spent in EU waters (or other waters with emissions restrictions) has important implications for the incentives to undertake emissions abatement. To correct this assumption, additional MACCs were developed based on the distribution of time spent in different waters. Although NERA also calculated a scenario of 200 EU nautical miles, only the EU 12-mile zone scenario was considered as they are quite similar. If the reduction technologies were applied only while ships are in port, the costs per unit reduced would, of course, rise. This is illustrated in figure 14.

**Figure 15: MACC for $NO_x$, at berth emissions only**




NERA 2005

### 7.3.3 Application of abatement technologies for $SO_x$ reductions

The measures involving low-sulphur fuel have the same cost per tonne for all vessel types because of the assumption that vessels are able to use the low-sulphur fuels whenever necessary without incurring any additional capital costs or fuel-switching costs[17], and fuel costs alone would not vary across vessels. Again, the costs of measures when the relevant emissions reductions occur only while in port (including the use of 0.1 per cent MDO and shore power) are only shown in the last section of the table.

**Figure 16: Cost of $SO_2$ technologies/tonne reduced by ship size and age, by area (€/tonne)**

| | Small | | Medium | | Large | |
|---|---|---|---|---|---|---|
| | New | Young and Old | New | Young and Old | New | Young and Old |
| *All Emissions* | | | | | | |
| 1.5% Sulphur | 1,230 | 1,230 | 1,230 | 1,230 | 1,230 | 1,230 |
| 0.5% Sulphur | 1,690 | 1,690 | 1,690 | 1,690 | 1,690 | 1,690 |
| 0.1% Sulphur | - | - | - | - | - | - |
| Scrubber | 390 | 579 | 351 | 535 | 320 | 504 |
| Shore Power | - | - | - | - | - | - |
| *12-Mile Emissions* | | | | | | |
| 1.5% Sulphur | 1,230 | 1,230 | 1,230 | 1,230 | 1,230 | 1,230 |
| 0.5% Sulphur | 1,690 | 1,690 | 1,690 | 1,690 | 1,690 | 1,690 |
| 0.1% Sulphur | - | - | - | - | - | - |
| Scrubber | 1,850 | 2,600 | 1,600 | 2,500 | 1,430 | 2,360 |
| Shore Power | - | - | - | - | - | - |
| *In Port Emissions* | | | | | | |
| 1.5% Sulphur | 1,230 | 1,230 | 1,230 | 1,230 | 1,230 | 1,230 |
| 0.5% Sulphur | 1,690 | 1,690 | 1,690 | 1,690 | 1,690 | 1,690 |
| 0.1% Sulphur | 2,326 | 2,326 | 2,326 | 2,326 | 2,326 | 2,326 |
| Scrubber | 30,060 | 46,200 | 36,040 | 56,800 | 29,460 | 45,070 |
| Shore Power | 9,889 | 12,370 | 5,498 | 6,788 | 3,937 | 4,815 |

NERA 2005[18]

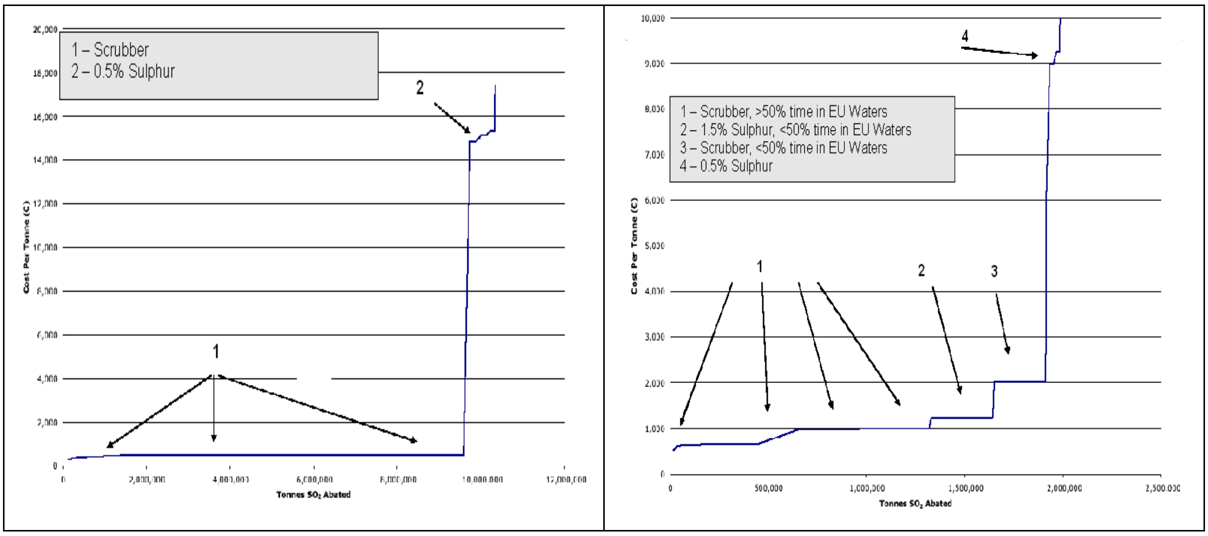
In the first of the following scenarios (no geographical considerations) it is obvious that – based on the assumptions made – scrubbers would make up the majority of the potential cost-effective solutions. This is due to the low variable cost compared to fuel-switching, which makes it less expensive than switching all activity to fuel with 1.5 per cent sulphur and almost as effective at removing emissions as a 0.5 per cent fuel. Since 0.5 per cent fuel is slightly more effective than removing emissions, it makes up the final portion of the MACC, but the

[17] In estimating the cost of different $SO_2$ abatement measures, Entec assumes that vessels switch entirely from high sulphur fuel oil to low sulphur fuel, to simplify the cost-effectiveness calculations. Vessels therefore do not need to install additional fuel tanks or modify existing tanks to accommodate multiple fuels, so the fuel switching measures involve no capital costs. Moreover, because vessels are assumed to use only one type of fuel, the variable cost estimates do not reflect the costs of switching between different fuels, which may require draining all fuel from the engine, heating the new fuel, and re-flooding the engine with the new fuel, all of which are likely to impose additional costs.

[18] Note: 0.1 percent sulphur fuel is also referred to as Marine Distillate Oil (MDO)

added incremental cost of using only 0.5 per cent fuel causes the additional tonnes to be more than 10 times as expensive as the per tonne cost of a scrubber.

**Figure 17: MACC for $SO_2$, no geog. considerations; MACC for $SO_2$, EU 200-mile zone**

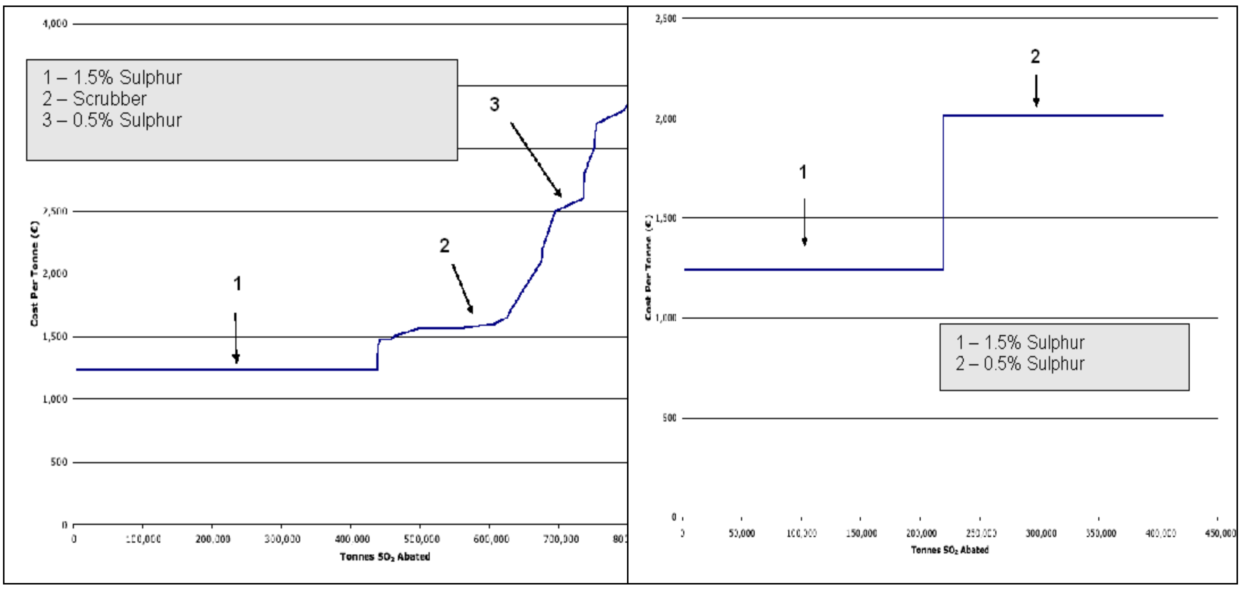



NERA 2005

The MACC for the EU 200-mile zone shows that installing and running scrubbers on ships that spend the majority of their time in EU waters could provide over half the potential emissions reductions. For these vessels, a scrubber is more cost-effective on a per-tonne-reduced basis than switching to fuel with 1.5 per cent sulphur. For vessels that spend less than half of their time in EU waters, 1.5 per cent fuel is slightly more cost-effective than a scrubber.

The left part of figure 16 considers emissions in the current SECAs, which are the only relevant emission zones, while the right part of the figure shows the MACC for $SO_2$ when emissions in the 12-mile zone are the only ones considered.

**Figure 18: MACC for $SO_2$, SECA zone; MACC for $SO_2$, EU 12-mile zone**

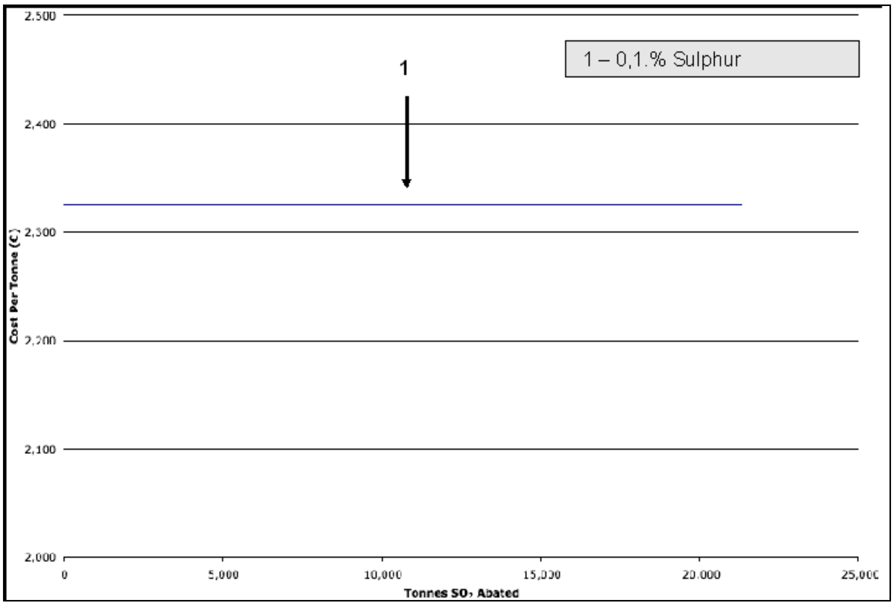



NERA 2005

The difference between the MACC of the EU 12-mile zone and those of the 200-mile and SECA zones is striking. If emissions in the former are the only issue of concern, scrubbing no longer appears to be an attractive abatement alternative. The strategy of using a lower-sulphur fuel when in a 12-mile zone and a higher-sulphur fuel elsewhere is significantly less expensive than incurring the fixed costs of installing a scrubber[19].

Finally, where the MACC for $SO_2$ at berth is concerned, the option to be considered is either the possibility of using 0.1 per cent sulphur fuel or shore power.

**Figure 19: MACC for $SO_2$, at berth, emissions only**




NERA 2005

As with other fuel-switching alternatives, data on potential additional capital costs and on additional operating costs (apart from the fuel costs themselves) were not available to NERA, so the cost analysis may overestimate the attractiveness of the fuel-switching option. However, there is no $SO_2$ benefit when moving between 0.1 per cent sulphur fuel and shore power. Therefore, since both reduce the same number of tonnes $SO_2$, and the respective table indicates that 0.1 per cent fuel is less expensive on a per tonne basis, only 0.1 per cent fuel is shown in this figure.

### 7.3.4 NERA's conclusions

NERA's assessment of the four approaches, considered separately for $SO_2$ emissions and $NO_x$ emissions, results in a preliminary recommendation to apply a consortium benchmarking programme for $SO_2$ and a credit-based programme for $NO_x$. Voluntary port dues appear less promising, unless a concerted effort is made to coordinate a large number of ports, which NERA thinks will not be possible in the medium term. Environmental subsidies also appear less promising as there is no apparent source of funding. NERA underlines that redirecting some of the existing ship subsidies would effectively reduce the net subsidy for other shipbuilding activities. However, NERA mentions the possibility of re-allocating a small part of

[19] Again, note that if data on the fixed costs and additional operating costs of adopting a dual-fuel approach had been available for our analysis it is possible that this conclusion would change for some vessel types.

the funds available under the Marco Polo II programme to be used to offset ports' costs of upgrading berths to permit the use of shore-side electricity.

NERA's main reasons for recommending a consortium benchmarking programme for $SO_2$ reductions are the following:

- Allowing shipowners to form a consortium and use a mix of $SO_2$ controls (1.5% sulphur, 0.5% sulphur, or seawater scrubbers) could lead to an average emission rate below the level that could be achieved with a universal requirement to use low-sulphur fuels.
- The flexibility provided would lead to substantial reduction (in the order of 35%) in control costs.
- Administrative procedures could be developed at reasonable cost.
- However, as the regulatory approach already provides some flexibility to use alternatives to low-sulphur fuel (i.e. seawater scrubbing), the cost savings from benchmarking are reduced, but they still appear to be significant.

One reason for NERA not recommending a credit-based approach for $SO_2$ is that because scrubbing can be more cost-effective than the use of low-sulphur fuels, credits based upon scrubbing could represent "anyway tonnes" as the Marine Sulphur Directive already permits scrubbing to be used to meet emissions levels. Another reason is that the allowance prices necessary to incentivise abatement – using either scrubbers or low-sulphur fuels – are higher than the prices observed under existing trading programmes. A third motive is that monitoring emissions would add to the cost of the credit-based approach.

NERA believes that the credit-based approach is more promising for $NO_x$ than for $SO_2$. The following are its reasons for this conclusion:

- Many control alternatives are available, with a wide range in cost.
- Preliminary cost information indicates that a substantial number of $NO_x$ credits would be available at $NO_x$ prices in a likely range under a cap-and-trade programme for large stationary sources.
- Credits could be based on the IMO $NO_x$ curve, presumably modified to provide some environmental benefits relative to business-as-usual.
- Monitoring would be feasible.

According to NERA, the consortium benchmarking approach is less attractive as it lacks a short-term $NO_x$ requirement for ships (although a benchmark level could be based on the IMO $NO_x$ curve, perhaps modified to ensure some environmental benefits relative to BAU, and consortia benchmarking could cut costs by 45%). NERA also says monitoring costs for $NO_x$ would be more expensive than for $SO_2$.

## 7.4 Assessment of the proposals of the NERA study

The previous sections offered a brief summary of NERA's two reports for the European Commission. This section presents our evaluation of NERA's analysis and recommendations.

It is worth noting that all programmes recommended by NERA are in fact voluntary schemes, and that probably none of them can be expected to result in a substantial reduction in emissions. Since the prime objective of launching market-based instruments would be to markedly reduce the emissions of shipping pollutants and help achieve the Community's environmental targets at lowest possible cost, priority should instead be given to options that are both cost-efficient and offer high reduction potentials.

### 7.4.1 Credit-based programmes

NERA believes that credit-based programmes would require more detailed baseline and monitoring procedures to reduce the likelihood of "anyway credits" and says that experience indicates that such additional administrative requirements can substantially increase participation costs.

However, a general observation from reading the two reports by NERA is that, where the abatement of $NO_x$ is concerned, all different market-based instruments presented would require participating ships to register their specific emissions (g/kWh or g/km at normal speed), or alternatively force them to invest in a technology for continuous emissions monitoring. Where sulphur dioxide is concerned, all programmes but one (fuel tax at the pump) that were assessed in NERA's first report (2004) would require participating ships to carry a certificate guaranteeing the sulphur content of the bunker oil, or alternatively evidence of being equipped with a scrubber. As all ships, according to the Technical Code of MARPOL's Annex VI, must carry a "bunker delivery note", the first requirement is already provided for.

Thus a vital part of the transaction costs would be more or less the same in all cases presented by NERA, although the number of participants would, of course, differ between voluntary and mandatory programmes. As all programmes involve transfer of substantial amounts of money, monitoring and penalties for non-compliance would have to be used regardless of whether the scheme is organised in a public or a private form. All programmes would presumably require a common, Europe-wide, environmental ships register and some type of monitoring. Large-scale programmes involving many vessels, however, may have the advantage of being able to distribute overhead expenditure among a large number of participants.

NERA recognises that the environmental effects of a tonne of airborne substances emitted at sea are clearly less significant than the effects of the same amount emitted in ports. Therefore there is a need for geographical differentiation. However, NERA also acknowledges that the need for differentiation is more pronounced in a credit-based approach where land-based sources would pay for reductions at sea in order to avoid a higher marginal abatement cost on land. Taking this and the issue of avoiding "anyway tonnes" into consideration, the stringency of the stringent credit-based approach would have to be considerable. This raises the issue of whether it is possible to strike a balance between stringency and effectiveness on the one hand and degree of participation on the other. How many shipowners would care to participate if they will be credited only for reductions that fall more than, say, 25 per cent below IMO's $NO_x$ curve and when at the same time the value of the credits will be multiplied by 0.5 or 0.75 for reductions that take place far from land? In this context one would also have to consider the transaction costs that come with creating a system for emissions trading among land-based sources that would not have been needed in a case where credits were not offered to measures on board sea vessels. If the trade ends up being small, the monitoring and compliance costs of the entire system would have to be distributed among relatively few tonnes.

NERA notes that a credit-based trading system would probably require modifications of the Large Combustion Plant Directive (LCPD) and the Integrated Pollution Prevention and Control Directive (IPPC). It would, in fact, also require an amendment to the National Emissions Ceiling Directive (NEC) as the trade could result in higher total emissions of $NO_x$ and $SO_x$ from the territories of some Member States than allowed in the directive.

Another issue that might have to be considered is whether emissions trading will create hot spots in the sense that the effects of emissions on health and terrestrial ecosystems will stay at a harmful level when a large land-based facility invests in control measures at sea to avoid higher abatement costs at home.

### 7.4.2 Consortia benchmarking

In its analysis of credit-based programmes, NERA recognises the need for a stringent approach to avoid giving credits to “anyway tonnes”. However, this problem appears to be equally relevant to consortia benchmarking. The benchmark needs to be set somewhat below 1.5 per cent as some ships, particularly in the Baltic Sea, already voluntarily use heavy fuel oils with a sulphur content well below the limit enforced by law. Another fact to take into consideration is that some vessels, in particular high-speed craft, run on distillates.

Given the complicated decision-making process in the IMO, it seems unlikely that the revisions of MARPOL Annex VI needed for applying consortia benchmarking will take place in the foreseeable future. However, when the next revision of the Sulphur Directive takes place it might be worth considering the use of a flexible mechanism such as consortia benchmarking. It may facilitate the introduction of emission limit values that are more stringent than would be accepted by the IMO in a situation without trading.

However, in the absence of new legislation, consortia benchmarking appears to have little to offer. A system based on voluntary benchmarks below the levels of the current IMO $NO_x$ curve and the current sulphur restrictions enforced within SECAs would hardly attract participation from high-emitting ships, because under such a regime they would not in any sense gain from the intra-consortia trade. To make them take interest, the IMO would have to change the current rules in order to allow the use of high-sulphur fuels in SECAs in cases where excess emissions are compensated for by other ships with emissions below the benchmark target.

### 7.4.3 Differentiation of port dues

A problem with port dues is that they are differently structured from country to country and sometimes from port to port within one Member State. Decisions on their structure and content are traditionally part of each individual port’s policy and based on local circumstances. Gross tonnage (GT) is often used as a basic parameter for setting port dues but diverse additional conditions and possibilities for dues reduction may also exist. Moreover, GT is not an ideal criterion for rewarding low-emission shipping as there is no clear relation between the GT of a vessel and the energy needed for its propulsion. An additional difficulty is that the environmental differentiation of port dues cannot easily be designed to reflect the overall emissions during a ship’s voyage from the previous port as, unlike differentiated en-route emission charges, port dues do not take into account the distance travelled.

NERA recognises that payments made to private firms offering different kinds of services in a port cannot be expected to be available for environmental differentiation. In this context, one should also observe that services that are currently offered by a port administration might five or ten years from now have been turned into privately operated businesses. Thus, the volume of charges available for differentiation may diminish over time. This makes port dues differentiation a less interesting option as it is important to be able to guarantee shipowners stable conditions for their investment decisions.

According to NERA a likely reason for the success of the Swedish voluntary scheme for port dues differentiation is the participation of a high proportion of Swedish ports, which has helped mitigate the risk of loss of business to other ports. In this context, however, one should recall that the Swedish programme also suffers from lack of transparency. This means that there is no way for an observer to know to what extent negotiated port dues have actually taken into account the officially stated environmental differentiation. Nor is it possible to know to what extent the voluntary differentiation of Swedish port dues has contributed to abatement measures that may to a large extent have been triggered by the environmental differentiation of the country's fairway dues. The latter are not negotiable.

NERA says that another option would be to base the environmental differentiation entirely on publicly managed mandatory infrastructure charges. However, a problem in this case, not analysed by NERA, is that fairway dues or their equivalent only exist in a few Nordic and Baltic Member States, and where enforced, they are generally too low to allow for any substantial environmental differentiation. In other European countries, no such dues are foreseen.

### 7.4.4 Environmental subsidies

In its evaluation of the credit-based approach NERA ends up saying that the only feasible way in the short to medium term to implement such a scheme might be via a government subsidy programme. A similar conclusion is reached in the section on voluntary port dues differentiation, i.e. the system could be designed in an asymmetric way, provided that government aid is used for compensating the ports for giving rebates to low-polluting vessels. In addition NERA (2005) devotes a full chapter to environmental subsidies other than the two just mentioned.

Lacking in NERA's analysis of subsidies are the possible negative side-effects of state aid, including such phenomena as distortions to trade and competition, leaks (e.g. higher profits among manufacturers of the equipment), and the fact that subsidies make goods and services artificially cheap which makes demand higher than what is socio-economically optimal. Another problem with subsidies is that they are vulnerable to political change and lack of sustainable funding. The recent case of Green Shipping in Hamburg demonstrates that subsidies depend on the financial means available and the short to medium term intentions of the provider, which makes it difficult for shipowners to rely on them. In Hamburg, the financial means were exhausted more quickly than calculated, largely due to the fact that many more ships than expected no longer used anti-fouling materials containing TBT. The programme thus provided windfall profits (a form of "anyway tonnes") rather than incentives to real change.

### 7.4.5 NERA's recommendations

At the end of its 2005 report NERA comes out in favour of using a credit-based programme for $NO_x$ and the consortium benchmarking approach for $SO_2$. The arguments for these preferences are not altogether convincing. Several of NERA's motives for favouring credits are equally valid for the consortium benchmarking approach (and vice-versa). Examples of such arguments include:

- Allowing shipowners to use a mix of $SO_2$ controls could lead to an average emission rate below the level that could be achieved with a universal requirement to use low-sulphur fuels (used in favour of benchmarking).
- The flexibility provided in the abatement of $SO_2$ would lead to a 35 per cent reduction in control costs (consortia benchmarking).
- Administrative procedures for $SO_2$ could be developed at reasonable cost (benchmarking).
- Scrubbing can be more cost-effective than the use of low-sulphur fuels (held against the credit-based approach)
- Credits based upon scrubbing could represent "anyway tonnes" as the Marine Sulphur Directive already permits scrubbing to be used to meet emissions levels.
- Monitoring $SO_2$ emissions would add to the cost of the credit-based approach.
- For $NO_x$ many control alternatives are available, with a wide range in cost (used in favour of a credit-based approach).
- Cost information indicates that a substantial number of $NO_x$ credits would be available at $NO_x$ prices in a likely range under a cap-and-trade programme for large stationary sources.
- Credits could be based on the IMO $NO_x$ curve, presumably modified to provide some environmental benefits relative to business as usual.
- Monitoring of $NO_x$ emissions would be feasible (used as an argument for credits).

The extent to which a certain type of programme is politically and legally feasible is likely to be of greater interest for the choice of programme than available abatement technologies, reduction potentials, and monitoring costs (which under mandatory regimes appear to be of the same magnitude regardless of policy instrument). Fear of difficulties in achieving political and legal feasibility was the reason given by NERA (2004) for not recommending cap-and-trade programmes, taxation or en-route charges. But from NERA's second report it is evident that the credit-based approach and consortia benchmarking are also linked to problems of this kind.

Applying a credit-based approach would require changes in three European Community directives or, alternatively, EU funding of the environmental credits offered to shipowners. Consortia benchmarking does not appear to be a valid proposal unless new decisions are taken by the IMO on the $NO_x$ curve and the $SO_2$ directive for SECAs. If the European Union, in the absence of a revision of MARPOL regulations, wants to go ahead with consortia benchmarking based on mandatory emission limits, legal difficulties would have to be tackled.

Given these restrictions, it might be better to start by making clear how an ideal scheme should be designed, and then undertake an unbiased analysis of the legal and political possibilities of introducing a pilot programme (which may in the end require some compromise). Some of the starting points, partly taken from NERA, for a pilot programme covering emissions from shipping in the Baltic Sea area should be to ensure that the scheme under consideration is:

- Capable of providing a substantial potential for emissions reduction

- Capable of reflecting real emissions as closely as possible
- Able to provide maximum flexibility where abatement measures are concerned
- Applicable to vessels regardless of type and flag
- Able to reflect the location of vessel activity and emissions (geographical differentiation)
- Easy to monitor and enforce
- Transparent and non-discriminating
- Legally, politically and institutionally acceptable
- Based, as far as possible, on the polluter pays principle
- Possible to implement and administer at low cost

This report will discuss these requirements in greater detail in the next chapter.

# 8 A pilot scheme for reduction of $NO_x$ in the Baltic Sea

Abatement of $NO_x$ emissions from maritime shipping differs from efforts to reduce $SO_x$, as several technological measures are available for use in new vessels and for retrofitting in old. They have differing abatement potentials and costs, which allows shipowners to select from the menu a method that fits the engine and the remaining life of the vessel. While a reduction by 90 per cent would be clearly cost-effective in some ships, others can minimise expenditure by choosing a less costly method, even in a case where the owner would have to pay a penalty on the ships' excess emissions. $NO_x$ abatement, therefore, is well suited for a scheme of market-based instruments.

## 8.1 A scheme for $NO_x$-differentiated en-route charging

To be able to investigate the feasibility of a pilot scheme for environmentally differentiated en-route charges in the Baltic Sea, it is necessary to present a draft scheme. The proposal, based on Kågeson (2005), is to mandate the port authorities around the Baltic Sea to assist a common authority that collects a mandatory charge reflecting the calling ship's emissions of $NO_x$ during its latest trip in Baltic Sea waters. The charge would correspond to emissions emitted from the point of entry into Baltic Sea waters (e.g. at 57° 44.43'N) or since departure from another Baltic port. The authority in charge of the scheme would check the distance and time travelled in Baltic Sea waters and carry out a limited number of random checks of on-board facilities for compliance with a certified situation on board and with available $NO_x$ abatement technologies.

The system could in future potentially be expended to include emissions of particulate matter.

## 8.2 A substantial reduction potential

In order to return to the 2004 level, i.e. to reduce the emissions in 2020 by around 88 per cent (339.000 tonnes) in the first and 55 per cent (211.000) in the second abatement scenario compared with the BAU scenarios, ships that regularly call at ports in the area would have to use HAM or SCR. As described in chapter 5, the cost of equipping an existing vessel with SCR falls in the range of €443 and €613 per tonne depending on the size of the ship. For new ships the range is €398-543 per tonne. In order to promote retrofitting with SCR of the most frequent visitors, we suggest that the en-route charge for $NO_x$ is set at €550 per tonne emitted.

## 8.3 Reflecting real emissions

As already noted, $NO_x$ is formed in the combustion process. Currently it is not possible to measure the exact amount of $NO_x$ being emitted from individual ships. For the time being, emissions will have to be estimated. The calculation can make use of official data on the amount of $NO_x$ that is released for each kilowatt-hour produced by the vessel's engines, assuming that on average 85 per cent of the engine capacity is utilised when the ship is moving. MARPOL's Annex VI sets limits on emissions of $NO_x$ from diesel engines. The Technical Code defines how this is to be done. This technical code could also be used for registering specific emission levels below the mandatory value. Assuming that the average capacity utilisation of the engines is equal to that prescribed in MARPOL's technical code, an authority responsible for collecting the en-route charges can with reasonable accuracy calculate the emissions from individual vessels, provided it also has access to information on the time and distance travelled by the ship.

Since the late 1990s, the Swedish National Maritime Administration has registered the specific emissions of $NO_x$ (per kWh) for ships applying for reduced fairway dues.

This simplified method, however, cannot consider differences that occur due to a higher or lower speed or the force and direction of the wind, and does not at all take into consideration emissions at berth or at anchor[20]. An additional opportunity would be to measure the true emissions of $NO_x$ as the ship moves. This is already standard for land-based furnaces of a size equal to those of the main machineries of large ships, and technologies for continuous monitoring of $NO_x$ from ships are now being developed. At a later stage, when emissions are continuously measured on board each ship, the scheme could be further developed.

Establishing a scheme for environmentally differentiated en-route charges in the Baltic Sea would necessitate a common environmental ships register, which could build on the existing register administered by the Swedish Maritime Administration that already includes more than one thousand commercial vessels.

To make charges reflect overall emissions, it would be necessary to register the time and distance travelled by each ship in the area covered by the scheme. This could be done by making participating ports register the port of departure for vessels calling at their facilities. The amount of fuel consumed on the journey would be calculated automatically by a computer that uses data from the ships register based on the assumption that the ship makes use of 85 per cent of its engine capacity.

The Automatic Identification System, AIS, which automatically transmits the identity of ships can be used for monitoring compliance and for verification of the travelling time between ports or from entry of the Baltic Sea to the first port call. The heart of the AIS is a transponder on board. It consists of three main components: a GPS-receiver, a VHF-transceiver, and in between them a computerised data processor. The Global Positioning System (GPS) uses signals from multiple satellites to give the position of its antenna and also a very accurate time reference. The system gives up-dated information about other ships in the vicinity that are also equipped with AIS and thus help the watch officer on board to take appropriate measures to avoid collisions or other calamities. In addition, the system also transmits information to on-shore coastal centres.

The nations around the Baltic Sea have agreed to establish shore-based AIS infrastructure to cover most of the Baltic. The information received will be exchanged among the countries. The implementation of this system is now well under way. The European Union requires all coastal states in the Union to establish shore-based AIS infrastructure by 1 July 2007.

The range of the VHF transmission is equal to “the line of sight” which in most cases is no more than 60 nm. A high antenna on board or a base station located on a hill or equipped with a tall antenna may extend the range somewhat. It is also possible to locate “repeater stations” on buoys at sea to extend the range. Yet another possibility is to use aircraft as relay stations. In the longer term an option might be to use specialised satellites for this purpose. The data received by different shore based stations can easily be linked by telecommunication to a common traffic surveillance centre.

The emissions per kWh would then have to be multiplied by the amount of energy used under normal/average circumstances to propel the ship during the time of the trip at 85 per cent en-

[20] The same kind of simplification is currently used in the environmental differentiation of road tolls.

gine capacity. In other words, this type of charge is aimed at limiting emissions per kWh used, rather than setting a cap on the total emissions emitted in the area concerned. The latter also depend on the growth (or decline) in traffic.

The conclusion is that determining emissions and/or registering the specific emissions from different vessels appear not to be a technical problem. The AIS system makes it possible to identify all ships and to measure the distance and time that each ship travels in the Baltic Sea area.

## 8.4 Providing maximum flexibility

Market-based instruments such as emission charges and cap-and-trade systems have the advantage of allowing subjects a large degree of flexibility in their choice of response.

Where the charge on $NO_x$ is concerned, it makes sense for ship owners under the proposed scheme to install abatement technologies in ships travelling only in the Baltic Sea provided that the vessel has an expected remaining life that is long enough to allow the equipment to be written off. For ships with few remaining years in operation and for infrequent visitors to the Baltic Sea it might be better to pay the full charge. Ships belonging to a category in between the two mentioned above might consider taking some abatement measures provided that the cost is relatively low.

However, there is sometimes good reason not to allow the subjects complete freedom in the way they respond. Risk of high concentrations of unwanted substances locally (hot spots) might be a reason for restricting the flexibility. This could potentially be the case in the Baltic Sea if a port that mainly attracts transatlantic traffic is located in the immediate neighbourhood of a large human settlement. However, in most cases, Baltic Sea ports are predominantly used by ferries, feeder ships and vessels used in short-sea shipping. The likelihood that such ports only attract old vessels with few remaining years in operation is small. Hot spots thus do not seem to be a problem in the context of applying market-based instruments on Baltic Sea shipping.

The conclusion is that environmentally differentiated en-route charges for reducing $NO_x$ in the Baltic Sea area offer a large degree of flexibility and would contribute towards the development/implementation of cost-efficient pollution abatement measures without causing negative effects (hot spots) in certain areas.

## 8.5 Acceptable in the context of inter-port competition

The launch of a market-based pilot scheme that applies to ports in the Baltic Sea area would give ports in neighbouring non-participating states and/or areas a competitive advantage. This might potentially be a problem for participating ports that to a large extent attract visitors from other parts of the world. The ships calling at such ports would in many cases pay en-route charges above average. If there is a non-participating port in the vicinity they may consider calling at that port. Such a move, however, is conditional on the approval of freight owners who would have to consider potential negative side-effects such as delayed deliveries or incremental costs of extended land transport by truck or train. The road tolls on the German motorways, which after the revision of the “Eurovignette Directive” (2006/38/EC) may be followed by the introduction of kilometre-charging on the roads of other Member States, is a system that would have to be considered in this context.

If inter-port competition is regarded as a problem, the founders of the Baltic Sea pilot project would have to consider lowering the charges in order to diminish the burden put on participating ports. However, in doing so they would also affect the cost-effectiveness of the scheme. To lower the en-route charge for $NO_x$ to a level where it no longer provides an incentive to ships with many remaining years in operation to install SCR would severely weaken the scheme. In such a case, it would be better to choose a cap-and-trade system as it would guarantee some improvement, even in a case where the cap is initially set relatively high in order not to disturb competition with outside ports.

One should also remember that the charge would only be enforced on journeys to participating ports in the Baltic Sea area. As a result, all trips from such ports to ports outside the area would not be covered. In addition, trips from outside ports to ports in the southern and western part of the Baltic, which are most vulnerable to competition from neighbouring North Sea ports, would only be charged for the relatively short distance from the Kiel Canal or 57°44.43'N to the ships' destination in the Baltic Sea.

One should be aware that the problem with competition from non-participating ports exists in all regional schemes. For example, if the ports of the North Sea, the British Channel and the Irish Sea were to be included, some participating ports would face problems with ports on the other side of the "border". Moving the limits of the pilot area to some other geographical point would just shift the burden to other participating ports.

The Baltic, being relatively well separated from neighbouring seas, should be the ideal place for a trial if all coastal states take part, and would provide better conditions for a pilot project than most other sea areas, even if Russia chose not to participate.

However, a potential problem with the Baltic Sea is that high-emitting ships calling at ports along the northern part of the Swedish Baltic coast will encounter higher costs than equally high-emitting vessels calling at the Port of Gothenburg on the North Sea coast. The fact that Sweden is part of the Scandinavian peninsula is a disadvantage to the former ports as many freight customers prefer to unload at Gothenburg and use road or rail for the journey across the peninsula. This is to some extent caused by the fact that the Swedish government makes sea transport pay for the fixed costs of the fairways while at the same time exempting rail from the financial burden of its much higher infrastructural costs. It could level the paying field by enforcing the same principle of liability on both modes.

## 8.6 Applicable to vessels of all types?

From a technical point of view, all types of vessels can be included in the pilot scheme. However, for practical reasons it might be better to exempt small vessels (e.g. fishing boats and small passenger ships).

The rules of MARPOL and AIS are relevant to reaching a decision on the minimum size of ships that are obliged to participate in the pilot scheme. According to MARPOL Annex VI, an International Air Pollution Prevention Certificate (IAPP) shall be issued to any ship of 400 GT or more engaged in voyages to ports under the jurisdiction of other Parties. All ships concerned must have received their certificate no later than the first scheduled dry-docking after entry into force of the Annex VI protocol, but in no case later than three years after entry into force of the protocol (i.e. 19 May 2008). The AIS is compulsory for all passenger ships and all cargo ships of 300 GT and more engaged in international voyages. Ships above 500 GT and not on international voyages will be equipped with AIS before 1 July 2008.

From these regulations it is clear that all vessels of 400 GT or more that engage in international traffic will carry both an IAPP Certificate and an AIS transponder by 1 July 2008. Ships of 500 GT or more engaged in domestic voyages will be equipped with AIS by the same date, but current regulations do not force them to carry an IAPP Certificate.

In order not to discriminate against ships in international traffic, it is necessary to set the limit at 400 GT and ask the participating states to demand all vessels in domestic traffic of that size be equipped with AIS transponders and an IAPP Certificate. The charges (or alternatively the cap) should, of course, apply to all ships of 400 GT or more regardless of flag. For an analysis of the legal implications, see chapter 10.

## 8.7 Reflecting location of vessel activity and emissions

The AIS system makes it possible to take account of where in the pilot area pollutants have been emitted and to differentiate the en-route charge for differences in environmental impact. It could potentially be interesting to enforce a higher fee on emissions close to land and in particular on emissions emitted when moving in ports. Several port cities have difficulties attaining the European air quality standards for $NO_x$ and $PM_{10}$, and to the extent that port activities contribute significantly to the violation of these standards, it might be worth contemplating a higher charge on high-polluting vessels when they operate in the vicinity of the port.

However, in the absence of continuous monitoring of exhaust emissions from the ships' auxiliary engines it would be difficult to charge vessels for their true emissions, as the use of these engines when the ship is moored differ greatly depending on the type of ship and whether it is loading or unloading. Where particulate matter is concerned, an additional difficulty is that MARPOL Annex VI does not yet include a technical code for particles. Moreover, attaining real low emissions of $PM_{10}$ would involve the use of particle filters (or a shift to a gaseous fuel), which in turn require the use of diesel fuel with a sulphur content below 15 ppm.

An alternative to differentiating the en-route charge for location would be to exempt emissions when moored (as ships at berth or at anchor by definition are not en-route) and to leave to the individual port and the local authorities to consider whether meeting the air quality standards requires measures to be taken on-board visiting ships. In such a case shore-side electricity would be an option. Differentiation of port dues can be used to stimulate such measures. Regardless of whether participating port cities undertake any supplementary actions, they will benefit from schemes that will make frequent visitors use low-sulphur fuel and invest in $NO_x$ abatement technologies.

The conclusion is therefore that at least during the initial phase of the pilot project all emissions of $NO_x$ should be equally treated regardless of where in the area the emission takes place.

## 8.8 A common Authority for monitoring and enforcement

A common agency needs to be in charge of the en-route system, here referred to as the Authority. Among the duties of the Authority should be to:

- Keep a Baltic Sea environmental ships register

- Receive and store data transmitted from participating ports on ship movements and port calls
- Use the AIS system for monitoring of compliance
- Use these data for calculating the charges to be paid by individual ships
- Collect the charges
- Redistribute the revenues
- Collaborate with port state authorities in making random inspections on board vessels calling at participating ports to ensure that they carry the appropriate documents and are equipped accordingly
- Fine ships that violate the rules.

There is no European authority for emissions at sea, but Kågeson (2005) identifies several existing institutions that could potentially harbour the Baltic Sea Authority.

HELCOM's authority could be extended to the tasks now in question, but a decision to that effect would have to be taken by the Parties to the Helsinki Convention. This might be difficult in a situation where, potentially, one or several coastal states may choose not to participate.

The new European Maritime Safety Agency (EMSA) is another option, at least if the decision is taken by the European Union rather than by some of its Member States. The goals of EMSA are to reduce the risk of maritime accidents, marine pollution from ships and the loss of human lives at sea. The agency, however, is primarily concerned with the prevention of accidents and illegal discharges rather than with the "normal" emissions of sea vessels, and it is based in Portugal, far from the Baltic Sea. In this context the SafeSeaNet may provide a good starting point: Since 2002 Member States of the EU and the European Commission are working together to harmonise and exchange information in order to establish a community vessel traffic management system (European Parliament, 2002). The system links a large number of maritime authorities across Europe and keeps track of information via a central index system which stores references to the data locations, not to the actual data. By sending a request to EMSA authorised users may retrieve the data from the relevant provider. This data may include ships specifications and voyage information.

The choice of a legal model for joint implementation of a scheme of en-route charges thus depends on whether the system set up for charging, recycling of revenues and surveillance of the ships concerned, would also be used for other purposes. One possible extension of the system would be to use it for charging ships for the cost incurred by port-based facilities of taking care of sludge and oily water. Creating a common scheme for handling the fees could be a fair way of making sure that all ships pay what they should, and that all ports are fully compensated for the costs. The Authority would in this case create a routine for reporting which all participating ships and ports would be obliged to use. The database and the AIS system would be used for monitoring compliance.

Kågeson (2005) believes that the Authority could potentially also be commissioned to carry out work on behalf of the Fisheries Control Agency (CFCA) and the relevant agencies of the Member States, i.e. to use the AIS system to check that fishing vessels do not operate in forbidden waters or unload in non-authorised ports. This would be particularly important if fishing quotas are changed from tonnes to number of permitted fishing days. All fishing vessels (15 m and longer) are already part of the European Vessel Monitoring System (VMS), which, however, does not currently make use of AIS transponders.[21]

As the Baltic Authority would operate around the clock, allowing it to carry out several tasks that involve the use of the AIS system would presumably save money. Coordination of rescue operations that involve ships, helicopters and aircraft from several coastal states is yet another task that the Authority could potentially be entrusted to carry out.[22] Maybe a special *Baltic Sea Inspectorate* or *Baltic Sea Monitoring Centre* would be the kind of body needed for the combined tasks.

The Authority would use vessel-specific data from its register and information from participating ports and the AIS-system to calculate the charges to be paid by individual ships. The responsibility of participating ports would be limited to controlling the ship's bunker delivery note (see chapter 9) and to make the shipowner or the captain sign a statement ensuring that he/she accepts the duty to pay the en-route charge for $NO_x$ based on the ship's latest journey in Baltic waters. Based on this information, the Authority would later bill the company. This could be done on a monthly, a quarterly or an annual basis.

The Authority, or alternatively the national maritime administration (port state control), should carry out random inspections on board vessels calling at participating ports to ensure that they carry the appropriate documents and are equipped accordingly. To deter ships from cheating, the scheme must also include rules on how the Authority and the participating states shall penalise ships that violate the regulations.

## 8.9 The polluter pays principle and recycling the revenue

According to the polluter pays principle anyone causing pollution should be liable for all damage done as well as for the cost of preventing further destruction. However, where emissions from road transport are concerned, the Council and the European Parliament have decided in the revised "Eurovignette Directive" (2006/38/EC) that trucks are liable only for the weighted average cost of constructing and maintaining the infrastructure. Road tolls can be differentiated for the environmental performance of vehicles, but the marginal cost of air pollution and noise may not be added to the weighted average cost of the infrastructure. In order not to distort inter-modal competition, maritime transport should in this respect not be treated differently than road transport.

However, maritime transport differs from road transport by giving rise to much lower infrastructure costs. Most Member States have open coastlines with short fairways between ports and sea. Only a few countries currently charge vessels for their use of fairways, and the fairway dues are in most cases not large enough to allow for an environmental differentiation that reflects the difference in emissions among ships. When it is not feasible to differentiate infrastructure charges for the environmental performance of ships, it makes sense, at the end of each fiscal year, to recycle the revenue from the en-route charges on shipping. This can be done in a variety of ways.

[21] Which means fishing vessels and commercial ships cannot "see" each other.

[22] Which if established would replace current arrangements for rescue cooperation.

In the case of the existing Swedish charge on $NO_x$-emissions from large land-based furnaces, the money is returned to the owners based on their annual net-energy production. However, in the case of shipping, a better basis for recycling money might be to divide the total annual revenue from the scheme by the number of GT kilometres produced in the designated area by each shipowner, provided that reliable data are available. One could also contemplate alternative ways of recycling, for instance to use the revenue for funding grants to ships that invest in $NO_x$ abatement technologies. There might be additional options for returning the money in ways that do not disturb the function of the charge.

Provided that the level of the charge is accurately set, the programme would provide a correct marginal incentive without causing the average ship to pay more than it will receive back. However, shipowners who invest in abatement technologies would receive more than they pay, and owners of high-polluting ships would pay more than they get back. Apart from administration costs for the industry as such it would be a zero sum game. In this respect, this type of charge would resemble a scheme of emissions trading.

## 8.10 A baseline-and-tradable-credit scheme

An alternative option for returning the revenue would be to design the en-route charge system as a baseline-and-tradable-credit scheme. In such a case ships would have to surrender emission credits for $NO_x$ that correspond to the exhausts emitted on their journey in Baltic waters; the credits would be handed over to participating ports. Each ship would receive credits equal to a baseline or benchmark value (g/kWh) that is successively lowered.

For $NO_x$ the initial baseline could be, say, 70 per cent of the respective value in the MARPOL Annex VI technical file-curve, to be gradually lowered over the years. These values would then have to be multiplied with the amount of energy used under normal/average circumstances to propel the ship at 85 per cent engine capacity and the time travelled. This type of baseline cap therefore limits emissions per kWh used rather than sets a cap on the total emissions emitted in the area concerned. The level of total emissions also depends on the growth (or decline) in traffic.

In the baseline-and-credit system, the Authority would collect credits surrendered by each individual ship that equate to the vessel’s emissions during its latest journey. Ships with emissions per kWh above the baseline would have to buy credits from ships with emissions below the baseline. The scheme would thus require either the industry or the Authority to establish a trading place for emission credits.

With a limited number of acting participants, there is always a risk that strong players will try to manipulate the market, for instance by withholding credits from trading. This may argue in favour of making the Authority collect not only the credits surrendered by a liable ship to match its emissions but also the surplus credits created by ships that under-score the benchmark value. The latter would then be sold by the Authority at auction to ships that have been recorded for excess emissions. The revenue from the auction would in such a case be returned to the initial owners of the credits in relation to the numbers surrendered. This could be done on the basis of the average price for $NO_x$ credits over a certain period of time. In order to minimise the number of transactions, in particular for frequent visitors to participating ports, it should be sufficient to make shipowners liable for final submission of credits for all their ships on a quarterly basis. Designing the system in this way should guarantee transparency and prevent discrimination.

The Authority would thus in the case of a baseline-and-credit system:

- register to what extent each calling ship has under-scored or exceeded the baselines for $NO_x$
- collect credits surrendered by individual ships
- sell excess credits at public auction and return the revenue to the shipowners who provided them.

An obvious advantage of a baseline-and-tradable-credit scheme is that it does not generate any revenue. The trade reallocates money between net-sellers and net-buyers without burdening the industry with any expenditure beyond the cost of compliance. Thus no effort has to be made to find a special model for recycling money. As will be shown in chapter 10, a baseline-and-credit scheme may also be more legally feasible than a system of charges.

# 9 A scheme for the abatement of $SO_x$ in the Baltic Sea

When considering policy instruments for the abatement of $SO_x$ it is essential to observe the differences in lead time among the available measures for reducing the emissions. While a shift to fuels with a lower sulphur content than 1.5 per cent (which is currently the maximum permissible amount allowed in the SECA) can take place almost overnight, the lead time for a massive introduction of sea water scrubbing on board new and existing ships may be as long as 10 years. Only a few trials have yet taken place with scrubber technologies and none of them with brackish water as a medium. As the salinity of the Baltic Sea is considerably lower than in the open ocean and also differs greatly between different parts of the sea, extensive trials with brackish seawater scrubbing would have be carried out before it is possible to say whether the technology is a viable option. Even if it is, a broad introduction of seawater scrubbing is unlikely to take place before 2015 in response to market-based instruments.

As shown in chapter 4, the fast increase in shipping activity in the Baltic Sea will soon bring aggregate $SO_x$ emissions back to the level that existed before the SECA rules went into effect. In order to prevent sulphur emissions from exceeding the 2006 level in 2020, the average sulphur content of the fuels used would have to be reduced, compared to 2004 by approx. 78 per cent (151.000 tonnes) in scenario I and 41 per cent (80.000 tonnes) in scenario II (Table 9). As seawater scrubbing is not commercially available for use in brackish waters, the usefulness of introducing a market-based instrument for providing shipowners flexibility in their response to a tougher baseline must be questioned. In addition, it would not make sense for ships involved in internal Baltic Sea traffic to trade allowances with each other as it would be easier to buy the right type of fuel. On the other hand, for in-frequent visitors who spend most of their time in other seas, an opportunity of not having to carry low-sulphur fuel (<1.5%) would be convenient. For them differentiated charges or emissions trading might be better than having to comply with an increasingly more stringent (1.0 or 0.5 per cent sulphur) SECA baseline.

## 9.1 Considerations by MEPC

In the absence of commercially available technological abatement methods suitable for brackish water, regulating the permissible content of sulphur in fuel oils would be the best way of reducing emissions in the short to medium term. The IMO's Marine Environment Protection Committee (MEPC) is currently in the process of revising the standards for emissions of sulphur and nitrogen oxides and could in this context consider more stringent limits for the sulphur content of fuels used in the Baltic Sea SECA. Several states, among them the United States (2007), have submitted views or proposals for tightening the current rules. The following options are under discussion:

- Leave unchanged the current regime (maximum 1.5% in SECAs and a global cap of 4.5 per cent sulphur in fuels used in other areas);
- Reduce the maximum permitted sulphur content of fuels used in SECAs from 1.5 per cent to 1 per cent and 0.5 per cent in two stages, possibly in 2012 and 2015 but subject to fuel supply considerations;

(a) Oblige all ships to use marine diesel fuels rather than residual fuel oil and reduce the sulphur content of this fuel to 1 per cent and 0.5 per cent in two stages, possibly in 2012 and 2015 but subject to fuel supply considerations: or

(b) Permit the use of abatement technologies and continued use of residual fuel oil but obtain the same environmental results as in 3(a).

## 9.2 Our proposals

Tightening the SECA rules could be done in a way that allows more flexibility than the current limits. One option is to rule that all traffic that is internal or where the major part of the journey takes place in the Baltic Sea should use fuels that contain no more than 0.5 per cent sulphur. In this context the shore states could also consider a mandatory shift to marine distillate fuels. If so, this would be a first step towards achieving the global standard for marine fuels proposed by Intertanko (see chapter 5). Ships calling at Baltic ports after having spent more than half of their journey from the previous port in non-Baltic waters could be allowed a higher content of sulphur, for instance the current limit of 1.5 per cent.

If making the SECA rules more stringent does not appear to be feasible in the near future, an alternative for the states around the Baltic Sea could be to require ships using fuel with more than 0.5 per cent sulphur to pay a charge equal to 125 per cent of the difference in market price between 1.5 per cent and 0.5 per cent sulphur when calling at Baltic ports. The fee would be paid to a common authority, just as in the case of the $NO_x$ charge, and would have to reflect the time travelled in Baltic waters and the specific fuel consumption at 85 per cent engine load. Alternatively, the port states can consider limiting voluntary port calls to ships that use bunker fuel with less than 1.0 or 0.5 per cent, with a derogation for ships that have spent more than a certain share of their journey in waters other than the Baltic Sea.

The supervision and the enforcement of the charge could follow the lines outlined for $NO_x$ in chapter 8. The emission of sulphur from ship engines in cases without abatement technologies is proportional to the sulphur content of the bunker oil. The amount of marine distillate or heavy fuel oil equivalent to one MWh is well known, and all ships must already carry a "bunker delivery note", which contains information from the provider on the maximum allowable sulphur content of the fuel. The installed engine capacity is also well known and possible to register. Provided that the time travelled is known (see chapter 8), calculating the emissions of $SO_x$ is just a matter of arithmetic.

In order to improve the quality of marine fuels used in the European SECAs, the European Parliament and Council could legislate that such fuels sold in the Member States, including their territorial waters, must comply with certain chemical specifications and make the supplier legally liable for the quality and the data provided in the bunker delivery note.

# 10 The legal feasibility of the proposed scheme

For political and institutional acceptance, it is important that any scheme for port-related en-route charges is in line with the principles expressed in the United Nations Convention on the Law of the Sea (UNCLOS). The convention provides a universal legal framework for the management of marine resources and regulates international aspects of marine-related activities. It was a result of the Third United Nations Conference on the Law of the Sea that was convened in New York in 1973 and ended nine years later with the adoption in 1982 of the convention.

UNCLOS is divided into 17 Parts and nine Annexes, containing provisions governing, amongst other things, the limits of national jurisdiction over access to the seas, navigation protection, and preservation of the marine environment. UNCLOS is a self-executing treaty, meaning that states do not need to pass additional national legislation to implement its terms. By acceding to the treaty, the states indicate their intention to be bound by the Convention.

Emissions and discharges from maritime shipping are regulated by IMO's International Convention for the Prevention of Marine Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78). Air pollution from ships is regulated by MARPOL's Annex VI, which entered into force on 19 May 2005. Annex VI covers ozone-depleting substances, nitrogen oxides ($NO_x$), sulphur oxides ($SO_x$) and volatile organic compounds (VOC).

This chapter attempts to answer two legal questions:

- Can a party to UNCLOS impose rules and/or charges on foreign flagged ships that voluntarily call on its ports if those requirements go beyond the standards of MARPOL?
- Can such rules and/or charges embrace requirements on the ships when travelling through the territorial waters or the Exclusive Economic Zone (EEZ) on their way to a voluntary port of call?

## 10.1 The right of innocent passage

UNCLOS gives coastal states a right to establish a territorial sea of up to 12 nautical miles measured from baselines determined in accordance with the Convention. Within this zone the coastal state is sovereign but is required to grant a right of innocent passage to foreign vessels passing through its waters. The majority of states (whether party to UNCLOS or not) maintain a territorial sea of 12nm or less.

According to UNCLOS Article 24, the coastal state shall not hamper the innocent passage of foreign ships through the territorial sea except in accordance with the Convention. Article 26 declares that no charge may be levied upon foreign ships by reason only of their passage through the territorial sea, and that charges may be levied upon a foreign ship passing through the territorial sea as payment only for specific services rendered to the ship and only in a non-discriminatory manner.

UNCLOS Article 21 states that a coastal State may adopt laws and regulations, in conformity with the provisions of the Convention and other rules of international law, relating to innocent passage through the territorial sea, in respect of (among others) the conservation of the living resources of the sea and the preservation of the environment of the coastal state and the prevention, reduction and control of pollution thereof. However, “such laws and regulations shall not apply to the design, construction, manning or equipment of foreign ships unless they are giving effect to generally accepted international rules or standards.”

However, Article 25(2) clarifies that the coastal state “in the case of ships proceeding to internal waters or a call at a port facility outside internal waters” has “the right to take the necessary steps to prevent any breach of the conditions to which admission of those ships to internal waters or such a call is subject”. In such a case, the state is in effect acting as a port state.

Within the Exclusive Economic Zone (EEZ, max. 200 nm), UNCLOS Article 56 grants coastal states sovereign rights for the purpose of the "protection and preservation of the marine environment.” Article 211(3) permits a coastal state to "establish particular requirements for the prevention, reduction and control of pollution of the marine environment as a condition for the entry of foreign vessels into their ports". Thus, a state may only regulate pollution discharges from vessels in the EEZ as a condition for port entry or to give effect to international standards.

Limiting the en-route scheme for $NO_x$ to ships calling at participating ports is therefore a way to avoid a conflict with the right of innocent passage. This means that no ship is charged for crossing the Baltic Sea on its way to a port that is not participating. This would, for instance, be the case for trips to Russian ports, if the coastal states belonging to the European Union chose to participate but Russia decided not to. If designed in this way, the charge would be connected to the procedure of being allowed to load or unload in a port. Shipowners or their customers could alternatively choose a port that is not part of the programme, a risk that those creating and adopting the scheme must be aware of.

## 10.2 Unilateral conditions for port entry

States have on different occasions used the opportunity provided by UNCLOS to enforce higher standards on ships calling at their ports. Examples of this are the United States Oil Pollution Act, the European Union’s ban on single hull tankers, the 1996 Stockholm agreement on roll-on-roll-off ferries, the US ballast water requirements, and a recent ruling by the Swedish Supreme Environment Court on the use of SCR in the case of the city of Helsingborg versus two ferry lines.

## 10.3 Examples

### 10.3.1 The US Oil Pollution Act (OPA 90)

The Oil Pollution Act of 1990 (OPA 90) was introduced in response to the Exxon Valdez oil spill which happened in 1989. The reason for the legislation was a need to protect the United States environment in the absence of adequately protective international standards. The rules thus exceed the standards of MARPOL. OPA 90 required a double hull for new tankers and a phase-out scheme for existing single hull tankers. Furthermore, foreign vessels lightering in the US EEZ, including “those not intending to enter United States waters,” must maintain certificates of financial responsibility if some of the oil is destined for the United States.

It could be argued that the US is not a signatory state to UNCLOS. However, according to the US Air Resources Board (1999), the United States has recognised UNCLOS as customary international law which the US would be bound to follow. However, the Board says that it is well established under international law that coastal states may place conditions on vessels wishing to enter ports. Vessels that voluntarily enter territorial waters and ports are subjecting themselves to the rules and regulations of the port. “Thus, the ability of states to impose reasonable conditions on port entry of foreign vessels, as permitted under the Clean Air Act, is consistent with well-established international law".

### 10.3.2 The EU approach on double hulls

After the Prestige incident in 2002, the EU proposed an amendment to MARPOL 73/78 for accelerating the phasing-out of single hull tankers and for an immediate ban on the carriage of heavy-grade oil in single hull tankers. The IMO’s MEPC discussed the European proposals in July 2003 and agreed on parts of them but decided that further investigation was needed before a final decision could be made.

However, the EU did not wait for the IMO to amend MARPOL. A new EU regulation was adopted on 22 July 2003. It was directly applicable to all Member States of the EU and entered into force on 21 October 2003. According to this regulation, the final phase-out for Category 1 tankers was 2005 and for Category 2 and 3 tankers in principle 2010. The regulation also applied an immediate ban on the transport to and from ports of EU Member States of heavy grades of oil in single hull tankers (van der Velde, 2003).

The Secretary-General of IMO expressed his serious concerns about the EU regulation at a meeting of the MEPC in December 2003, because of its unilateral character and negative effects on the shipping industry. However, as a result of the step taken by the EU, the MEPC in December 2003 found it necessary to adopt a revised accelerated phase-out scheme and a new regulation banning the carriage of heavy grades of oil in single hull tankers.

### 10.3.3 The 1996 Stockholm Agreement on roll-on-roll-off (ro-ro) ferries

An example of a regional standard is the Stockholm agreement on ferry safety of 1996, which initially applied more stringent survivability standards than SOLAS 90[23] to ro-ro ferries operating to and from ports in northern Europe.

In 1995, the IMO refused to adopt an amendment to the SOLAS 90 standard proposed by Sweden, Estonia and Finland. Instead, in February 1996, eight European states (Denmark, Finland, Germany, Ireland, the Netherlands, Norway, Sweden and the UK) adopted the Stockholm agreement to the same effect. The agreement supplemented the SOLAS 90 standards by taking account of water entering the car deck, thus making ships safer in heavy seas. It required ro-ro passenger ferries to become capsize-resistant if up to 50 cm of water entered the car deck. The timetable for compliance began on 1 April 1997 and ended on 31 October 2002, by which time all operational ships had to comply.

The requirements of the Stockholm Agreement were initially proposed by the Panel of Experts commissioned by the IMO to review all aspects of ferry safety following the loss of the Estonia in September 1994. Notably, the Panel was instructed to concentrate on developing safety standards that would be applied to existing ships, a major departure from the normal procedures where major safety innovations, especially those involving structural modifica-

[23] International Convention for the Safety of Life at Sea (SOLAS), 1974. The SOLAS 90 standard applies to ships of 100 metres or more in length built on or after 1 February 1992. In the provisions important changes were made to the way in which the subdivision and stability of dry cargo ships is determined.

tions, are normally applied only to new ships, using so-called grandfather clauses for old ones (Williams et al, 2002).

The Stockholm Agreement enabled the participating countries to take the action they considered appropriate in relation to stability with water on deck, although some of those countries would have preferred to have the standards written directly into the SOLAS Convention. Based on the provisions laid down in the Stockholm agreement, the European Commission studied the sea conditions for ro-ro ferries in all European waters, and concluded that the seas of the southern Member States were comparable to those of the eight countries of the Stockholm Agreement. Thus the Commission proposed a new directive to apply the specific stability requirements of the Agreement to all ro-ro passenger ships operating on international routes in the EU. The Community also revised Directive 98/18/EC on the implementation of the SOLAS 90 standards to apply the new requirements to ro-ro ships on domestic voyages.

### 10.3.4 Ballast water legislation

The introduction of invasive species via ships' ballast water is a challenge for the protection of coastal states' resources. UNCLOS does not address this problem, and the international standard for the treatment of ballast water (IMO's Ballast Water Convention) is not yet in force. Thus, more stringent measures by single states could be interpreted as being "beyond generally accepted international rules or standards."

In the absence of international law, the only remaining option for states is to use the authority granted in UNCLOS Article 211 to require special practices as a condition of entry into port. Since 1996 the United States has required ships to exchange ballast water outside the EEZ as a condition for entering the Great Lakes to minimise the spread of invasive species.

The state of California enforces provisions on ballast water treatment for vessels in innocent passage. The rules apply not only to the discharge of ballast water into the territorial waters of the state but also into waters that may impact waters of the state (Faulkner, 2003).

### 10.3.5 Sulphur in fuels used by ferries and in EU ports

From 2010 the European Union will require all ships calling at ports of the Member States not to use fuels containing more than 0.1 per cent sulphur while in port. The EU enforces a lower sulphur limit on fuels used by ferries at sea, regardless of whether the voyage takes place in a SECA or not.

### 10.3.6 Requiring ferries to use SCR

A recent decision by the Swedish Supreme Environment Court in the case of the city of Helsingborg versus two ferry lines shows that a port state can, without violating UNCLOS, require ships of all nationalities calling at a specific port to install technologies for reducing $NO_x$ below the $NO_x$ curve of MARPOL's Annex VI, if this is needed for the port city's compliance with the European Union's air quality standards or for compliance with national environmental law. Annex 1 to this report provides detailed information on the case.

Similar difficulties may arise in connection with the implementation of the EU Air Quality Directive on ozone (2002/3/EC) that sets long-term objectives equivalent to the World Health Organisation's new guideline and target values for ozone in ambient air to be attained by 2010. Non-compliance requires Member States to work out reduction plans and programmes.

$NO_x$ is an important ozone precursor, and shipping emissions may in many cases contribute to violations of the directive.

It thus appears legally acceptable for port states to require ships involved in voluntary port calls to install technologies for reducing $NO_x$ below the $NO_x$ curve of MARPOL's Annex VI and to use this equipment in port and during its journey through the territorial water of the port state. The same conditions should apply to requirements on calling ships to use bunker oil with sulphur content below the permissible level of the SECA. However, it is less clear whether a port state can demand that the abatement technology be actively used in the economic zone as well.

## 10.4 Demands on ships travelling through the territorial waters or EEZ

As shown above, all of the unilaterally introduced requirements on foreign flagged ships for the right of entry of a port also affect vessels travelling in the territorial sea and the Exclusive Economic Zone on their way to the port.

From this evidence it seems reasonable to conclude that the states around the Baltic Sea should legally be able to design a scheme for differentiated charges that take account of emissions from a journey to a port of those states. This is actually already the case with the Swedish differentiation of its fairway dues, although the length of the individual fairway is not accounted for.

There are also some examples of coastal states enforcing, or trying to enforce, unilateral standards on ships that traverse their territorial waters on innocent passage. As mentioned above, the American OPA rules on the use of double hulls were aimed both at ships calling at US ports and at ships using the territorial sea.

## 10.5 Use of flexible instruments

In view of the wide discretion that port states have under UNCLOS, it would in principle be possible to require all ships to be equipped with technologies for the abatement of $NO_x$, e.g. SCR, as a condition of entry into a port, if this is deemed necessary for the protection of human health and the environment in the country concerned. However, from a cost-effectiveness point of view, it does not appear reasonable to require infrequent visitors or ships with few remaining years in operation to install technologies that would require 10 or more years to be written off. In such cases charging high emitters appears to be a more flexible and less costly solution. As this offers a greater flexibility to owners and operators of foreign flagged ships, it should in principle be regarded as less far-reaching than a fixed standard.

However, as shown above, charges may be levied on a foreign ship passing through the territorial sea as payment only for specific services rendered to the ship and only in a non-discriminatory manner. However, in a case of revenue-neutral charges there would be no net payment levied on the average ship, though low-emitting ships would receive more than they pay, and owners of high polluting ships would pay more than they get back. The latter would thus pay a net fee, which reflects higher than average damage to the environment. This is exactly what happens within the existing Swedish scheme for environmentally differentiated fairway dues.

When the scheme is designed as a baseline-and-credit system, no charges are involved at all.

The Swedish Maritime Administration (SMA) did not consult the IMO on the introduction of the differentiation of its fairway dues, and no flag state or shipping company has filed a complaint (Lars Vieweg, SMA, personal communication, November 2005). The only difference between the current Swedish system and the scheme proposed in this paper is that the latter would reflect the time travelled in the Baltic waters of the participating states, including the economic zones.

## 10.6 Acting through the Convention on Long Range Transboundary Air Pollution

UNCLOS Article 212 regulates the rights and duties of states where pollution from or through the atmosphere is concerned. The article reads as follows:

1. States shall adopt laws and regulations to prevent, reduce and control pollution of the marine environment from or through the atmosphere, applicable to the air space under their sovereignty and to vessels flying their flag or vessels or aircraft of their registry, taking into account internationally agreed rules, standards and recommended practices and procedures and the safety of air navigation.
2. States shall take other measures as may be necessary to prevent, reduce and control such pollution.
3. States, acting especially through competent international organizations or diplomatic conference, shall endeavour to establish global and regional rules, standards and recommended practices and procedures to prevent, reduce and control such pollution.

According to one consulted expert on maritime law, the UN Economic Commission for Europe (ECE), through its Convention on Long Range Transboundary Air Pollution (from 1979), could be regarded as a competent international organisation with respect to airborne pollution from ships in European waters in accordance with UNCLOS Article 212(3). If this is correct, more stringent rules on permissible emissions from shipping in the Baltic Sea (and other European waters) could be introduced by a new protocol to the Convention on Long Range Transboundary Air Pollution without a mandate from IMO and its MARPOL convention. Politically, this may be an easier way to achieve substantial emissions reductions than trying to change MARPOL's Annex VI to the same effect.

## 10.7 When the legal situation is unclear

The legal situation is not entirely clear. Both UNCLOS and MARPOL where adopted at a time when air pollution from ships was not a major concern, and cap-and-trade systems and schemes for baseline-and-tradable credits had not yet been invented. Therefore it is difficult to say how far a port state can go in introducing schemes that take account of emissions from ships in the territorial water and the economic zone on their way to a voluntary port of call. However, one may assume that what is not prohibited according to general principles or specifically forbidden, should be legitimate.

As baseline-and-credit schemes neither enforce mandatory standards that go beyond generally accepted international rules nor raise any charges, they seem to be more feasible from a legal perspective than en-route charges, even in a case where the latter are designed in a revenue-neutral manner. A baseline-and-credit system that takes account of the time that ship engines are used should be equally feasible.

The survival of a scheme that potentially operates under legal uncertainties depends to an extent on whether any flag state or any owner of a foreign flagged ship cares to complain. The risk of complaints is presumably small as long as the scheme is fair and efficient and the rules are transparent. And if a complaint were made, it would have to be dealt with according to the rules of UNCLOS. The text in the box is from UNCLOS' website and describes the procedures for settlement of disputes.

Settlement of Disputes

Provisions for the settlement of disputes arising out of an international treaty are often contained in a separate optional protocol. Parties to the treaty could choose to be bound by those provisions or not by accepting or not accepting the Protocol. The Convention on the Law of the Sea is unique in that the mechanism for the settlement of disputes is incorporated into the document, making it obligatory for parties to the Convention to go through the settlement procedure in case of a dispute with another party.

During the drafting of the Convention, some countries were opposed in principle to binding settlement to be decided by third party judges or arbitrators, insisting that issues could best be resolved by direct negotiations between States without requiring them to bring in outsiders. Others, pointing to a history of failed negotiations and long-standing disputes often leading to a use of force, argued that the only sure chance for peaceful settlement lay in the willingness of States to bind themselves in advance to accept the decisions of judicial bodies.

What emerged from the negotiations was a combination of the two approaches.

If direct talks between the parties fail, the Convention gives them a choice among four procedures - some new, some old: submission of the dispute to the International Tribunal for the Law of the Sea, adjudication by the International Court of Justice, submission to binding international arbitration procedures or submission to special arbitration tribunals with expertise in specific types of disputes. All of these procedures involve binding third-party settlement, in which an agent other than the parties directly involved hands down a decision that the parties are committed in advance to respect.

## 10.8 Introducing the scheme

The introduction of en-route charges that apply to calls at ports in some Member States would not require a decision by the European Union. According to the EU Treaty's principle of subsidiarity, Member States are free to act in areas that do not require common legislation, provided that the measures taken are non-discriminatory and proportional to the objective pursued. If Member States bordering the Baltic Sea feel that they need to protect their environment from airborne pollutants from ships, other Member States have no reason to object so long as ships or cargo owners registered in their countries are not discriminated against. In a case where some Member States act together they would, of course, have to check to what extent a scheme of this kind might require change in national legislation governing ports and the use of charges.

Alternatively, if the European Commission thinks that the Baltic scheme is of such importance that it should be introduced as Community law, a decision on the directive can be taken by the Council of Ministers by qualified majority as it does not involve setting any tax rates. It is rather a framework of much the same character as the existing directive on road tolls.

# 11 Results and cost/benefit-analysis

The purpose of this chapter is to compare the likely effect of the incentives proposed in chapters 8 and 9 on the emissions of $NO_x$ and $SO_x$ in the Baltic Sea. The outcome of this emission abatement scenario (EAS) will be compared with the business-as-usual scenario (BAU) that was presented in chapter 4. The development between 2004 and 2010 is identical in the two scenarios as the market based instruments and regulations outlined in chapters 8 and 9 cannot be expected to enter into force until 2010 at the earliest

In this chapter an emission abatement scenario (EAS) will first be explained, it will then be compared to the business-as-usual scenario (BAU) as presented in chapter 4. The assumptions for how the EAS will develop are based on the inclusion of new technology in newly-built ships and retrofitting of existing ships after a certain number of years. The distribution of ship-ages for the different types of vessels is based on a study by Sjöfartens Analys Institut[24]. In general it is noted that about 35 per cent of all the calls in northern Europe were made by ships older than 20 years. Among bulk carriers over 50 per cent of all calls were made by ships older than 20 years. However, in the Baltic Sea region the ships are expected to be below the average age. As the groups of ships in the study have several differences, the following types were merged for the calculation (types set out in chapter 4):

- FC
- Roro
- Container
- General Cargo
- Others

"Uncertain ships" and offshore units were omitted as they are not relevant and the numbers were low anyway.

The regions are defined by the bounders depicted in the chart in chapter 4, and the emission development is based on the calculation and figures of the same chapter.

## 11.1 $NO_x$ emissions in the emission abatement scenario

The abatement scenario for $NO_x$ is based on the business-as-usual-assumptions presented in chapter 4 and the following assumptions:

For the ships involved mainly in intra-Baltic Sea shipping (including for example feeder traffic from nearby North Sea ports) the assumptions for the $NO_x$ emissions scenario are:

- Significant further measures for $NO_x$ abatement will not enter into force before 2010.
- All new ships ordered after 2009 are equipped with SCR (-90 per cent $NO_x$ emissions)
- 40 per cent of all ships 10 years or younger (in 2010) are equipped with SCR by 2015 (-90 per cent $NO_x$ emissions)

[24] Sjöfartens Analys Institut: A Report into the Strategic Maritime Information System, Göteborg, 2007-06-15; the study covers all ship-types except ferry liner services.

- 40 per cent of all ships 10 years or younger (in 2010) are equipped with HAM by 2015 (-77.5 per cent $NO_x$ emissions)
- 75 per cent of all ships older than 10 years but younger than 20 (in 2010) are retrofitted with DWI by 2015 (-55 per cent $NO_x$ emissions)

For infrequent visitors operating mainly in other seas, the assumptions are:

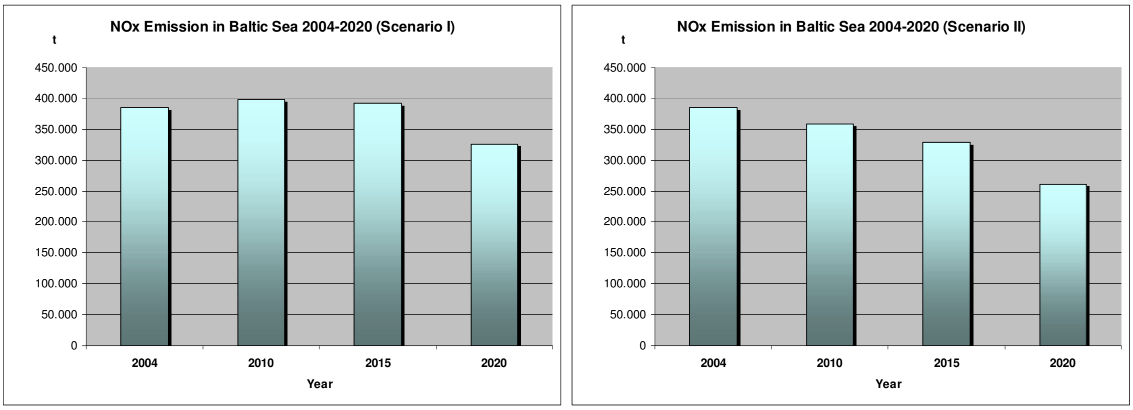
- 40 per cent of new ships ordered after 2009 are equipped with DWI (-55 per cent $NO_x$ emissions)
- 20 per cent of ships 10 years or younger (in 2010) are equipped with DWI by 2015 (-55 per cent $NO_x$ emissions)

Although there is currently very little experience available of how HAM performs in practice, and thus the long-term prospects are uncertain, HAM was considered for $NO_x$ abatement (and maybe looked at as a forerunner of technological development).

The average rate at which newly built ships are coming into service is assumed to be above 20 per cent every five years: Ferry/Cruise 25 per cent, Roro 22 per cent, Container 28 per cent, General Cargo 20 per cent and Others 21 per cent. The age of the vessels is thus low compared to other sea regions, which is in line with the fact that the Baltic Sea is reckoned to be a precursor of new technology, especially in Ferry and Roro.

The expected development of total $NO_x$ emissions in the abatement scenario is shown in Figure 20 for the two growth scenarios.

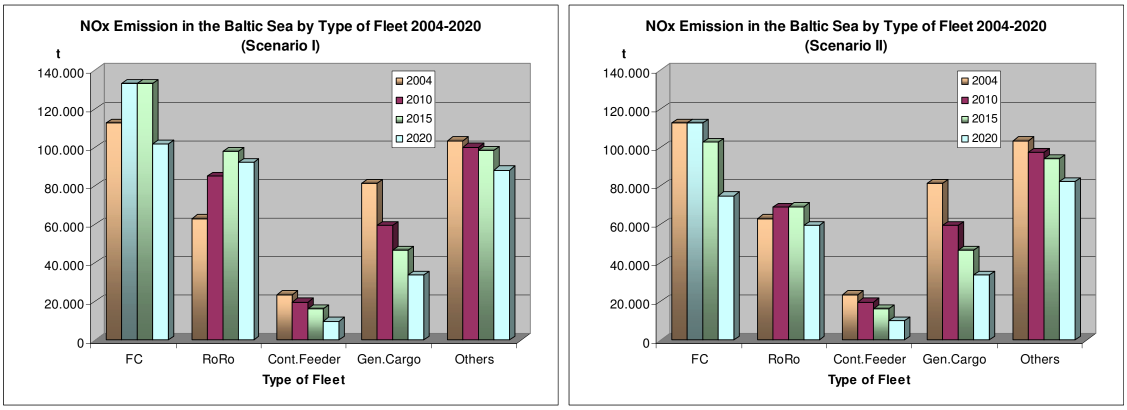
**Figure 20: $NO_x$ Emission 2004 – 2020 in the abatement scenarios (tons), scenarios I and II**




Source: GAUSS, 2007

In the two BAU scenarios, emissions would rise by 88 per cent and 55 per cent respectively between 2004 and 2020 due to traffic growth (Table 9) whereas emissions decline by 15.1 and 32.2 per cent in the two abatement scenarios. The distribution according to ship-types and type of traffic is as follows:

**Figure 21: $NO_x$ Emissions by type of fleet 2004 – 2020, scenarios I and II**



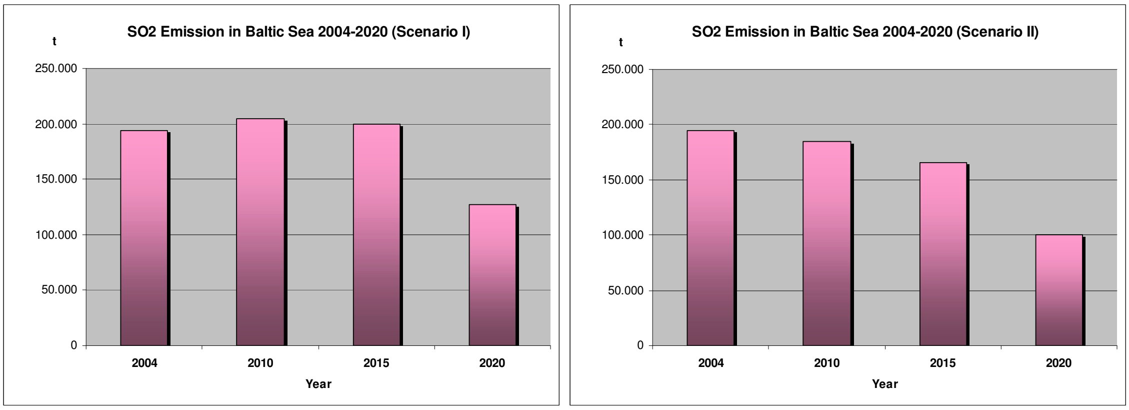

Source: GAUSS, 2007

The portion of Container's share made up of newly built ships is assumed to be about 28 per cent within five years, with the potential for much greater reductions up to 2020 on the basis of them being fully equipped with SCR. The decline in General Cargo and Others is partially due to the expected decreasing level of traffic with these types of ships.

## 11.2 $SO_2$ Emissions in the abatement scenario

The assumptions for the development of $SO_2$ emissions are such that the SECA limits for sulphur content in the Baltic and the North Sea are lowered in two stages to 1.0 per cent from 2011 and to 0.5 per cent from 2016. Due to the uncertainties with regard to the operation of scrubber technology for $SO_2$ abatement in general and especially in brackish waters, this technology was not considered.

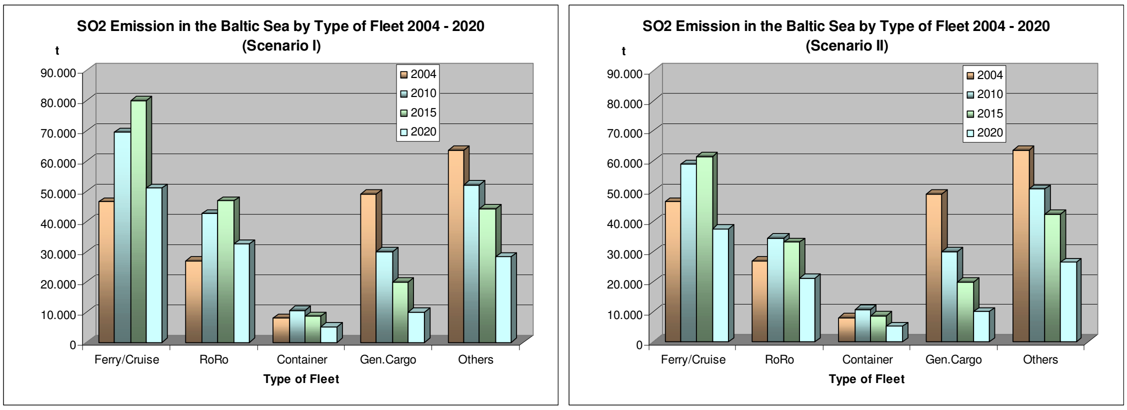
**Figure 22: $SO_2$ Emissions 2004 – 2020 in the abatement scenarios (tons), scenarios I and II**




Source: GAUSS, 2007

In the first scenario, $SO_2$ emissions are initially still rising as the number of ships already using low sulphur fuel in intra-Baltic traffic is quite high. Only the second tightening of the threshold in the year 2015 to 0.5 per cent sulphur in fuel oil leads to a significant decline in $SO_2$ emissions.

**Figure 23: $SO_2$ Emissions by type of fleet 2004 – 2020 (tons), scenarios I and II**



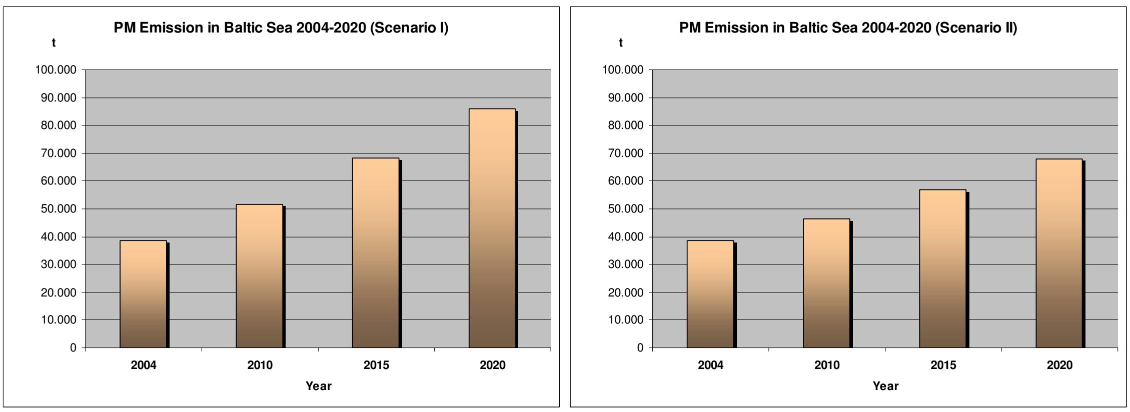

Source: GAUSS, 2007

Again, the annual growth in and shift to Cruise/Ferry and Roro is responsible for the initial rise and later decrease in these sectors. Although in Ferry traffic both passengers and cargo are transported, the expected increase is currently assumed to come from cargo transport only[25].

## 11.3 PM Emissions

PM emissions are partly correlated with the sulphur content of fuel oil[26] thus a change to LSF reduces these emissions as well. According to the IMO (IMO/BLG 1/2/11, 2006) the “use of 0.5 per cent sulphur distillate fuel rather than HFO containing 2.7 per cent sulphur could reduce PM emissions by about 63 per cent ….”. A decline from lower levels is smaller not only in absolute but also in relative terms. As with the intra-Baltic traffic, the sulphur content is assumed to be already below 1.5 per cent in 2006, so the potential for reduction is not very high and therefore any overall reductions are wiped out by traffic growth.

**Figure 24: PM Emissions in the Baltic Sea 2004 – 2020 (tons), scenarios I and II**




Source: GAUSS, 2007

[25] Figure 7 p. 31; ShipPax Market 2007, p. 150 ff.

[26] Although there is a correlation with the sulphur content of the fuel, the correlation is not linear

The rise of emissions in Ferry and Roro is mainly due to the high expected growth-rates in these segments. As General Cargo is assumed to have no significant traffic growth and is expected to be employed in extra traffic, the emissions of this sector remain more or less constant after the implementation of the SECA the Baltic Sea in 2006.

**Table 18: Total development of PM emissions, scenarios I and II**

| Year | 2004 | 2010 | 2015 | 2020 |
|---|---|---|---|---|
| Emission (Scenario I) | 38,563 | 51,574 | 68,222 | 85,614 |
| Emission (Scenario II) | 38,563 | 46,278 | 56,608 | 67,523 |

Source: GAUSS, 2007

## 11.4 Comparison of benefits with abatement costs

According to Holland and Watkiss (2002) the benefits emanating from the reduction of $NO_x$ and $SO_2$ emissions in the Baltic Sea are 2.100 euro per ton and 1.600 euro per ton respectively. As PM emissions are partly correlated with the sulphur content of fuel oil the benefit of reduced PM emissions would add slightly to the total benefit.

**Table 19: Benefits in the Baltic Sea[27]**

| Region / Emission Group | $SO_2$ | $NO_x$ |
|---|---|---|
| **Baltic Sea** | 1.600 €/t | 2.100 €/t |

Source: GAUSS, 2007

In the following paragraphs the results from scenario II are put in brackets. According to the assumptions made in the EAS scenario, a total of 4.43 (3.68) million tons of $NO_x$ emissions and 0.86 (0.65) million tons of $SO_2$ emissions would be abated. In monetary terms, the reduced emissions would amount to 9,298 (7,735) million euro reduced external costs on $NO_x$ and 1,369 (1,044) million euro reduced external costs on $SO_2$ emissions.

The costs for installing the respective abatement technology would be from 2010 to 2020 1,537 (1,271) million euro for $NO_x$ emission reduction. The total economic benefit would thus be 6,929 (5,712) million euro for the period of 2010-20. The total benefit would be even higher due to the fact that the parallel reduction in PM emissions was not considered in the calculation.

Tables 20 and 21 show the total costs and benefits for the abatement scenario, i.e. the costs for measures taken in the BAU scenario are included together with the incremental costs.

[27] Mike Holland; Paul Watkiss: SHIPPING Marginal external costs from emissions at sea, year 2000 prices, Benefits Table database: BeTa Version E1.02a, DG Environment.

**Table 20: Comparison of total costs and benefits (EAS) for $NO_x$ (million euros), scenarios I and II**

| Scenario<br>Year | Costs I | Costs II | Benefits I | Benefits II | Difference I | Difference II |
|---|---|---|---|---|---|---|
| 2015 | 138 | 115 | 725 | 606 | 587 | 491 |
| 2020 | 215 | 171 | 1.281 | 1,018 | 1,066 | 847 |
| TOTAL ´10-´20 | 1,537 | 1,271 | 8,467 | 6,984 | 6,930 | 5,713 |

Source: GAUSS, 2007

**Table 21: Comparison of total costs and benefits (EAS) for $SO_2$ (million euros), scenarios I and II**

| Scenario<br>Year | Costs I | Costs II | Benefits I | Benefits II | Difference I | Difference II |
|---|---|---|---|---|---|---|
| 2015 | 11 | 8 | 120 | 93 | 109 | 85 |
| 2020 | 55 | 40 | 307 | 226 | 252 | 186 |

Source: GAUSS, 2007

For the period 2010-20 the cost/benefit ratio for $NO_x$ is 1:5.5 and for $SO_2$ 1:5.6 in 2020 for both scenarios (I and II), which means that on economic considerations it would be positive to invest in abatement technologies like low-sulphur fuels and $NO_x$ reduction technology.

The incremental costs and benefits of $NO_x$ abatement are given in tables 22 and 23. These tables therefore show only the difference in costs and benefits between the BAU and the EAS scenarios.

**Table 22: Comparison of incremental costs and benefits for $NO_x$ in the EAS scenario (million euros), scenarios I and II**

| Scenario | Scenario I | | Scenario II | |
|---|---|---|---|---|
| Year | 2015 | 2020 | 2015 | 2020 |
| Incremental Costs | 93 | 137 | 81 | 116 |
| Incremental Benefits | 479 | 834 | 421 | 702 |
| Difference | 386 | 697 | 340 | 586 |
| Ratio | 1:5.2 | 1:6.1 | 1:5.2 | 1:6.1 |

Source: GAUSS, 2007

For 2020 the cost/benefit ratios for the incremental values for $NO_x$ are 1:6.1 (scenario I) and 1:6.1 (scenario II) which means on economic considerations it would positive to invest in abatement technologies like SCR, DIW and HAM for $NO_x$ reduction.

**Table 23: Comparison of incremental costs and benefits for SOx in the EAS scenario (million euros), scenarios I and II**

| Scenario | Scenario I | | Scenario II | |
|---|---|---|---|---|
| Year | 2015 | 2020 | 2015 | 2020 |
| Incremental Costs | 7 | 50 | 5 | 36 |
| Incremental Benefits | 80 | 256 | 53 | 175 |
| Difference | 73 | 206 | 48 | 139 |
| Ratio | 11.4 | 5.1 | 10.6 | 4.9 |

Source: GAUSS, 2007

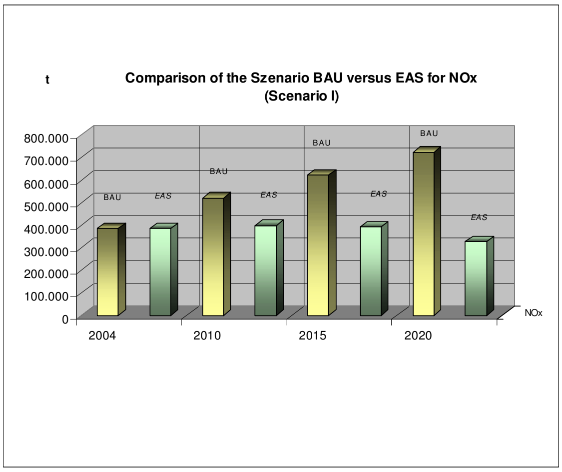
For 2020 the cost/benefit ratios for the incremental values for $SO_x$ are 1:5.1 (scenario I) and 1:4.9 (scenario II). Between 2015 and 2020 the ratio decreases because the costs of better fuel quality are rising whereas the value of the benefits is assumed to be constant.

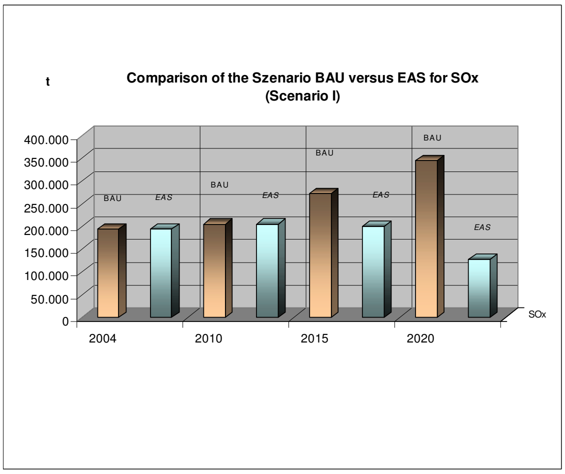
## 11.5 Conclusion

The comparison between the BAU and EAS scenarios shows, that it should be possible in the period between 2010 and 2020 to reduce the yearly level of $NO_x$ as well as $SO_2$ emissions to the point where they get nearly below the level they were 2004. This could be done with a 15.1 per cent (32.2 per cent) reduction for $NO_x$ and a reduction of 34.6 per cent (48.5 per cent) for $SO_2$, instead of an increase of 88.2 per cent (54.8 per cent) for $NO_x$ and an increase of 77.7 per cent (41.3 per cent) for $SO_2$ in the BAU scenario.

Compared to the initial situation in 2004, the reduction seems to be quite small, but it has to be taken into account that a considerable increase in traffic more than wiped out the benefits gained by the technologies (fuels and $NO_x$ abatement technology).

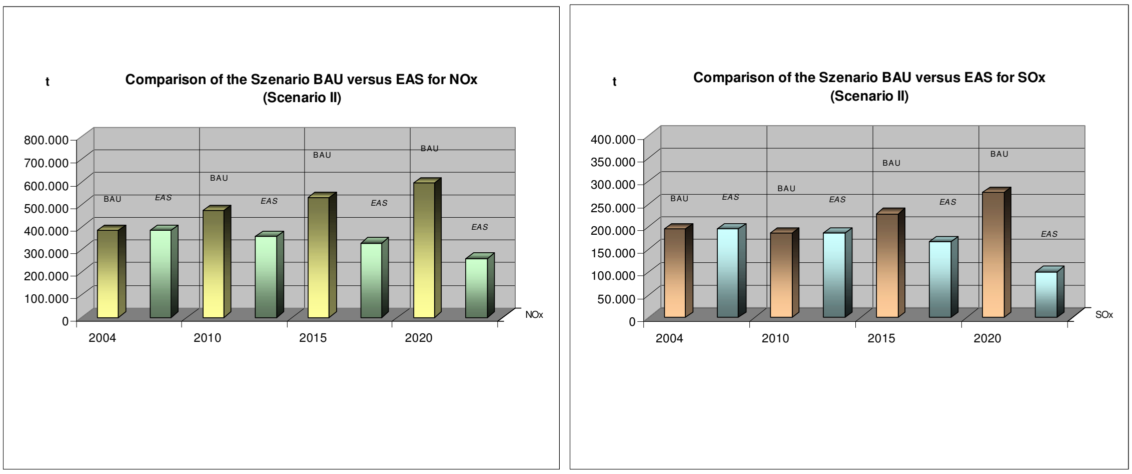
**Figure 25: Comparison of BAU versus EAS for $NO_x$ and $SO_x$ 2004 – 2020, scenario I**




Source: GAUSS, 2007

**Figure 26: Comparison of BAU versus EAS for $NO_x$ and $SO_x$ 2004 – 2020, scenario II**




Source: GAUSS, 2007

As can be seen from the figures in the period from 2004 to 2010, there is just a small change in the development of $NO_x$ emissions and none for $SO_x$ as the measures implemented in the EAS scenarios take effect only from the periods there after.

With $NO_x$ the overall development in the two scenarios clearly drifts apart, with a total decrease from BAU to the EAS scenarios averaging of 55.5 per cent (for scenarios I and II) by the end of 2020 due to the implemented measures. With $SO_2$ this trend is also noticeable, however not so clear as a comparable initial low base of sulphur content in fuel oil was assumed. The lowering of the sulphur content in 2011 to 1.0 per cent and even further in 2016 to 0.5 per cent results in a total decrease by an average of 63.4 per cent (for scenario I and II) for $SO_2$ by the end of 2020 from the BAU to EAS scenario.

The assumptions made for the reduction scenarios are based on the response to the incentives given to the shipping industry. Thus there is quite a lot of uncertainty based on the development of various factors e.g. technical and cost developments, shareholder pressure etc. Furthermore it is unknown whether the assumptions can be met by the availability of suitable ship-yard capacity, sufficient amount of respective fuel for $SO_2$ reduction as well as the number of plants for the installation to abate $NO_x$ emissions. However a hesitant reaction of the shipping industry would not prevent the positive effects of the implementation – it would merely delay the development.

# 12 Schedule for implementation

Launching a Baltic Sea pilot project probably requires a preparatory period of at least three years. The first step after the completion of the report would be to start a dialogue with a wide range of potential stakeholders in order to seek their support and to invite them to submit their assessment of the proposal. The scheme should be regarded as preliminary until the dialogue has been completed. There may be scope for improvement.

## 12.1 Stakeholder dialogue

The UBA can distribute the report to the potential stakeholders and invite them to comment on its analysis and proposals. However, initiating a stakeholder dialogue with government agencies of other coastal states in order to prepare a possible formal agreement on the scheme would require the consent of the German government. Besides Germany, Sweden has been the coastal state of the Baltic Sea that has shown the greatest interest in promoting the abatement of emissions from shipping. One possibility could be for Germany and Sweden to jointly invite representatives of the coastal states as well as commercial stakeholders and other NGOs to participate in a dialogue based on the proposals of the report.

Key institutions and persons could be invited to seminar or conference. Some of them may in addition have to be contacted in a bilateral process.

## 12.2 Potential stakeholders

The list of organisations of potential importance in the context of the pilot project is quite long. The stakeholders can be divided up based on a number of categories:

State ministries and government agencies

The environment and transport ministries of the coastal states and relevant state agencies must be engaged from the start.

Intergovernmental organisations

The IMO and its environment committee should be informed and given an opportunity to respond to the proposal for unilateral action around the Baltic Sea. The European Commission (several DGs) and the European Parliament should be invited to follow the process. HELCOM and the body responsible for the Baltic Sea under the Marine Framework Directive are other intergovernmental bodies potentially affected by the scheme.

Ship-owners

The national shipowners associations around the Baltic Sea are an important potential partner in creating the pilot scheme. The most important shipping companies operating in the Baltic Sea might have to be approached separately, as well as Intertanko.

Ports

It is essential to approach the ports and their national organisations at an early point in the process as the $NO_x$ scheme is based on port calls so their participation and support is required, at least in a case of distance-related charges (rather than tradable credits). The Baltic Sea Port Organisation should also be invited to become a partner in the process of developing the pilot scheme.

Major freight customers

Major freight customers, such as Otto Versand, Ikea, Stora-Enso and Volvo, have in recent years shown an interest in promoting environmentally sound freight operations. They should be informed about the draft pilot scheme and invited to participate, as should the International Business Council on Sustainable Development.

Other commercial firms and organisations

Other potentially affected firms include classification societies, major shipyards - especially those involved in retrofitting - and manufacturers of $NO_x$ abatement equipment. The oil industry will be affected if the SECA standard becomes increasingly more stringent.

Environmental NGOs

Environmental NGOs such as Coalition Clean Baltic (CCB), Friends of the Earth, World Wildlife Fund for Nature (WWF), Greenpeace, European Federation for Transport and Environment (T&E) and European Environmental Bureau (EEB) have historically shown interest in marine issues.

Other stakeholders

Other organisations with a potential interest in the pilot scheme include Union of the Baltic Cities (publisher of the Baltic Cities Environmental Bulletin), the Alliance of Maritime Regional Interests in Europe (AMRIE), various universities and research institutions, ongoing projects around the Baltic Sea, e.g. Baltic United and Baltic Sea 2020, and some EU projects sponsored by the structural funds.

It should also be noted that, according to the Marine Framework Directive, the coastal states of the Baltic Sea are required to present a joint abatement programme by 2010. The European Parliament has proposed that the Baltic Sea to become a pilot area in this context.

## 12.3 Preparing for the "Baltic Sea Monitoring Centre"

This report only provides an early outline of the administration and the supervision of the en-route charges. Before the pilot project can start there is a need for consultations with relevant experts. In addition a Baltic Sea environmental ships register must be created. It can depart from the pre-existing register developed by the Swedish Maritime Administration and make use of the existing IAPP certificates.

Organisations with a potential interest in co-using what we will name the "Baltic Sea Monitoring Centre" should be approached separately. They include the European Maritime Safety Agency (EMSA), the Fisheries Control Agency (CFCA) and the Baltic Sea Regional Advisory Council (on fishing).

## 12.4 A preliminary timetable for launching the pilot programme

The first phase is expected to take at least 18 months. This will include dialogue with the stakeholders, the simultaneous political process and working out the details about the monitoring centre, and making a choice of method for recycling the money. After a decision by the governments around the Baltic Sea, at least a year must be devoted to creating and staffing the monitoring centre.

A relevant question is whether shipowners need additional time beyond this year to prepare for the new regime? Should they be given less/greater notice in order to be able to undertake investment in abatement technologies prior to the date when the scheme becomes operational? It could be argued that an early start (with short notice) does not achieve anything besides remunerating early action, i.e. shipowners who invested in $NO_x$ reduction technologies before the proposal for a Baltic Sea pilot project was made.

From the list below, January 2011 appears to be the earliest time when the pilot scheme can become operational.

1. Report published early 2008
2. German initiative for a stakeholder dialogue spring 2008[28]
3. Stakeholder dialogue spring 2008 – autumn 2008
4. Report on the stakeholder dialogue before the end of 2008
5. Conference of interested Parties in the first half 2009 with the aim to sign an agreement with subsequent confirmation and ratification, possibly by end of 2009
6. Informing ports and ship owners in 2009-2010
7. Creating the administrative frame including an "authority" after final agreement of participating states in 2010
8. Entry into force on January 1st 2011 (or later).

[28] Possibly jointly with Sweden and perhaps in agreement with the European Commission.

# 13 Summary and conclusions

Emissions of $NO_x$ from international shipping are expected to increase by two thirds between 2000 and 2020, and those of $SO_x$ by nearly half (Amann, et al, 2004). $NO_x$ and $SO_x$ emissions from international shipping in Europe may have surpassed the emissions from all land-based sources in the EU Member States combined by 2020.

Designating the Baltic Sea as a Sulphur Emission Control Area (SECA) made it possible to introduce an upper limit of 1.5 per cent for the sulphur content of marine fuels used in the area. However, the resulting reduction will within few years be offset by the increase in emissions resulting from the fast growth in ship movements. Without further measures, emissions of $NO_x$ and $SO_x$ from shipping in the Baltic Sea are expected to increase by respectively 88 and 78 per cent in 2020 compared to 2004.

The Baltic Sea is highly sensitive to eutrophication and most of its drainage area suffers from acidification. Many cities in the region have difficulties attaining the Community's air quality standards for $NO_2$ and $PM_{10}$.

## 13.1 Abatement technologies and costs

Low-cost techniques for considerably reducing the emissions of $NO_x$ and sulphur from shipping are available. Studies for the European Commission show that in relative terms it is now very cost-effective to reduce emissions from shipping.

One obvious way of reducing $SO_x$ emissions from shipping in the Baltic Sea would be to lower the current maximum permissible sulphur content of fuels used in the SECA from 1.5 per cent to 1.0 and 0.5 per cent. This is one of the options under consideration by IMO's Marine Environment Protection Committee (MEPC).

An alternative option is to use seawater scrubbing to remove the $SO_2$ from the exhaust gases. Trials with prototype scrubbers have been carried out, but currently only one vessel is equipped with a scrubber. The evidence from these tests suggests that the technology is able to reduce the exhausts of $SO_x$ by up to 90 per cent when the ship is running on HFO. There is only limited experience of how sensitive scrubbers are to various operational parameters, the most important being the alkalinity of the seawater. In non-marine waters and freshwater-dominated waters there may be an insufficient alkaline reserve to neutralise acid compounds by seawater scrubbing. In general all European waters except the Baltic Sea have normal marine alkalinity (as the alkalinity is proportional to salinity). The seawater consumption needed for 90 per cent $SO_x$ removal is substantial, and may in fresh and brackish waters have to be significantly increased to ensure reduction efficiency (CE Delft et al, 2006). Although generally in IMO and EU papers “other means” to reduce emission are accepted, the scrubber technology is still looked at with substantial scepticism due to questioned availability of reliable systems in the near future and important side-effects like discharge quality of effluent, required reception facilities, etc.

CE Delft et al (2006) recommend that seawater scrubbers should not be operated in waters where there is insufficient ability to absorb $SO_x$. Problems of this kind may appear not only in the Baltic Sea, where the salinity differs greatly between the Sound and the Gulf of Botnia, but also in connection with entries into river-based ports.

Several established methods exist for reducing $NO_x$ from ship engines, among them basic and advanced internal engine modifications, Direct Water Injection (DWI), Humid Air Motor (HAM) and Selective Catalytic Reduction (SCR). The most advanced of these techniques can reduce $NO_x$ by well over 90 per cent but at greater cost per tonne than the less efficient abatement technologies.

## 13.2 Current instruments and market-based mechanisms proposed by others

Since 1998, the Swedish Maritime Administration has differentiated its fairway dues for ships' emissions of $SO_x$ and $NO_x$. Together with similar differentiations of the harbour dues in major Swedish ports, this has made around 1,000 vessels register for use of lower-sulphur fuels – less than 0.5 per cent sulphur content for ferries and less than 1.0 per cent for cargo vessels. In addition some 47 ships have been certified for a $NO_x$ -related discount of the fair-way due. However, as most coastal states have very short fairways and generally do not charge ships for the use of them, extending the Swedish model to the rest of the Baltic Sea does not appear feasible.

In 2004 and 2005, NERA Economic Consulting produced two reports for the European Commission on the feasibility of market-based mechanisms to promote low-emission shipping in European Union sea areas. In the second of these, NERA recommends the use of three different voluntary instruments. However, according to our assessment none of these voluntary measures can be expected to yield results that can balance the negative impact on emissions from the anticipated growth in Baltic Sea shipping. Our conclusion is that mandatory economic instruments must be used in order to achieve substantial reductions; either that or increasingly more stringent regulations must be enforced.

## 13.3 A pilot scheme for $NO_x$ emissions in the Baltic Sea

Abatement of $NO_x$ emissions from maritime shipping differs from efforts to reduce $SO_x$, as several technological measures are available for use in new vessels and for retrofitting in old. They have differing abatement potentials and costs. $NO_x$ abatement, therefore, is well suited for a scheme of market-based instruments.

The proposal in this report, based on Kågeson (2005), is to mandate the port authorities around the Baltic Sea to assist a common authority that collects a mandatory charge reflecting the calling ship's emissions of $NO_x$ during its latest trip in Baltic waters. The charge would correspond to emissions emitted from the point of entry into the Baltic (e.g. at 57° 44.43'N) or since departure from another Baltic port. The authority in charge of the scheme would check the distance and time travelled in Baltic waters and carry out a limited number of random checks of on-board facilities for compliance with a certified situation on board and with available $NO_x$ abatement technologies.

The time and distance travelled by each ship in the area can be registered by using the Automatic Identification System, AIS, which automatically transmits the identity of all ships to coastal centres. The AIS is compulsory for all passenger ships and all cargo ships of 300 GT and more engaged in international voyages. Ships above 500 GT not on international voyages will be equipped with AIS before 1 July 2008.

According to MARPOL Annex VI, an International Air Pollution Prevention Certificate shall be issued to any ship of 400 GT. From these regulations it is clear that all vessels of 400 GT or more that engage in international traffic will carry both an IAPP Certificate and an AIS transponder by 1 July 2008. Ships of 500 GT or more engaged in domestic voyages will by the same date be equipped with AIS, but current regulations do not require them to carry an IAPP Certificate.

In order not to discriminate against ships in international traffic, it is necessary to set the limit at 400 GT and ask the participating states to demand that all vessels in domestic traffic of that size be equipped with AIS transponders and an IAPP Certificate. The charges (or alternatively the cap) should, of course, apply to all ships of 400 GT or more regardless of flag.

The emissions per kWh according to the IAPP certificate would have to be multiplied by the amount of energy used under normal/average circumstances to propel the ship during the time of the trip at 85 per cent engine capacity. This type of charge is thus aimed at limiting emissions per kWh hour used, rather than setting a cap on the total emissions emitted in the area concerned. The level of total emissions also depend on the growth (or decline) in traffic.

A common agency needs to be in charge of the en-route system, here referred to as the Authority. Among the duties of the Authority should be to:

- Keep a Baltic Sea environmental ships register
- Use the AIS system for handling and storing data from movements of all individual ships of 400 GT or more that call at participating ports
- Use these data for calculating the charges to be paid by individual ships
- Collect the charges
- Redistribute the revenues
- Collaborate with port state authorities in making random inspections on board vessels calling at participating ports to ensure that they carry the appropriate documents and are equipped accordingly
- Fine ships that violate the rules.

A basis for recycling the money might be to divide the total annual revenue from the scheme by the number of GT kilometres or tonne kilometres produced in the designated area by each shipowner, provided that reliable data are available. One could also contemplate alternative ways of recycling, for instance to use the revenue for funding grants to ships that invest in $NO_x$ abatement technologies. Provided that the level of the charge is accurately set, the programme would provide a correct marginal incentive without causing the average ship to pay more than it will receive back.

An alternative option for returning the revenue would be to design the en-route charge system as a baseline-and-tradable-credit scheme. In such a system, ships would have to surrender emissions credits for $NO_x$ that correspond to the exhausts emitted on their journey in Baltic waters; the credits would be handed over to participating ports. Each ship would receive credits equal to a baseline or benchmark value (g/kWh) that is successively lowered.

In the baseline-and-credit system, the Authority would collect credits surrendered by each individual ship that equate to the vessel's emissions during its latest journey. Ships with emissions per kWh above the baseline would have to buy credits from ships with emissions below the baseline. The scheme would thus require either the industry or the Authority to establish a trading place for emission credits.

An advantage of a baseline–and-tradable-credit scheme is that it does not generate any revenue. The trade reallocates money between net-sellers and net-buyers without burdening the industry with any expenditure beyond the cost of compliance. Thus no effort has to be made to find a special model for recycling money.

## 13.4 Effects on inter-port competition

The launch of a market-based pilot scheme that applies to ports in the Baltic Sea area may give ports in neighbouring non-participating states and/or areas a competitive advantage. This might potentially be a problem for participating ports that to a large extent attract visitors from other parts of the world. Ships calling at such ports would in many cases pay above average charges. If there is a non-participating port in the vicinity they may consider calling at that port instead. Such a move, however, would be conditional on the approval of freight owners, who would have to consider potential negative side-effects such as delayed deliveries or incremental costs of extended land transport by truck or train.

One should also remember that the charge would only be enforced on journeys to participating ports in the Baltic Sea area. As a result all trips from such ports to ports outside the area would not be covered. In addition, trips from outside ports to ports in the southern and western part of the Baltic Sea area, which are most vulnerable to competition from neighbouring North Sea ports, would only be charged for the relatively short distance from the *Kiel Canal or* 57°44.43’N to the ship’s destination in the Baltic Sea.

## 13.5 Abatement of $SO_x$ in the Baltic Sea area

A shift to fuels with a lower sulphur content than 1.5 per cent can take place almost overnight, but the lead time for a massive introduction of seawater scrubbing on board new and existing ships may be as long as 10 years. As the salinity of the Baltic Sea is considerably lower than in the open ocean and also differs greatly between different parts of the sea, extensive trials with brackish seawater scrubbing would have be carried out before it is possible to say whether the technology is a viable option. Even if it is, a broad introduction of seawater scrubbing is unlikely to take place before 2015 in response to market-based instruments.

IMO’s Marine Environment Protection Committee is currently in the process of revising the standards for emissions of sulphur. One option to be considered is to reduce the maximum permitted sulphur content of fuels used in SECAs in two stages to, first, 1.0 and then 0.5 per cent, possibly in 2012 and 2015.

Tightening the SECA rules could be done in a way that allows more flexibility than the current limits. One option is to rule that all traffic that is internal or where the major part of the journey takes place in the Baltic Sea should use fuels that contain no more than 0.5 per cent sulphur. In this context the shore states could also consider a mandatory shift to marine distillate fuels. If so, this would be a first step towards achieving the global standard for marine fuels proposed by Intertanko (2006). Ships calling at Baltic Sea ports after having spent more than half of their journey from the previous port in outside seas could be allowed a higher content of sulphur.

If making the SECA rules more stringent does not appear to be feasible in the near future, an alternative for the states around the Baltic Sea could be to require ships using fuel with more than 0.5 per cent sulphur to pay the difference in market price between 1.5 per cent and 0.5 per cent sulphur when calling at Baltic. The fee would be paid to a common authority as in the case of the $NO_x$ charge, and would have to reflect the time travelled in Baltic waters and the specific fuel consumption at 85 per cent engine load.

## 13.6 Legal implications

According to the analysis carried out in chapter 10, a party to UNCLOS may impose rules and/or charges on foreign flagged ships that voluntarily call at its ports, even in a case where those requirements go beyond the standards of MARPOL. UNCLOS Article 25(2) clarifies that the coastal state "in the case of ships proceeding to internal waters or a call at a port facility outside internal waters" has "the right to take the necessary steps to prevent any breach of the conditions to which admission of those ships to internal waters or such a call is subject". In such a case, the state is in fact acting as a port state.

States have on various earlier occasions used the opportunity provided by UNCLOS to enforce higher standards on ships calling at their ports. Examples of this are the United States Oil Pollution Act, the European Union's ban on single hull tankers, the 1996 Stockholm agreement on Roro ferries, the US ballast water requirements and a recent ruling by the Swedish Supreme Environment Court on the mandatory use of SCR in the case of the city of Helsingborg versus two ferry lines.

According to UNCLOS Article 24, the coastal state shall not hamper the innocent passage of foreign ships through the territorial sea except in accordance with the Convention. Limiting the en-route scheme for $NO_x$ to ships calling at participating ports is a way to avoid a conflict with the right of innocent passage. This means that no ship is charged for crossing the Baltic Sea on its way to a port that is not participating.

The introduction of en-route charges that apply to calls at ports in some Member States would not require a decision by the European Union. According to the EU Treaty's principle of subsidiarity, member states are free to act in areas that do not require common legislation provided that the measures taken are non-discriminatory and proportional to the objective pursued. If member states bordering the Baltic Sea feel that they need to protect their environment from airborne pollutants from ships, other member states have no reason to object as long as ships or cargo owners registered in their countries are not discriminated against.

Alternatively, if the European Commission thinks that the Baltic scheme is of such importance that it should be introduced by Community law, a decision on the directive can be taken by the Council of Ministers by qualified majority as it does not involve setting any tax rates.

## 13.7 The cost-effectiveness of the schemes

To forecast the growth rates of Baltic Sea shipping is not easy for the reasons mentioned above. Therefore chapters 4 and 11 feature emission volumes based on two different growth scenarios. In scenario I, the average annual growth rate between 2004 and 2020 is held to be 5.9 per cent, while the average growth in scenario II is assumed to be 4.3 per cent.

Table 23 shows the volumes of $SO_x$ and $NO_x$ emitted in 2020 under business-as-usual (BAU) and in the abatement scenario (EAS) as well as the change from the 2004 levels. Where $NO_x$

is concerned the abatement scenario shows the results of the assumptions presented in chapter 11.1 on how shipowners would respond to the introduction of emission charges in 2010.

**Table 24: Emissions in 2020 and change since 2004 in the BAU and EAS scenario, 1 000 tons and per cent**

| Scenarios | 2020 | | | % change 2004-2020 | | |
|---|---|---|---|---|---|---|
| | $NO_x$ | $SO_x$ | PM | $NO_x$ | $SO_x$ | PM |
| BAU I | 723 | 345 | 88 | +88 | +78 | +127 |
| EAS I | 326 | 127 | 86 | -15 | -35 | +122 |
| BAU II | 595 | 275 | 69 | +55 | +41 | +79 |
| EAS II | 261 | 100 | 68 | -32 | -48 | +75 |

Source: Gauss, 2007

From the table and the figures, it is evident that the $NO_x$ charges and step-wise lowering of the SECA limits would in growth scenario I reduce emissions in 2020 by 15 and 35 per cent whereas in the BAU scenario they would increase by respectively 88 and 78 per cent. The tendency in scenario II is similar but the difference is smaller due to the lower underlying traffic growth rate. The reduction for $NO_x$ is modest compared to the cuts needed in order to reduce $NO_x$ emissions to an environmental sustainable level. However, in the longer term, post 2020, the emissions will continue to fall as new ships equipped with SCR or other techniques replace pre-existing vessels.

Table 24 shows the incremental cost of introducing a scheme for $NO_x$ charges as laid out in chapter 8 and enforcing more stringent SECA rules for $SO_x$ in line with the assumptions presented in chapter 9. Readers should be aware that some improvement also takes place in the BAU scenario. It was assumed that under business-as-usual 20 per cent of all ferries and Roro-vessels would be equipped with SCR, mostly in response to the existing Swedish environmental differentiation of port and fairway dues. For $SO_x$ the assumption for BAU is that the share of “good guys” who voluntarily use fuel with a sulphur content of less than 1.5 per cent would remain constant throughout the period. The figures for costs and benefits in table 24 thus represent the difference between the BAU and EAS scenarios in 2020. All benefits have been calculated using the BeTa Version E1.02a database of DG Environment.

**Table 25: Incremental costs and benefits in the EAS scenario 2020 and the cost-benefit ratio (million euro)**

| | Growth scenario I | | Growth scenario II | |
|---|---|---|---|---|
| Emissions | $NO_x$ | $SO_x$ | $NO_x$ | $SO_x$ |
| Costs | 137 | 50 | 116 | 36 |
| Benefits | 834 | 256 | 702 | 175 |
| Cost-benefit ratio | 1:6.1 | 5.1 | 1:6.1 | 4.9 |

Source: Gauss, 2007

Where $SO_x$ is concerned, it might be interesting to know that the cost-benefit ratio in 2015, reflecting a SECA limit of 1.0 per cent sulphur, is 1:11.2 (not shown in the table). The higher ratio in 2015 compared to 2020 is explained by the fact that the cost premium for 0.5 per cent sulphur is much higher than the premium that shipowners have to pay for 1.0 per cent sulphur. For $NO_x$, on the other hand, the cost/benefit ratio is lower in 2015 (1:5.2) than in 2020 (1:6.1 for scenario I). This is explained by falling costs due to increased competition among suppliers and economies of scale as the market grows and the abatement technologies become more mature.[29]

It is evident from the cost/benefit ratios in table 24 that implementation of the proposed $NO_x$ charges and the increasingly more stringent SECA limits are socio-economically beneficial. The ratios are such that even doubling or trebling the cost assumptions would not significantly alter the outcome. The results are therefore robust.

## 13.8 Schedule for implementation

Launching a Baltic Sea pilot project probably requires a preparatory period of at least three years. The first step after the completion of the report would be to start a dialogue with a wide range of potential stakeholders in order to seek their support and to invite them to submit their assessment of the proposal.

The report only provides an early outline of the administration and the supervision of the en-route charges. Before the pilot project can start there is a need for consultations with relevant experts. In addition a Baltic Sea environmental ships register would have to be created. It can depart from the pre-existing register developed by the Swedish Maritime Administration and make use of the existing IAPP certificates.

From the analysis in chapter 12, January 2011 appears to be the earliest time when the pilot scheme for $NO_x$ can become operational.

[29] In the cost calculation a reduction of 25 per cent was assumed over the entire period.

# 14 Annex

## 14.1 The Swedish Supreme Environment Court's decision on Helsingborg versus HH-Ferries and Sundsbusserne A/S

A recent decision by the Swedish Supreme Environmental Court in the case of the city of Helsingborg versus two ferry lines shows that a port state can, without violating UNCLOS, require ships of all nationalities calling at a specific port to install technologies for reducing $NO_x$ below the $NO_x$ curve of MARPOL's Annex VI, if this is needed for the port city's compliance with the European Union's air quality standards or for compliance with national environmental law.

## 14.2 The court's ruling

"The Supreme Environment Court finds that the provisions of UNCLOS do not prevent a Swedish authority, as a representative of the port state, from intervening against a foreign ship, requiring it to reduce emissions of $NO_x$ in order to protect human health. According to the judgement of the court, neither do the provisions of MARPOL stand in the way for making demands on ships that call at Swedish ports to go beyond the requirements expressed in the convention, if this is motivated according to national environmental law. This action is possible as the convention does not express any rule that limits the possibility of the port state to make such demands in relation to foreign vessels. Such demands, however, may not be discriminatory. In this case the demand is directed towards shipping companies that are engaged in extensive regular traffic to and from the port of Helsingborg, and the requirement is enforced regardless of flag; therefore the demand cannot be regarded as discriminatory. According to the judgement of the Supreme Environment Court, the decision is not in conflict with Sweden's international obligations." (non-authorised translation)

## 14.3 Statements by relevant authorities

The decision by the Environment Supreme Court is in line with statements made to the court by relevant state and local agencies.

In a statement on behalf of the environment council of the city of Helsingborg, the professor of law Jonas Ebbesson claims that the measures enforced on the ferry lines by the environment council are not in conflict with Sweden's international obligations as Sweden as a port state is free to make demands for the protection of air quality that go beyond the rules expressed in MARPOL, and that the way by which the demands have been made is not in conflict with UNCLOS. According to Professor Ebbesson, the environmental rules defined by MARPOL constitute minimum requirements for flag states and maximum requirements for coastal states in relation to ships under their jurisdiction. However, the regulations of MARPOL do not limit port states in relation to foreign vessels, but the port state's right to enforce national requirements on foreign ships that call at its ports must not be misused. It is essential that the UNCLOS requirement on promptness is met and that national rules that go beyond MARPOL and UNCLOS are well motivated. UNCLOS Article 211(3) (states which establish particular requirements for the prevention, reduction and control of pollution of the marine environment as a condition for the entry of foreign vessels into their ports or internal waters shall give due publicity to such requirements and shall communicate them to the competent international organisation) should be observed even though the article in a formal sense only applies to actions for the protection of the marine environment (and not to the protection of air quality).

The fact that the city's decision to demand investments in Selective Catalytic Reduction (SCR) for the reduction of $NO_x$ only applies to two ferry lines, and not to other ships that call at the port of Helsingborg, should, according to Professor Ebbesson, not be regarded as an act of discrimination as the effect on the environment from the many daily visits by the ferries should be compared to similar emissions from land-based sources rather than to emissions from ships that do not frequently call at the port.

As the demand was only applied to two locally operating ferry lines, there was, according to Professor Ebbesson, in this particular case no need to communicate the new environmental requirement to "the competent international organisation" (IMO). However, had it been directed towards all ships calling at the port, the city would have been obliged to give due publicity to the requirement and communicate with the IMO.

In its statement, the Swedish Maritime Administration (SMA) says that UNCLOS Article 21 only applies to coastal states, which may not enforce rules on foreign vessels that go beyond internationally agreed standards, but not to port states. According to the SMA, UNCLOS, "in all probability", does not stipulate any conditions for the right of the port state to take legal action against a foreign ship.

The Swedish Environmental Protection Agency says in its statement that international law does not prohibit a local community in a port state from taking legal action against foreign ships if this is deemed necessary, according to Swedish law, for the protection of the environment, at least where emissions emitted in the port area are concerned. According to the principle of port jurisdiction, a state has complete jurisdiction over its ports, and there is no general right for foreign ships to call at them. However, a Member State of the EU may not enforce rules that discriminate against ships from another Member State.

# 15 References

Amman, M., Bertrok, I., Cofala, J, Guyarfas, E., Heyes, C., Klimont, Z., Schöpp, W and Winiwarter, W. (2004), Baseline scenarios for the Clean Air For Europe (CAFE) Programme. Final report to the European Commission, DG Environment, October.

Bakewell, R., Eichelberger, R., Matisoff, D., Ruseva, T., and Sundar, N. (2004), Choosing the Optimal Policy Instrument for $SO_2$ Abatement, May.

CE Delft, Germanischer Lloyd, MARINTEK, and Det Norske Veritas (2006), Greenhouse Gas Emissions for Shipping and Implementation Guidance for the Marine Fuel Sulphur Directive, Delft, December.

Committee on the Environment, Public Health and Consumer Policy (2003), Report on a European Union strategy to reduce atmospheric emissions from seagoing ships, (COM(2002) 595, 2003/2064(INI)), FINAL, A5-0400/2003.

CONCAWE (2006), Techno-economic Analysis of the Impact on the Reduction of Sulphur Content of Residual Marine fuels in Europe. CONCAWE Report Nr.2/06, Brussels.

Corbett, J. (2006), Environmental Impacts of Ocean Shipping in a Freight Context, A report to the OECD, Paris, November.

Corbett, J. and Eyring, V. (2007), Comparing Fuel Consumption, $CO_2$ and other Emissions from International Shipping and Aircraft: A Summary of Recent Research Findings, Institute of Atmospheric Physics, Release Date: 8/3/07

EEA (2004), Environmental signals 2004. The European Environmental Agency.

Entec UK Limited (2005a); Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments. Task 1 – Preliminary Assignment of Ship Emissions to European Countries. European Commission.

Entec UK Limited (2005b), Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments. Task 2 – General Report.

Entec UK Limited (2005c), Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments. Task 2a – Shore-side Electricity in Ports.

Entec UK Limited. 2005d. Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments. Task 2b – $NO_x$ Abatement Technologies.

Entec UK Limited (2005e), Service Contract on Ship Emissions: Assignment, Abatement and Market-based Instruments. Task 2c – Sea Water Scrubbing.

European Commission (1995), Towards Fair and Efficient Pricing in Transport, Policy options for internalising the external costs of transport in the European Union, Green paper, COM(95) 691 final.

European Commission (1998), Fair Payment for Infrastructure Use: A phased approach to a common transport infrastructure charging framework, COM(1998) 466 final.

European Commission (2002), Proposal for a directive of the European Parliament and of the Council amending Directive 1999/32/EC as regards the sulphur content of marine fuels. COM(2002) 595 final.

European Parliament (2002), DIRECTIVE 2002/59/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 27 June 2002 establishing a Community vessel traffic monitoring and information system and repealing Council Directive 93/75/EEC

European Commission (2005a), Thematic Strategy on Air Pollution. COM(2005) 446.

European Commission (2005b), Commission staff working paper: Impact assessment of the thematic strategy on air pollution and the directive on "Ambient air quality and cleaner air for Europe". SEC(2005) 1133.

Groß, M. (2000), Abgasemissionen von Schiffsantriebsanlagen vor dem Hintergrund sich ändernder Grenzwerte, Diplomarbeit, 05.07.2000, Bremen

Hagström, U. (2005), Humid Air Motor (HAM) and Selective Catalytic Reduction (SCR)" presentation at Swedish Maritime Administration Symposium/Workshop on Air Pollution from Ships, Stockholm 24-26 May.

Ian Williams and Associates (2002), Canberra, ACT, AUSTRALIE, Improvements in the safety of passenger ferries, Proceeding of the institute of marine engineering, science and technology. Part B, journal of marine design and operations (Proceeding Inst.mar. Eng., Sci. Technol. Part B, j. mar. des. oper.), no1, pp. 11-15.

IIASA (2007), Janusz Cofala et.al: Analysis of Policy Measures to Reduce Ship Emissions in the Context of the Revision of the National Emissions Ceilings Directive, Final Report, Submitted to the European Commission, DG Environment, Unit ENV/C1, Contract No 070501/2005/419589/MAR/C1, April 2007.

IIASA, MET.NO, and Entec UK Limited (2006), Analysis of Policy Measures to Reduce Ship Emissions in the Context of the Revision of the National Emissions Ceilings Directive, Service Contract N 070501/2005/419589/MAR/C1.

IMO (2006), MEPC 55/4/1, 55th session, Agenda item 4, Sulphur monitoring 2005, Submitted by the Netherlands, 2 June 2006.

IMO (2006), BLG-WGAP 1/2/11, Revision of MARPOL Annex VI, the $NO_x$ Technical Code and related guidelines, 20.October 2006, submitted by the Friends of the Earth International (FOEI)

IMO (2007), BLG12/Inf.10, Revision of MARPOL Annex VI and the $NO_x$ Technical Code, Input from the four subgroups and individual experts on the final report of the Informal Cross Government/Industry Scientific Group of Experts, 28.December 2008, Note by the Secretariat

Intertanko (2006), Revision of MARPOL Annex VI and the $NO_x$ Technical Code and related guidelines. Proposed amendments to MARPOL Annex VI. Submitted by Intertanko to the IMO's Sub-Committee on Bulk Liquids, 17 October.

IPCC (2001) Climate Change 2001: The Scientific Basis, Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press.

IPIECA (2007), Review of MARPOL Annex VI and the $NO_x$ Technical Code. Global environmental impact and marine fuel supply impact of proposed options to revise MARPOL Annex VI. Submitted by the International Petroleum Industry Environmental Conservation Association (IPIECA) to the IMO's Sub-Committee on Bulk Liquids, 9 February.

Ives, R. and Klokk, S.N. (1993), Exhaust gas sulphur removal by seawater washing, marine diesel engines. CIMAC, London.

Jonson, J.E., Tarrasón, L. and Bartnicki, J. (2002), Effects of international shipping on European pollution levels. EMEP/MSC-W Note 5/00. EMEP, Meteorological Synthesizing Centre – West, Norwegian Meteorological Institute, Oslo.

Kågeson, P. (2005), Reducing Emissions from Ships in the Baltic Sea Area. The feasibility of introducing a distance-related en-route charge, European Federation for Transport and Environment and Svenska Naturskyddsföreningen, Brussels and Stockholm.

Lindquist, T, Rosén, P. And Olsson, L.O. (2001), Humid Cycles, A novel Way to Increase Performance of Marine Propulsion Systems, International Council on Combustion Engines, Congress 2001, Hamburg.

Maurya B. Falkner (2003), California State Lands Commission, Marine Facilities Division: REPORT ON THE CALIFORNIA BALLAST WATER MANAGEMENT PROGRAM, February 2003

Mike Holland; Paul Watkiss (2002), SHIPPING Marginal external costs from emissions at sea, year 2000 prices, Benefits Table database: BeTa Version E1.02a, DG Environment, 2002

Oftedal, S, Martens, O, Ellingsen, H., and Ågren, C. (1996), Air Pollution from Sea Vessels, the need and potential for reductions, T&E 96/6, European Federation for Transport and Environment, Brussels..

SMA (2007), Certified $NO_x$ measures in ships, Swedish Maritime Administration, 2007-01-10.

SUB-COMMITTEE ON BULK LIQUIDS AND GASES (2007), 11th session, BLG 11/5/5: REVIEW OF MARPOL ANNEX VI AND THE NOX TECHNICAL CODE; New global and regional inventories of air pollution from international shipping Submitted by the Friends of the Earth International (FOEI), 12 January 2007

Sweden (2007), Review of MARPOL Annex VI and the $NO_x$ Technical Code. Comments related to fuel issues and the sole use of low sulphur distillates fuel. Submitted by Sweden to the IMO's Sub-Committee on Bulk Liquids, 16 February.

Toll- og Avgiftsdirektoratet (2007), Avgift på utslipp av $NO_x$. Rundskriv nr. 14/2007 S, Oslo 12 January.

United States (2007), Review of MARPOL Annex VI and the $NO_x$ Technical Code. Development of Standards for $NO_x$, PM and $SO_x$. Submitted by the United States to the IMO's Sub-Committee on Bulk Liquids, 9 February.

WELMOED VAN DER VELDE (2003), THE POSITION OF COASTAL STATES AND CASUALTY SHIPS IN INTERNATIONAL LAW, CMI YEARBOOK 2003, PART II - Document 14.

WHO (2005) Particulate matter air pollution: how it harms health. Fact sheet EURO/04/05. Berlin, Copenhagen, Rome, April.