EMISSION TRADING FOR SULPHUR AND NITROGEN OXIDES –

MEANS TO GREEN MARITIME SHIPPING

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1. Background

On 2nd May 2007 the Swedish Maritime Administration, the Swedish Energy Agency, the Swedish Environmental Protection Agency and the Swedish Institute for Transport and Communications Analysis (SIKA) reported in response to a joint government commission concerning a system for trading with emission rights for sulphur and nitrogen oxides that covers the shipping sector. The Swedish Maritime Administration has processed and translated the original report in order to make the material available to an international readership

The government commission that was given to the four authorities is based on the fact that Sweden has worked internationally for a number of years in respect of measures against shipping emissions of air pollution. One area of concentration has been an attempt to widen the application of environmentally differentiated shipping charges with the Swedish differentiation of fairway dues as a model. The Swedish approach has won acknowledgment but the consequences have been very few. In tandem with the work aimed at spreading awareness regarding environmental differentiation of shipping charges an alternative, or possibly supplementary, route is now being analysed. The fact that emissions trading has started to be applied in respect of carbon dioxide at the European level (EU Emissions Trading Scheme, EU ETS) has also, in part, contributed towards a readiness to study new ways of limiting the sulphur and nitrogen oxide emissions by shipping in greater detail.

The Swedish Shipowners’ Association’s proposal to introduce a system for trading with emissions credits for sulphur and nitrogen oxides should also be seen as a background to the government commission. The Shipowners’ Association proposes emissions trading that covers both shipping and shore installations. The Shipowners’ Association’s assessment is that the system has a significantly greater control potential than the current fairway dues while, at the same time, it can potentially contribute towards a more optimal balance between measures ashore and at sea.[1]

The debate surrounding economic instruments of control for limiting shipping emissions has been wider and has involved a range of authors and

[1] Swedish Shipowners´ Association, 2006 05 12.

organisations. Nature Associates has proposed a form of mileage tax for shipping – a system that has the potential for better reflecting the socio-economic costs than the current Swedish fairway dues.[2] NERA[3] and IVL[4] have also published analyses within this sector.

The question of trading with emission rights has also been out on the IMO environment committee's agenda. For example the United Kingdom has argued that emissions trading has the potential to contribute towards emissions reduction with shipping in a cost-effective manner and has proposed that IMO should consider which role such an instrument of control should be given in the future.[5]

Trading with emissions rights has recently caught the attention of the Swedish government as well. In a joint article regarding efforts aimed at cleaning the maritime environment, the Minister of the Environment and the EU Minister refer to a trading system that includes emission rights within shipping for nitrogen and sulphur oxides.[6]

In contrast with Europe, there are experiences from USA of an emissions trading system for sulphur and nitrogen oxides, among others.

1.1 The government commission

In June 2006 the Swedish government commissioned the Swedish Maritime Administration, the Swedish Environmental Protection Agency, the Swedish Energy Agency and the Swedish Institute for Transport and Communications Analysis (SIKA) to examine jointly how a trading system with emission rights can be formulated for nitrogen and sulphur oxides in which shipping is included. The Swedish Maritime Administration was given the assignment of co-ordinating the work.[7]

The assignment specified that the investigation shall cover:

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[2] Kågeson, 30 11 2006.
[3] NERA, 26-09-2005.
[4] Holmgren et al., 2006.
[5] IMO, MEPC 55/INF.7, 10 August 2006.
[6] Carlgren, Malmström, 2007.
[7] Government decision 21-06-2006, II 10, N2006/4907/TP.

- Investigating whether trading with emissions rights is cost effective in relation to other instruments of control for reducing emissions of sulphur and nitrogen oxides from shipping.
- Comparing the effects of an open sector-wide trading system that can include emissions from shipping as well as emissions from land-based installations with a closed system that only covers shipping.
- Analysing how the separate systems can be co-ordinated with the existing tax system.
- Investigating trading system’s conformity with international law.
- Comparing the effects of a trading system with other possible instruments of control from both an environmental and socio- and commercial economic perspective.

According to the assignment the work shall take note of existing systems as well as ongoing studies and trials.

1.2 Emissions trading

Emissions trading is a form of economic instrument of control in which those covered by the system are given an incentive to limit emissions through being able to earn money by selling emission rights and/or reducing their need to purchase these. The theoretical foundation surrounding emissions trading was developed during the 1960s. At the end of the 1970s the first emissions trading system was introduced in USA under the management of the federal Environment Protection Agency (EPA).

A pre-requisite for trading to be an effective instrument of control is that there is interchangeability between emissions from different sources and areas within the trading area. Certain cost differences can be dealt with by means of ”exchange rates” that reflect these differences. One kg of emission in one area may thus, for example, be assessed as corresponding to two kg in another area.

Another pre-requisite is that there are differences in the cost of abatement measures between different activities.

In principle there are two types of system for emissions trading: trading within an emissions bubble (*Cap and trade)* and credit-based trade (*Baseline and credit).*

With trade within an emissions bubble the total amount of emission that is to be permitted within an area that is well-defined in geography is determined, as well as the activities that are to be included. Viewed generally the system can give rise to adjustments to lower costs, the greater the system is – the more activities or sectors are included. In contrast with the majority of other instruments of control, such as environmental charges, this instrument is aimed at a certain overall emissions level. On the other hand it is not possible to know in advance how costly measures that are to be taken will be. An initial distribution of emission rights takes place between those involved in the system (distributed free of charge or sold). The opportunity for trading between the parties concerned creates flexibility within the system. A player who has low costs for lowering his emission can undertake more far-reaching reductions and thereby be given the opportunity to sell emission rights to someone who has higher adjustment costs. By means of the opportunity for trading an incentive is created for the taking of measures where the regulation costs are lowest.

In a credit-based trading system a permitted emissions level is pre-determined. For reductions below the level emissions credits are generated that can be sold to someone else who is thereby permitted to generate greater emission.

The fact that costs of measures differ between different players tends to be seen as a basic pre-requisite for a trading system to be meaningful. According to experiences from USA, however, there is also a significant potential in the system being able to permit players to re-time their emission. The costs of measures not only vary between different installations but also in respect of individual installations over a period of time.

An evaluation of six American emission trading systems for such emissions as sulphur and nitrogen oxides reveals positive experiences. Reductions in emissions have been made possible at relatively low costs without the emission targets being jeopardised. Low costs of measures are, on the contrary, deemed to have meant that the environmental targets could be made stricter according to the American study compared with traditional regulation.[8]

1.3 Environmental policy, air pollution and shipping

An overall environmental policy objective is for us to be able to hand over a society to the next generation in which the major environmental problems have been solved. This includes a good living environment and health, preserved biological diversity, preserved production ability for eco-systems and protection of natural and cultural landscapes.[9] In addition to this aim the three fundamental environmental policy principles also serve as a basis for the policy developmental work:

- The precautionary principle involves society taking measures as soon as one sees a possible risk that an activity gives rise to significant environmental effects.
- Polluter Pays Principle (PPP) means that the one who causes the environmental effect shall also be the one who pays for it.
- Best Available Technology (BAT) shall be used in order to limit the environmental effect of an activity.

Within the area of air protection there is an increasingly large imbalance perceived in that far-reaching measures are taken within different land-based sectors while measures at sea have been much more moderate. The environmental policy pressure aimed at adjusting shipping environmentally is growing.

1.4 Geographical demarcation

The system for emissions trading can be applied to separate geographical demarcation areas. Several reasons argue in favour of an international introduction:

- Large-scale introduction has a greater potential for contributing to reduced emissions.

[8] Ellerman, et al., 2003.
[9] Government bill, 2004/05:150.

- Trading with emissions rights tends, as an instrument of control, to be more effective the more comprehensive the system is.
- Through international introduction separate national solutions are avoided, something which is generally seen as a goal within shipping policy, primarily in order to avoid distortion of competition.
- There are economies of scale in terms of administration.

In purely technical terms some form of trading can be introduced on a national scale. An effective obligatory system should, however, require international introduction in practice. If only individual countries introduce obligatory trading with emission rights this can lead to the ports in such countries losing the opportunities of serving as transit ports and thereby losing the activity that means the ports cannot exploit economies of scale in the same way as would otherwise be the case. Such a development would lead to transports to and from the participating country or countries becoming more expensive. Added to this is the fact that the trading system itself, seen as a whole, involves a certain greater expense in commercial-economic terms.

In the context of this commission it is natural that the Baltic on the one hand and the North Sea on the other have been discussed as possible demarcation areas. These areas have been internationally defined as so-called special areas under Marpol 73/78, Annex VI Air pollution or sulphur-control areas. The international community has thereby agreed that it is of particular importance to take measures against air pollution within these areas.

In earlier work Nature Associates has argued in favour of the Baltic Sea Area (according to the Helsinki Commission’s definition, out to a line between the Skaw and Gothenburg) being a suitable pilot area for the type of environmental charge for shipping that is proposed there. The reason is that it is a relatively defined sea and that all its coast countries apart from Russia are members of the EU. [10]

The North Sea too is mainly surrounded by EU countries (7 EU countries together with Norway). The North Sea’s environmental problems have, for example, been noted at ministerial level in connection with the so-called

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[10] Kågeson, 2006.

North Sea conference that was held in Gothenburg in May 2006. In the declaration from the conference the countries' North Sea ministers stressed the need, among other things, to limit the emissions of sulphur and nitrogen oxides from shipping in the North Sea and it was agreed to assess the possibility of integrating shipping in the in the emissions trading system in order to bring about further reduction of shipping emission.[11]

The report has collectively chosen to analyse different systems of trading with emission rights for an area that covers both the Baltic Sea and the North Sea. The rationale that is given in the analysis and in its result is, however, mainly regarded as being relevant and also provides a degree of guidance in respect of a possible introduction of such a system in only one of both these sea areas.

[11] The North Sea declaration, 2006.

2 Environmental effects and emissions

2.1 Environmental effects of sulphur and nitrogen oxide emissions

The emissions of sulphur and nitrogen oxides affect health and the environment in a wide perspective. Emissions, primarily those of sulphur, are also regarded as affecting climate.

Effects on health

Nitrogen oxide and sulphur dioxide, in the concentrations that normally occur in the outdoor environment in Sweden (background levels) are in themselves regarded as having a limited effect on health.

Shipping's greatest contribution to health effects is instead linked to emissions of particles. Increased particle concentrations derive partly from the direct emission of particles and partly from secondary formed particles, primarily as a result of the emission of sulphur and nitrogen oxides. Measures aimed at reducing the emission of sulphur and nitrogen oxides therefore have a positive effect through reduced presence of particles.

Ozone is the form of pollution that is regarded as causing the second greatest effect on health by outdoor air in Europe. Together with hydrocarbons and sunlight, nitrogen oxides give rise to increased levels of ground-level ozone.

Effects on the environment

Sulphur and, to a certain extent, nitrogen have an acidifying effect. Lakes, watercourses and vegetation on land with a poor buffering capacity are prone to acidification. This type of land is found in Sweden and in the Nordic region in general while it is less common in the rest of Europe. Of the sulphur deposited in 2004 in Sweden an average of 20 percent had its origin in shipping emissions. For oxidising nitrogen compounds, the corresponding proportion was 23 percent.[12] These proportions have increased since the emissions from land-based activities have decreased and emissions at sea have risen.

[12] EMEP, MSC-W, Note 1/2006.

Apart from the nitrogen’s acidifying effect, nitrogen also contribute as a fertilizer. In many pristine ecosystems there is lack of the nutrient nitrogen and these ecosystems are discernibly affected by increased nitrogen deposits. Nitrogen oxides also contribute to the eutrophication of the sea. Nitrogen oxides that are emitted from vessel traffic thus largely end up in the sea serving as nutrient for plankton growth. Increased input of nutrients to the sea in most cases result in increased biologic production and changes to the ecosystem with several negative effects on the marine environment. Examples of such effects are:

- Increased sedimentation of organic material and increased oxygen consumption in deep water resulting in oxygendeficit and disturbed life environments as a consequence. Under such conditions phosphorus may also be released from the sediment and give rise to further increased biological production in the surface water.
- Altered species composition of fish.
- Increased turbidity causing poor light conditions and consequently poor life conditions e.g. for bladder wrack and other fixed algae and plants that constitute an important environment for many animals.
- Blue-green algae blooming.

Ground-level ozone, the formation of which is promoted by nitrogen oxides under sun radiation has, in addition to an affect on human health, a damaging effect on vegetative growth and for example, loss of crops production within agriculture.

Climatic effects

The debate on greenhouse gases and climatic effects is mainly related to carbon dioxide emissions. Nitrogen oxides have a certain, but very limited, greenhouse effect. On the other hand they have a greater importance through their contribution to the creation of ozone, a gas that has a climatic effect. In principle, sulphur is merely of importance in this context.

On the other hand sulphur and particle emissions are deemed to have a certain effect on the climate by their shadowing effect, which means that less sunlight reaches Earth. This shadowing is thus regarded as having a cooling effect that in turn counteracts the greenhouse effect.

2.2 Emission of sulphur and nitrogen oxides

There is no doubt that shipping gives rise to significant emissions of pollution that affects health and the environment. In general the emission of both sulphur and nitrogen oxides is currently greater per tonne-kilometre for goods that are carried by sea than by land.

The information regarding the extent of the emission reported in different contexts varies considerably. The most significant cause for this is the use of different geographical demarcation areas. Uncertainties in the calculations are also significant in other contexts.

With international reporting of shipping emissions the point of departure is the fuel bought in the respective country, not the area in which the emissions occur. An alternative to reporting of shipping emission, also employed in this present work, is to base it on emissions within a geographical demarcation area. Shown in the table below are shipping emissions within different geographical areas. The reporting relates primarily to the year 2000. Different sources have employed different assumptions regarding emission factors and activity data.

Table 1**.** Emissions year 2000 from shipping according to separate studies for different geographical areas, in thousands of tonnes.

Demarcation	**NO_x**	**SO_2**	**PM**	**CO_2**
The Baltic	270[2]	110[2]	5,2[2]	14 000[2]
	350[3]	230[3]		
	315[1]	224[1]	26[1]	13 447[1]
The Baltic + North Sea	560[2]	260[2]	10[2]	27 000[2]
	1 000[3]	680[3]		
	1 035[1]	740[1]	87[1]	44 325[1]
Europe's Immediate Area	3 200[4]	2 300[4]		
	3 990[3]	2 830[3]		
	3 719[1]	2 615[1]	316[1]	157 000[1]

Footnote: [1] CAFE IASA et al. Oct 06 regarding year 2000; [2] Mariterm regarding year 2000; [3] EMEP regarding year 2000: [4] Entec (2005b) regarding year 2000.

The differences in the sulphur emissions between the calculations carried out by Mariterm and, among others, IASA are due to different assumptions regarding the sulphur content in the fuel used in The Baltic. Mariterm has assumed a sulphur content of 1 percent, but IASA has assumed over 2 percent. Since year 2000 shipping has increased and, at the same time, the specific sulphur emissions have generally fallen through the Baltic and the North Sea (including the English Channel) now constituting sulphur control areas (SECA) where the highest permitted sulphur content in bunkers is now 1.5 percent.

Upon analyses of sulphur and nitrogen oxide emissions' future development, a clear picture emerges. The emissions on the land-side diminish as a result of measures taken, while emissions at sea increase. The measures that have been taken do not compensate the increased emissions as a result of increased traffic. In the figures below the calculated Swedish emissions of sulphur dioxide and nitrogen oxide from 1990 to 2005 are shown. The account is made in respect of all Sweden's emissions, the transport sector's emissions and Swedish domestic shipping emissions. Reported in addition is Sweden's international shipping, defined as vessels that take onboard bunker in Sweden and proceed to foreign ports.

Figure 1. Swedish emissions of sulphur dioxide 1990 to 2005. Source: The Swedish Environmental Protection Agency.

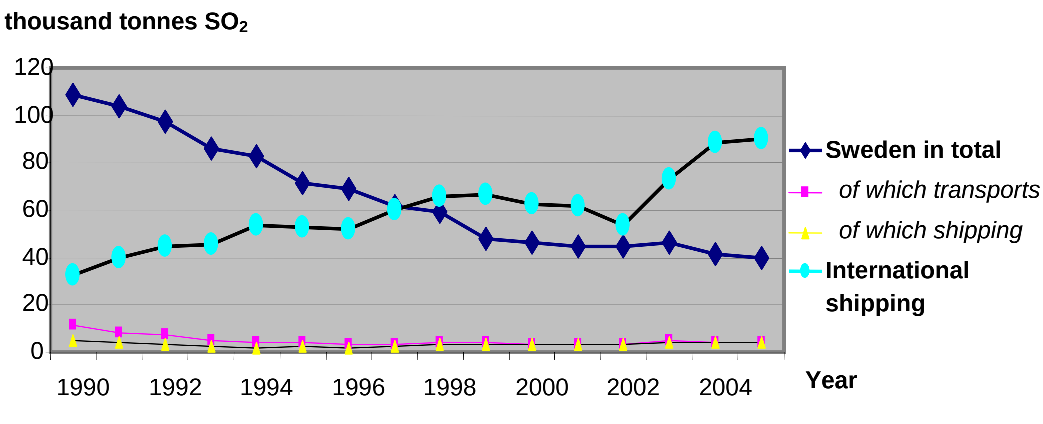
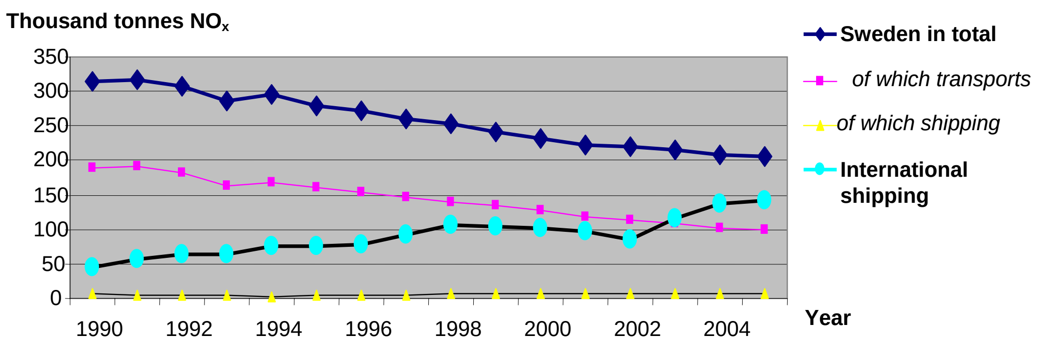


Figure 2. Swedish emissions of nitrogen oxides from 1990 to 2005. Source: The Swedish Environmental Protection Agency.



In the European debate on shipping and air pollution a study by IASA with what is termed the RAINS model has often been cited in recent time. It shows that shipping's emissions in Europe's adjacent areas are approaching the scope of the overall land-based emissions by the year 2015 for sulphur dioxide and 2020 for nitrogen oxides. This is in spite of requirements via IMO and the EU of limited sulphur content in marine fuels as well as the requirements of nitrogen emission limitations for new vessels that have been introduced.[13] An analysis of the global emission picture has recently drawn the conclusion that shipping's overall emissions of sulphur dioxide is now greater than the total emission from all the road vehicles in the world.[14]

As a basis for an analysis of trading systems that cover both shipping and land-based emissions, there is cause to describe how the emissions on the land-side break down. The circumstances differ sharply between sulphur and nitrogen oxides. As is seen from table 2 below, road traffic is the dominant emission source regarding nitrogen oxides, while the production of energy is also responsible for considerable emissions. Emissions from industrial processes and electricity and heating production, respectively, are also significant in this context. Where sulphur is concerned, industrial processes, energy production within industry and electricity and heating production account for the greatest emission on the land-side.

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[13] www.iiasa.ac.at.
[14] ICCT 2007.

Table 2. Emissions of sulphur and nitrogen oxides in Europe 2004. Source: The European Environmental Agency (EEA), *Annual European Community LRTAP Convention Emission Inventory.*

	SO_X kton/yr (%)	**NO_X kton/yr (%)**
Public electricity and heating production	2 602 (53)	1 483 (16)
Housing	201	419
Manufacturing and construction industry	848	1 404
Chemical industry	78	
Refineries	458	158
Solid fuels and other energy industry	56	119
Oil and natural gas	175	
Agriculture, forestry and fishing		706
Road traffic	67	3 860
Domestic shipping	65 (3)	329 (4)
Commercial/Institutions	89	188
Direct soil emissions		170
Other non-specified	212	453
EU 15 total	**4 951 (100)**	**9 289 (100)**
EU 25 total	7 010	10 918

3. Objectives and means

3.1 Introduction

This chapter aims to describe regulations that have an impact on emissions into the atmosphere and the possibilities of regulating such emissions. The chapter deals with the possibilities of imposing requirements on installations and vessels. The account is limited to what is primarily relevant to emissions of sulphur and nitrogen oxides. The effect of the various regulations on the specific possibilities that are analysed in this report is discussed in chapters 5 and 6.

3.2 Land-side legislation

Each country exercises jurisdiction over the installations and other sources of pollution that are located within the national territory. Certain requirements relating to such installations can, however, follow from international obligations, e.g. in conventions or through the EU's legal instruments. Regulating emissions has a long tradition.

International law

Emissions of harmful matter with a global or regional effect have come to be regulated by various international conventions. One such example is the Convention on Long-Range Transboundary Air Pollution (LRTAP) that came into effect in 1983. This is a regional convention for Europe together with USA and Canada aimed at reducing emissions of air pollutants. The convention has been drawn up within the UN's Economic Commission for Europe (UNECE).

A number of protocols relate to the convention that specify objectives and measures aimed at reducing emissions of different types of air pollutants, including emission or transboundary flows of sulphur and nitrogen oxides. The protocol regarding acidification, eutrophication and ground level ozone (known as the Gothenburg protocol) contains national emission ceilings that shall be achieved by 2010 for, e.g., sulphur dioxide and nitrogen oxides. Within the framework of UNECE and the Convention on Long-Range Transboundary Air Pollution, there is currently an extensive international work aimed at assessment, control and evaluation of the European air protection work.

EEC law

Within the framework of the EU the Sixth Environment Action Programme of the European Community has, for example, adopted a thematic strategy for air pollution.[15] The strategy, which is one of seven thematic strategies, is based on research carried out under the programme Clean Air For Europe (CAFE) and aims to achieve an air quality that does not lead to significantly negative consequences and risks to people's health or the environment.

The strategy sets up long-term objectives for air pollution and indicates proposals for how these are to be achieved no later than year 2020. For example, it states that the emission of sulphur dioxide needs to be reduced by 82 percent and that of nitrogen oxides by 60 percent compared to year 2000. As a part of this strategy amendments and simplifications of legislation in the air pollution area are proposed. Where shipping is concerned the strategy aims primarily at further negotiations within IMO and the introduction of the possibility for vessels in port to have access to shore-based power supply.

The EU acceded to The Convention on Long-Range Transboundary Air Pollution and, partly with the aim of fulfilling the obligations that follow from the convention, has adopted a number of legal instruments for the prevention of air pollution. The national emission ceilings directive[16], imposes an emissions ceiling for the respective member states' emission of certain pollutants (e.g. SO_2 and NO_x) by 2010. The emission ceilings in the stated directive are the same or stricter than those shown in the Gothenburg protocol that was drawn up within the framework of The Convention on Long-Range Transboundary Air Pollution. The ceiling directive leaves it up to the member states to elaborate how they ensure that the maximum emission levels are not exceeded. The obligations that follow from the national emissions ceilings directive exclude, however, emissions caused by international shipping.

[15] COM(2005) 446.
[16] Directive 2001/81/EEC.

The EU's so-called Air Quality Framework Directive[17] includes four sub-directives that regulate the limit values and target values for different pollutants in the atmosphere. The rules primarily aim to protect people's health and state the maximum concentrations of different pollutants that the member states are required to achieve by stated points in time. Each country ensures how the limit values are to be managed but there are requirements for a programme of measures to be produced in some form in order to apportion the efforts as required.

The limit values for particles (PM 10) and nitrogen dioxide are exceeded or are expected to be exceeded in many built-up areas and conurbations in Europe. This gives rise to different efforts at the local, regional and international level, aimed at reducing emissions from traffic in the first instance, but also from industrial plants and the heating sector.

With regard to shipping's emissions they contribute, in the first instance, to an increase of the background counts, but in certain seaports shipping can also make a discernable local contribution. The framework directive and its subsidiary directives are under revision with, for example, a regulation of PM 2.5 over and above the present PM 10, being planned for particles.

A number of the community's legal instruments aim at a general limitation of different types of emission from certain types of activity and thereby also have an effect on the emission of sulphur and nitrogen oxides. Examples of such legal instruments are the directive for the limitation of emissions of certain pollutants into the air from large combustion plants[18] and the so-called Waste Incineration Directive[19]. Both directives establish e.g. limit values for the emission of sulphur and nitrogen oxides.

By and large all large plants that are covered by the two directives above are also covered by the directive concerning integrated pollution prevention and control[20]. The directive imposes requirements for all plants covered by the directive's annexe I must have a license from an appropriate authority in the respective member state to conduct the activity in question (including all major industrial combustion plants).

[17] Dir. 96/62/EEC.
[18] Dir. 01/80/EEC.
[19] Dir. 00/76/EEC.
[20] The IPPC directive, dir. 96/61/EEC.

According to the directive the license must be based on e.g. the employment of the Best Available Techniques (BAT). What is intended by best available techniques is defined in the directive but is decided upon ultimately by the relevant authority in each individual case, e.g. with regard to what can be regarded as reasonable in terms of cost. To assist in deciding what is to be regarded as best available techniques there are, for example, so-called BREF documents (BAT Reference documents) for different sectors. Proposals for these documents are produced by separate workgroups with participants from industry and the member states. The Commission decides upon publication. The Directive for the Co-ordination of measures for prevention and limitation of pollution is currently the subject of a review.

3.3 Rules governing emissions from vessels

The possibilities for States to exercise jurisdiction over vessels as mobile pollution sources are to follow certain rules. Provisions relating to this are primarily to be found in the UN's Convention on the Law of the Sea (UNCLOS). This convention differentiates between different forms of jurisdiction that tend to be designated flag state, coastal state and port state jurisdiction.

Flag state, coastal state and port state jurisdiction is further broken down in UNCLOS depending upon whether it relates to the states' legislative or exclusive jurisdiction. The legislative jurisdiction indicates the scope to which states may adopt revisions and rules and the exclusive jurisdiction regulates the extent to which states can take measures in order to ensure that the provisions are observed.

Flag state jurisdiction

The primary jurisdiction over vessels is exercised by their flag state, i.e. the state in which the vessel is registered and whose flag the vessel is entitled to sail under. The flag state thus has the primary responsibility for controlling the vessel's construction, equipment and manning as well as which requirements relating to environmental protection that are to be met. The flag state's jurisdiction applies irrespective of where the vessel is located but is exclusive when its vessels is sailing in the flag state's own waters. The same applies, with some exceptions in UNCLOS[21], when vessels are sailing in international waters (open sea).

A state may, however, also exercise certain jurisdiction over other flag states' vessels when these are present in it's territorial waters. This tends to be designated coastal state or port state jurisdiction respectively.

Coastal state jurisdiction

A state has the right to exercise jurisdiction over vessels that are to be found in its territorial waters (12 nautical miles from the coast or the so-called baseline). In the environmental sector this so-called coastal state jurisdiction is, however, limited to the right to establish special protection areas, to regulate and control fairways and to undertake measures for the prevention, limitation and control of pollution. This jurisdiction is limited in such a way that it is not able to restrict the internationally adopted principles of the right to so-called innocent passage or the free passage of international straits. For vessels who claim the right to innocent passage the coastal state can only assume rules regarding construction, design, equipment or manning if these constitute an expression of an internationally accepted standard i.e. in principle the rules that are laid down in various international conventions[22]. A certain jurisdiction can also be exercised over zones outside territorial waters.

Port state jurisdiction

A state exercise jurisdiction over the vessels that call at its ports and inland waters. The port state can impose requirements on such vessels in order for them to be at all able to call at the ports or enter inland waters. The above stated exceptions in UNCLOS[23] thus do not apply to states when they exercise jurisdiction in their capacity as port state. Requirements may not be discriminatory however. If such requirements are aimed at preventing, limiting or controlling pollution of the *marine* environment, the port state must notify IMO of the requirements.

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[21] UNLCOS, compare Art. 218.
[22] UNCLOS, Art. 21.
[23] UNLCOS, Art. 21.

International rules

The international character of shipping is also to be largely acknowledged with regard to the actual regulation of this sector. A majority of international agreements have been concluded with the aim of finding joint solutions and standards for shipping. The implementation of these is primarily down to the flag state but port state control has become an increasingly more important means of dealing with deficiencies in relation to the requirements imposed by the convention. In the environmental sector the most extensive set of rules is the 1973 International Convention for the Prevention of Pollution from Ships with associated protocol from 1978[24].

The Convention for the Prevention of Pollution from Ships imposes two requirements on member states in their capacity as flag states, partly to ensure that their vessels meet the requirements shown in the various annexes to the convention and partly to issue certificates for the respective vessels. These certificates are deemed to constitute evidence that the vessel meets the technical requirements in the convention. For the port states who are signed up to the convention this means that they shall, on the one hand, inspect a certain number of the vessels who call at their ports but, on the other hand, that they thereby have to accept certificates issued by the flag state. Only if there are clear grounds to suspect that the vessel deviates from the certificate or if a valid certificate is lacking, can the port state detain it in the port.[25] There is also a special arbitration procedure set up for conflicts regarding the application of the convention.[26]

With a view to, e.g. prevent vessels calling at ports with deficient port state control and to ensure uniform and high quality control, a separate agreement has been concluded between 17 Western European countries and Canada regarding co-operation concerning the port state control, the so-called Paris Memorandum of Understanding on Port State Control (Paris MoU). Corresponding regional agreements have also been concluded elsewhere in the world based on the Paris MoU. These agreements are limited to requirements that are imposed in international conventions but do not differentiate with regard to whether the vessels that are inspected ratified the convention in question or not. What is crucial is

[24] MARPOL.
[25] Art. 5.

that the same requirements, according to the non-discrimination principle, are imposed on all vessels that are inspected.

Annexe VI to the Convention on Prevention of Pollution from Ships, which came into force on 19th May 2005, regulates emissions into the air. Annexe VI imposes requirements of limitations on emission of sulphur and nitrogen oxides from vessels and prohibits intentional emission of ozone-depleting substances. The sulphur content of fuel oil is limited globally to 4.5 percent by mass but this requirement can be made stricter in special sulphur control areas (so-called SECA). The Baltic (up to a line between the Skaw and Gothenburg) as well as the North Sea and the English Channel (the latter from and including 11th August 2007) constitute such areas and there the corresponding limits for sulphur content are 1.5 percent by mass. As an alternative to the use of certain fuel oil, vessels can be equipped with special exhaust gas cleaning technology in order to reduce emissions in this way. A review of the rules in Annexe VI is currently being undertaken and a final report is expected in 2007. Alongside this, for example, also work in limiting the emission of carbon dioxide from shipping is being undertaken.

EEC law

The EU has drawn up legal instruments both for the regulation of port state control within Community ports as well as limiting emissions from shipping into e.g. the air. The Directive on Port State Control[27] imposes requirements on the member states to have proper and competent authorities for carrying out the port state control as well as an obligation to undertake checks. With certain exceptions the directive covers each vessel that calls a port of a member state or are at anchor outside such a port and is limited to the requirements that are shown in a number of international conventions, e.g. the convention for the prevention of pollution from ships.

The EU’s directive for reducing the sulphur content in certain liquid fuels, the so-called sulphur directive[28], also covers marine fuels. In the directive requirements are imposed on the member states to take actions to ensure that diesel fuel oil is not employed within their territory from and including 1st July 2000 if the sulphur content exceeds 0.20 percent by mass and from

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[26] Art. 10.
[27] Dir. 1995/21EEC.

and including 1st January 2008 if the sulphur content exceeds 0.10 percent by mass.[29] Marine fuel that is used within the sulphur control areas (also including economic zones) may not contain a higher sulphur content that 1.5 percent by mass.[30]

The directive relates to the rules in the convention for the prevention of pollution from ships and also includes such areas that may be classified as sulphur control areas through future amendments to the convention. The member states are responsible for control of the application of the provision for vessels reside within the state's jurisdiction area.

The provision regarding maximum 1.5 percent by mass of sulphur in the fuel also includes passenger vessels in regular traffic to or from a community port.[31] The requirement of using certain fuel applies within a state's sea territory, the exclusive economic zone and supervision zones for pollution and is controlled by the jurisdiction principles that are laid down in the international maritime law convention (UNCLOS). In this respect too it is incumbent upon the member states to be responsible for checking observance by their own vessels and for vessels under other flags when these are at port stay in the member states.

In the preamble to both directives reference is made to the subsidiarity principle and the proportionality principle. In this respect the importance is stressed of these measures being taken at community level. In the preamble to the sulphur directive's amendment directive it is even stated expressly that the objective of reducing emission of sulphur dioxide from certain types of liquid fuel cannot be achieved in an effective manner if certain member states act independently. On the other hand it is stated that the directive is limited to the *minimum requirements* that are necessary in order to achieve environmental objectives and the directive shall not prevent any member state from introducing stricter protective measures. The directive thus does not prohibit member states from introducing stricter requirements but these must, in such an event, be compatible with the agreement and must also be reported to the Commission. [32]

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[28] Dir. 1999/32/EEC, amended through Dir. 2005/33/EEC.
[29] Art. 4.
[30] Art. 4a.
[31] Art. 4a.
[32] Dir. 1999/32/EEC.

Through the so-called machine directive[33] requirements regarding nitrogen oxide emission for new vessels on inland waterways will be introduced during 2007 after which further restrictions will apply to these vessels.

Sweden's environmentally differentiated fairway dues

The Swedish Maritime Administration administers the Swedish system for fairway dues, which are regulated by the Swedish Maritime Administration's statute book.[34] The fairway due comprises two parts one being charged according to the vessel's size, measured as gross tonnage and the other according to loaded and discharged goods (for domestic traffic only for loaded goods). A certain part of the fairway due, the so-called sulphur supplement, is based on the sulphur content of the fuel. Special regulations have been introduced regarding conditions for so-called environmentally differentiated fairway dues.[35] For passenger vessels and other vessels, respectively that only use bunker oil with a sulphur content that does not exceed 0.5 and 1.0 percent by mass respectively, the fairway due is lower than for other vessels. For vessels whose bunker oil has a sulphur content less than 0.2 weight percent sulphur, no sulphur supplement is charged. Vessels that have installed equipment to reduce the emission of nitrogen oxides receive a discount on the gross tonnage-based fairway due in relation to the achieved emission level.

[33] Dir. 2004/26/EEC.
[34] SJÖFS 2004:26.
[35] SJÖFS 1998:13, amended through SJÖFS 2004:27.

4 Measures for reducing emissions

The analysis of possible effects of a system for trading with emission rights presupposes an understanding of which adjustment possibilities or measures may be relevant, and also which costs and which effects on actual emission with which these are deemed to be associated.

In purely principle terms, the possible measures for reducing emissions from transports are often categorised as follows:

- Altered traffic pattern, for example measured in ton km or in person km, or
- Altered specific emission, for example measured in gram per ton km or gram per person km.

With regard to the reduction of sulphur and nitrogen oxides from shipping, technical measures for reducing emission are of supreme importance. Technical measures can be taken at comparatively low costs and major improvements can be achieved without harm to the benefit of the traffic. The model that is built up to describe the costs of measures and adjustment possibilities is therefore wholly focused on technical measures in this report.

Changes of traffic patterns are, in this context, more of theoretical interest, however. The most obvious change of traffic pattern that affects the emissions is, of course, that certain traffic ceases. Other possible changes that are covered by this point are that certain trips with smaller vessels are replaced by larger vessels that are better able to exploit shipping’s energy and environmental economy of scale as well as being better able to optimise logistics with increased load factors in available vessels. It can also be a question of a port being omitted in a line in order to save distance.

The fact that possibilities for emission reduction through altered traffic patterns are referred to without further analysis does not preclude certain such adjustments if a trading system is introduced. The assessment is rather that such adjustments will be marginal and will lack importance in this context.

4.1 Technical measures for reducing emissions from shipping

Selective catalytic reduction, direct water injection and the HAM technique represent the technical possibilities of reducing the vessel's nitrogen oxide emissions that are today regarded as having the greatest potential. Sulphur emissions are lowered today exclusively through the use of low-sulphur oil, flue gas cleaning technology, so-called scrubbers, is under development.

Selective catalytic reduction

Selective catalytic reduction (SCR) means that an urea/water solution is injected into the hot exhaust stream for pyrolysis to ammonia over a catalyst where the ammonia reacts with the nitrogen oxides and reduces them to nitrogen gas. The supply of urea is regulated by the power outlet. The consumption is 5 to 8 percent by mass of the fuel consumption. The maintenance requirement depends on the type of fuel. If marine gas oil is used the maintenance requirement is minimal. With a supplementary oxidisation catalyst the emission of liquid organic hydrocarbons, carbon monoxide and particles can also be reduced. Noise is also efficiently reduced in the catalyst.

Selective catalytic reduction is the most usual marine application for reducing nitrogen oxide emission. There are over 300 installations in vessels worldwide. The technology, correctly installed and optimised, is very reliable.

Direct water injection

Direct water injection, DWI, means that fresh water is injected under high pressure to become water vapour in the combustion chamber separately or mixed with the fuel as a water emulsion. The water vapour reduces the combustion temperature leading to a reduced formation of nitrogen oxides. The consumption of salt-free fresh water amounts to an order of magnitude of 40 to 70 percent of the fuel consumption, which can be solved via large fresh water tanks and the bunkering of fresh water. One alternative is to desalinate sea water through reverse osmosis or by means of evaporators. Direct water injection involves somewhat increased fuel consumption (usually up to 2 %) depending on how far one wishes to push the reduction of nitrogen oxides. The water obtains its steam-forming heat from the combustion whereby the engine's fuel efficiency is somewhat reduced.

The technology has been available on the market since 1998. There are currently installations on some ten vessels.

HAM

The HAM technology is to some degree related to direct water injection (DWI). HAM means, however, that sea water is vaporised by means of waste heat from the engine’s cooling system and turbo-chargers and is mixed in as vapour prior to the combustion chamber in order to lower the combustion temperature and reduce the nitrogen formation. The process also works with high salt contents in sea water through lowering the surface tension in the process water chemically in order to prevent the build up of salt. The technique also reduces the consumption of lubricants and the lowered temperature also involves a markedly lowered thermal loading on exposed parts of the engine reducing the maintenance requirement and extending maintenance intervals.

HAM has been installed on two vessels, a Swedish coastguard vessel and on Viking Line’s ferry Mariella. In the latter the technology has been operational since 1997 and the experiences have been very good.

Theoretically there is reason to presume that the HAM technology also involves fuel consumption increasing somewhat through the already vaporised waters enthalpy level increasing in the combustion chamber. This is compensated through energy recovery in the exhaust turbine through the increased mass flow through the engine. Viking Line has noticed that the vessel with the HAM installed is more energy-efficient than corresponding vessels that do not have this equipment. The technology can be developed further so that the waste heat and the increased mass flow through the engine are exploited in the outgoing exhausts at another stage. This can be done via a high-speed turbine generator in order to reduce the total fuel consumption through raising the total efficiency for the installation and thereby reduce the emissions still further.

This is a matter that has been increasingly focused on recently with regard to carbon dioxide emissions and the climate change issue. The HAM technology is well-suited to ocean-going vessels as well, since the reduction means does not involve further costs when the installation once has been done.

Sulphur reduction

To date the use of oil with lower sulphur content has been the completely dominant method for lowering emissions of sulphur dioxide from shipping. Recently, however, technology that has long been used at stationary combustion plants and for the production of inert gas in tankers, so-called scrubbers, has been launched as a possibility whereby shipping can reduce the emission of sulphur oxides. The waste water from such scrubbers requires treatment in areas with low saline or alkaline water through-put, however, in order not to constitute a new environmental problem.

4.2 Model for calculation of the cost of measures and emission effects

As an aid to analysing different control means' potential for reducing shipping emission of nitrogen oxides the Swedish Maritime Administration has developed a model in connection with this assignment. It describes the costs associated with different techniques and can, for example, be used for estimating demand and supply for emission credits in respect of different systems of emission trading within shipping. The model is, in principle, also applicable to corresponding analysis of sulphur dioxide, but no such application has been made within the framework of the project.

Vessels and their use

Ten vessel types that have different technical and economic characteristics as well as different traffic patterns represent the overall shipping in the model. Vessel types are described in terms of size (GT)[36], average lifespan and engine output. This data is reproduced in table 3.

[36] GT is a measure of vessel size that is calculated in accordance with an international convention and has its historical background in gross tonnage that was a measure of the vessel's enclosed volume.

Table 3. The model's vessel types and certain technical characteristics.

		Engine power, kW		Estimated lifespan,
	GT	Main engine, kW	Auxiliary engine % of main engine	Years
Bulk	20000	8000	25	20
Dry cargo	5000	4000	25	20
Container, over seas	70000	45000	25	20
Container, feeder	5000	10000	25	25
Ro-ro	20000	13000	25	25
Reefer	10000	9000	25	20
Ferry	30000	25000	20	25
Supertanker, overseas	150000	23000	25	20
North Sea tanker	80000	15000	25	20
Coastal tanker	10000	5000	25	30
Chemical tanker	10000	5000	25	20

The model differentiates between newbuildings, older vessels approaching scrapping and other existing vessels. The distinction is important since the costs may vary considerably, depending upon which phase of its life-cycle the vessel holds. The investment costs are lower for newbuildings than for existing vessels and shipowners are generally more hesitant about investments in older vessels. The model reflects the latter by applying direct depreciation for investments in vessels that have an anticipated remaining lifespan of five years or less. For newbuildings and other newer existing vessels, the model allows for depreciation periods to vary. When the model is used to describe shipowners' inclination towards investing in cleansing technology a depreciation period of five years is employed while a socio-economic perspective would require a longer depreciation period to be employed.

The distinction between the three age classes relates to the year a means of control is introduced. This means that the model assumes that when a means of control is fully established it will be taken into consideration in respect of all relevant decisions that relate to how a fleet is to be developed. A consequence of this is that when the model is applied to a system that is introduced at that time but the effect calculation is made for a year in a distant future, all vessels will be defined as newbuildings in the model.

The vessel type’s use is defined in the model in terms of the number of hours per year that the main engines and auxiliary engines, respectively, are utilised, as well as the engines’ average load during operation, both at sea and in port.

Where ferries are concerned the operating time for the main engine is deemed to be 4 380 hours per year while, for other vessel types, it is deemed to be 6 100 hours. For all vessel types the average load on the main engine is stated as being 75 percent output while in port, it is zero. The auxiliary engines are regarded, in principle, as being operational at all times, all year (8 760 hours) and the output is exploited during operation at an average of 50 percent in ferries and 8 percent in other vessels. In port a tanker’s auxiliary engines output is used 80 percent while ferries’ auxiliary engines output is employed at 65 percent and other vessel types’ auxiliary engines at 40 percent.

The model can be utilised for different geographical demarcation areas. In this assignment the demarcation area has been consistently defined as the North Sea together with the English Channel and the Baltic Sea Area. How much of the time the vessel types are used within the demarcation area according to the calculations, is shown in table 4.

Table 4. Vessel types’ employment within the demarcation area (North Sea + Baltic) in the model calculations.

	Time within demarcation area, percent
Bulk	80
Dry cargo	80
Container, over seas	5
Container, feeder	90
Ro-ro	80
Reefer	30
Ferry	100
Supertanker, overseas	5
North Sea tanker	100
Coastal tanker	95
Chemical tanker	70

Nitrogen oxide reduction

With regard to the reduction of nitrogen oxide the model considers three different reduction technologies, direct water injection (DWI), HAM (humid air motors) and selective catalytic reduction (SCR). Technical improvements such as new fuel valves of slide type are assumed to normally be employed spontaneously, without being directly dependent upon economic incentives.

The costs that these reduction technologies are associated with have been taken from the so-called Entec report.[37] The Swedish Maritime Administration's experiences from installations on its own vessels, as well as from following up of installations on board vessels included and certified in the Swedish system of environmentally differentiated fairway dues, is that the Entec report underestimates the reduction potential of the technologies.[38] It should also be pointed out that the costs in the Entec report are mostly based on yesterday's technology, while a wider introduction should, with the greatest certainty, lead a falling price level. This would be the result of economies of scale in production as well as increased development efforts and increased competition on the market. For example it is worth mentioning the possibility of developing the HAM technique by, at a later stage, exploiting the recovered waste energy from the engine back in the process. The potential enhancement of energy efficiency, with turbo-electric compound technology is of the order of magnitude of 10 to 15 percent under optimum conditions, without increased emissions. Such a development would impose a radical impact on the cost position.

In annexe 1 the achieved nitrogen oxide reductions are shown for vessels that have a nitrogen oxide certificate in the Swedish fairway dues system.

The reduction levels that are employed in the model with regard to nitrogen oxide are identical, irrespective of the vessel type and whether they are installations in newbuildings or are retrofits. The reduction levels are shown in table 5.

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[37] Entec, 2005.
[38] The Swedish Maritime Administration considers that the typical reduction effect is, instead, the following: DWI 30 – 50 percent, HAM 70 – 85 percent and SCR 90 – 99 percent, which can be compared with Entec's estimate according to table 5.

Table 5. Typical degree of reduction for different techniques according to Entec, 2005.

Reduction technology for nitrogen oxides	Reduction, percent
Direct injection (DWI)	50
HAM (Humid Air Motors)	70
Selective catalytic reduction (SCR)	90

The model calculates the costs of the measures in terms of € per kg for all vessel types and, where relevant, for three age classes. At the same time the corresponding emission reduction is calculated.

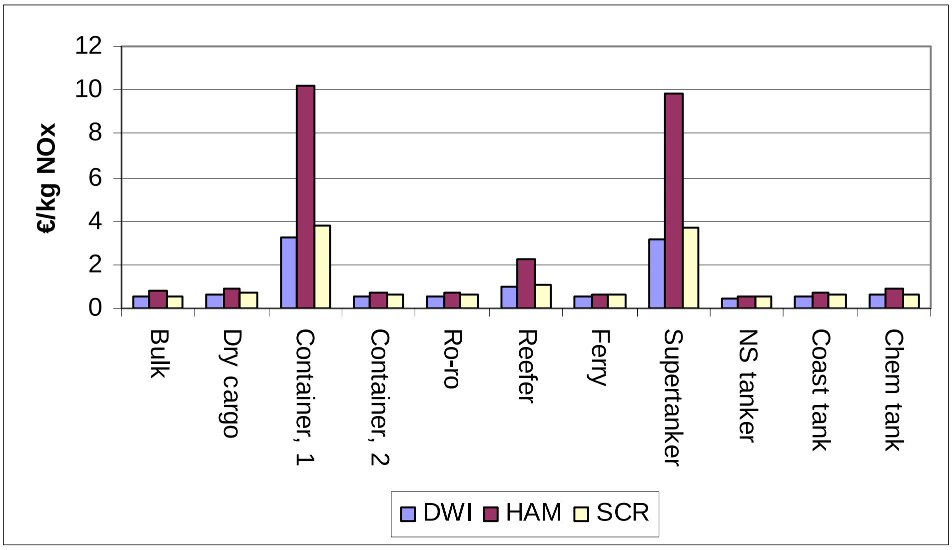
Which technology who provides the greatest reduction per invested € depends upon the vessel's characteristics, its age, engine type and its use.

Costs of applied measures

The cost calculations include investments in, and operation of, relevant reduction technology. On the other hand the costs associated with administration of the system are not included.

The three technologies can according to the model, be considered comparable in terms of cost, calculated in € per reduced kg of nitrogen oxides. The calculation result for new vessels is shown in figure 3. Under these circumstances direct water injection (DWI) is consistently somewhat less costly than catalytic reduction (SCR), while the costs for the HAM technology are somewhat higher, due to the higher installation costs. The costs of measures for direct water injection vary from just over 0.4 € per kg to just over 3 € per kg nitrogen oxides reduction. The former value represents a North Sea tanker that spends all its time within the demarcation area, while the latter represents a large ocean-going containership that only spends 5 percent of its time within the demarcation area. Vessels that only spend a little time in the area (”Container, 1” and ”Supertanker”) can only make use of emission rights for a short time while the costs affect the vessel in full (the NO_x-reducing equipment is assumed to be in continuous operation even when proceeding outside the demarcation area). Cost differences are thus affected to a greater extent by traffic patterns than by technical differences between different types of vessel.

Figure 3. Costs of measures for new vessels, calculated as € per kg nitrogen oxide reduction within the demarcation area.



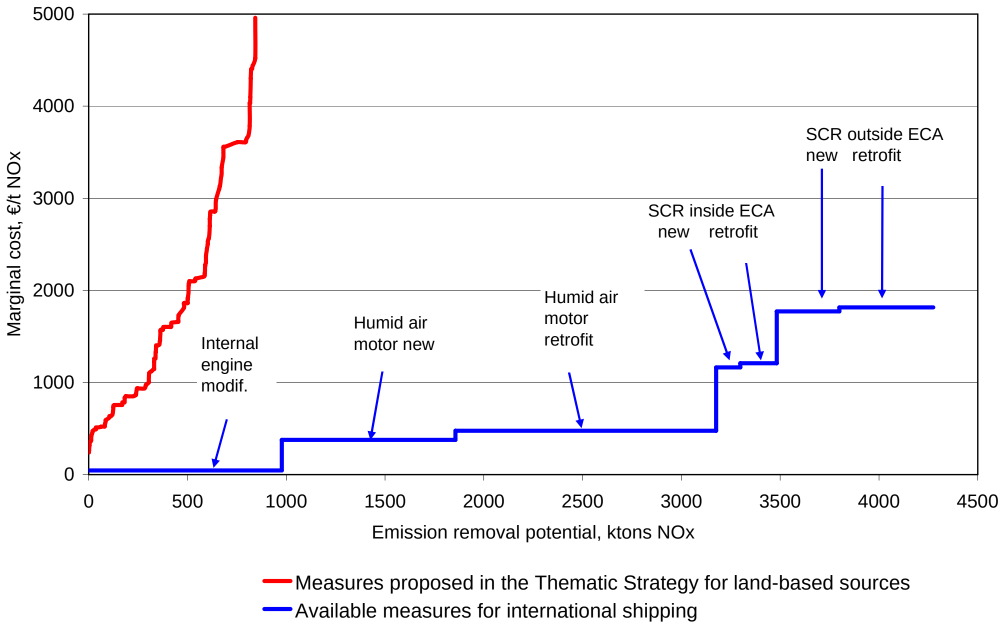
For the existing vessels in the fleet the circumstances are slightly different however. When retrofit are considered catalytic reduction is the most economic measure in most cases, followed by HAM technology while direct water injection is somewhat more costly. The costs of catalytic reduction vary from 0.75 to c. 30 € per kg according to the calculations.

If a longer depreciation time is applied both SCR and HAM become increasingly more competitive compared with direct water injection.

4.3 Cost of measures on land-side

Within the framework of this study no calculations have been made of costs of measures on land-based emission sources. Such analyses have been made in other context however. In a relevant IIASA study the calculated costs of measures for shipping have been compared with earlier estimates of costs of measures on land, see figure 4. The information concerning costs of measures reported for shipping can be compared with the calculations made within the framework of this present work, which are reproduced in a similar manner in figure 8 in the following chapter.

Figure 4. Technical reduction potential for nitrogen oxide emissions in EU25 and marginal costs of measures for land-based sources in year 2020 according to the EU's thematic strategy for land-based sources as well as for international shipping according to an IIASA study. Source: Cofala et al., 2006.



The IIASA study thus indicates that the cost of measures differ extensively between the two sectors. The study reports corresponding information for sulphur dioxide as well. There, too, the pattern is the same. The costs of measures differ sharply between both the sub-sectors.

4.4 Conclusions

The principal conclusion of the model calculations is, in this respect, that there are three competitive technologies. The costs leves for measures illustrated by the model calculations can be regarded as reliable. On the other hand the outcome between the different technologies is not considered to be entirely robust. Minor changes of cost assessments and effects can change the relative cost-efficiency of the technology applied.

Compilations from the cited IIASA study indicate that the costs of measures regarding nitrogen oxide emissions, like those of sulphur dioxide emissions, differ sharply between sea and land. Differences in the costs of measures between different sources are a prerequisite for emissions trading to be a means of control with potential.

5. System for emissions trading – sea-side

This chapter describes how the trading system with emission rights for nitrogen and sulphur oxides can be formulated where the shipping sector is included. In the second part of the chapter the effects of both systems are analysed.

5.1 System for trading with emissions rights

The government commission specifies that an open, sector-wide trading system that covers emissions from both the shipping sector and from land-based plants within the industry and energy sectors, shall be compared with a closed trading system that only covers the shipping sector. The present chapter describes how the systems that are analysed are formulated in detail.

The open trading system is presumed to be a voluntary participation for shipping. Vessels with good emissions performances generate credits that can be saved and sold to the land-side where demand is created through the regulations governing large plants within the industry and energy sectors being altered or, alternatively, through states purchasing credits for the land-side or nations account. The credits reflect actual reductions below the reference level[39] within a geographical demarcation area. The alternative is based on the proposal put forward by the Swedish Shipowners' Association.[40] In this present chapter we deal with the system's sea-side while the land-side is dealt with in chapter 6.

The closed trading system that is analysed is presumed to be obligatory for shipping and means that vessels with emissions performance below a certain level generate emissions credits that can be saved, used for other vessels with poorer environmental performance in the same fleet or sold to shipowners with vessels that have emissions above the defined level. A settlement takes place at each call to a port within the demarcation area when a calculation is made of the actual emission (in relation to the

[39] Reference level in the open system relates to the level under which credits start to be issued. In the closed system the reference level indicates the level above which vessels need to buy emissions rights, while vessels with emissions below the reference level generate emissions rights that can be sold.
[40] The Swedish Shipowners' Association, 2006.

reference level) since the preceding port call or since the vessel entered the demarcation area. The alternative is based on a proposal put forward by Nature Associates.[41]

Both the trading system alternatives that are discussed here can be applied to separate geographical demarcation areas. As previously reported analysis and discussion takes place here on the basis of the demarcation area comprising the North Sea with the English Channel and the Baltic Sea Area.

The ambition should be that any emissions trading system should be given an administrative form right from the start that enables the administration to be used for trading with other matters as well. The question of trading with emissions rights for carbon dioxide is very relevant today[42], but other matters may also become relevant as well. Shipping's emissions of primary and secondary particles are being given increasing attention.

One ambition should also be for a system to permit other countries or other regions to join in addition to those originally included. It does not necessarily have to be so that a region that joins up also trades with the original system. It could, for example, be another region that benefits from the administrative processes that are built up and for certification to be approved bilaterally. A vessel that is connected to a European system should, for example, without undergoing a separate examination, be able to generate emissions credits and to trade in an American trading system. Economies of scale for the administration can then be achieved and the overall adjustment costs can be lowered.

In both the systems that are analysed emissions from the main engine as well as from auxiliary engines should be covered, at least in the long-term. Both systems should, tentatively, include vessels over 300 GT.[43] Both alternatives are described in greater detail below.

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[41] Kågeson, 2006.
[42] In the middle of April the EU commission announced that it intends to work towards shipping being included in the existing European trading system for carbon dioxide. Source: ENDS Europe Daily 18 04 2007.
[43] 300 GT is the same limit that applies for vessels to be obligatorily covered by the AIS system. The presence of AIS facilitates control.

5.2 The open system

The open trading system provides an opportunity for vessels with emissions below a certain level to acquire credits in relation to a reference level. It should correspond to the emissions required of new vessels according to the convention for the prevention of pollution from ships, Annexe VI. The formulation means that emissions credits are issued and traded separately for nitrogen oxide emissions and sulphur emissions. An alternative that the investigation rejected is that of a weighing of the emissions together in one and the same emissions right.

The limit imposed by the current regulations is regarded as being a suitable reference level since this level still has to be achieved and does not therefore deserve any reward, while reductions below this level cannot be expected to occur without stronger incentives and each further reduction has the same environmental value in principle.[44] The requirement level regarding nitrogen oxides is described by the so-called IMO curve, according to which the specific emission (emission in relation to a certain shaft horsepower) that is allowed to vary with the engine's rpm. For engines with an rpm of up to 130 the limit value is 17.0 gram per kWh, while that for engines with an rpm over 2000 it is 9.8 gram per kWh. These parts of the IMO curve are brought together by a curve that describes a function that is reproduced in figure 5 below.

The design of the trading system thus means that a vessel with a low speed engine that installs catalytic reduction and reduces the emissions to 1 gram nitrogen oxides per kWh, generates credits corresponding to 16 gram nitrogen oxides per kWh, while credits for a high speed engine that reaches down to the same emissions level corresponds to c. 9 gram nitrogen oxides per kWh.[45]

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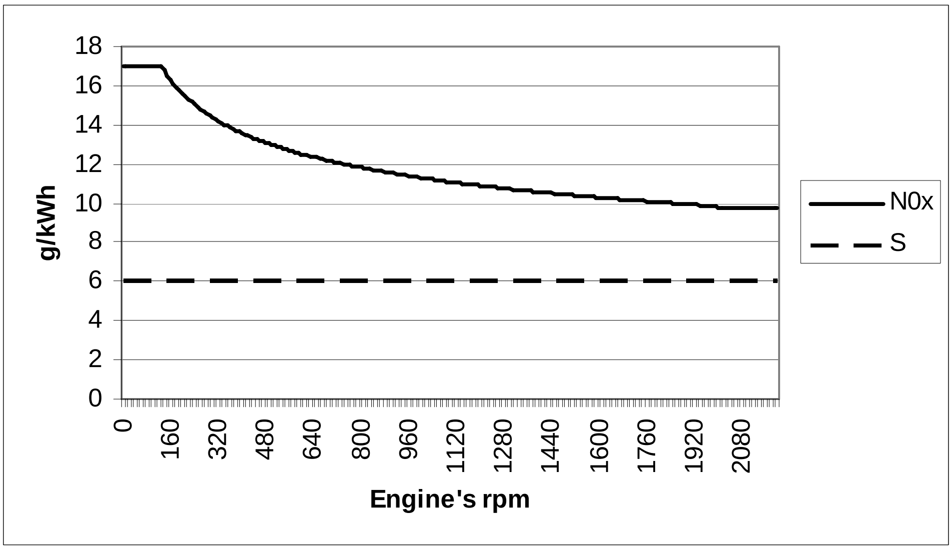
[44] Upon a final formulation of a possible system the reference curve should probably be places somewhat below the requirement level in order to reflect that bunker oil and engine performance, respectively, exceeds the requirement on average – in order to ”be on the safe side”.

[45] It may be regarded as being socio-economically doubtful for the reference level to vary in this way depending upon engines' properties. The report does not adopt a position regarding the matter but notes that the proposal builds further on an agreement that was made in international negotiations and notes that it is not more remarkable to use the IMO curve in this context than the fact that the IMO curve is used in MARPOL. The prerequisites for reaching acceptance for the system are deemed to be more favourable when the IMO curve is applied as a reference rather than if an alternative is sought.

Figure 5. Reference levels for nitrogen oxides (NO_x) and sulphur oxides (S, calculated as SO_2) in the open system. The reference level for nitrogen oxides is identical to the so-called IMO curve for engines installed from year 2000 and onwards.



The nitrogen oxide requirement laid down in the convention for the prevention of pollution from ships does not so far apply to vessels built before year 2000. It may therefore be felt that older vessels should be able to credit themselves with reductions from a higher reference level. Reductions above the reference level are, of course, environmentally just as valuable as reductions below that level. The report, however, makes the assessment that such rules would, on the one hand, complicate the system and, on the other hand, would give the system a design that could be put in question in terms of principle. Shipowners with older, less modern tonnage would potentially be given greater rewards from a measure compared to a shipowner who has invested in newer vessels with better environmental performance. Such an incentive could also counteract a desired renewal of the vessel fleet.

At the same time as there is a value in stable regulations there is the possibility to adjust the reference levels in both systems. It can, for example, be a part of the development to adjust the reference levels for nitrogen oxides in line with the regulations that will be brought forward within IMO regarding permitted emissions from vessels (the IMO curve).

In line with this argument and the system design it also follows that shipowners with vessels that have already invested in emission reduction may gain credits in the same way as those that make environmental investments after the system is introduced. It might possibly be argued that these shipowners do not take any further measures that should generate credits. The reality is however that these shipowners voluntarily assist with emissions reductions every day they keep their equipment for nitrogen oxides reduction in operation and should earn credits for this in the same way as others. It would appear incorrect to develop the incentive system in such a way that progressive players became disadvantaged. The review of the fairway dues that the Swedish Governmental Offices presented in 2003 and that led to the present charges system, made due note of this question.[46] The raising of the so-called charge cap[47] was limited under the proposal to a level that meant that the vessels that had undertaken nitrogen oxide reducing measures and had the lowest frequency at Swedish ports, would not have a reduced environmental incentive. A similar view should apply with regard to the views on the prerequisites for crediting emissions limiting measures already taken on land and at sea.

In a corresponding manner the reference level for sulphur emissions is determined according to the emissions that correspond to the permitted sulphur content in bunkers (without further reduction) in the sulphur control areas that the North Sea and the Baltic Sea constitute, i.e. a maximum sulphur content of 1.5 weight percent, equivalent to c. 6 g sulphur oxides (calculated as SO_2) per kilowatt hour.

The report suggests that consideration should be given to applying an ”exchange rate” upon possible trading with emissions credits generated within shipping for use on land. Such an exchange rate is intended to reflect differences in damage costs depending on where the emission and deposition is taking place. Calculating differences for emissions is complicated however. Table 6 shows the result of cost calculations for emissions of nitrogen oxides and sulphur for separate sea and land areas.[48]

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[46] Ds 2003:41.
[47] The fairway dues system contains a charges cap in the sense that the vessel-based charge is only imposed for a maximum number of calls during a certain time. The environmentally differentiated vessel-related charge came to be charged a maximum of 2 times per month in the new system as opposed to 12 times per year previously.
[48] AEA Technology Environment. March 2005. The calculations have been made within the framework of the European project, Clean Air for Europe (CAFE). They cover health effects of particles and ozone and then also of secondarily formed particles from e.g. SO_2 and NO_x as well as the ozone’s effects on crops. Other effects have been omitted in the calculations, e.g. acidification and eutrophication of watercourses and forests.

The interval depends upon different assessments upon the evaluation of mortality and the effects of ozone upon health. The cost calculations include certain known effects of air pollution e.g. certain health effects of particles and ozone and also of secondarily formed particles e.g. from nitrogen oxides and sulphur dioxide as well as detrimental effects on crops from ozone. Other effects that are significant when large regional consequences are discussed, have not been evaluated in economic terms and are therefore not covered by the calculations. It applies primarily to the acidification of lakes, watercourses and forests and the eutrophication of the land eco-system and certain sea areas in addition to corrosion.

Table 6. Calculated marginal costs for emissions of nitrogen oxides (NO_x) and sulphur dioxides (SO_2) in different sea areas and countries in € per kg.

Emissions in area:	**NO_x** (€/kg)	**SO_2** (€/kg)
Mediterranean	0.5-1.4	2.0-5.9
N E Atlantic	1.6-4.8	2.2-6.3
Baltic	2.6-7.2	3.7-11
North Sea	5.1-14	6.9-20
Sea means	**2.5-6.9**	**3.7-11**
Finland	0.8-2.0	1.8-5.1
Estonia	0.8-2.2	1.8-5.2
Latvia	1.4-3.7	2.0-5.7
Lithuania	1.8-5.0	2.4-6.8
Poland	3.9-10	0.5-1.6
Germany	9.6-26	1.1-3.2
Sweden	2.2-5.9	2.8-8.1
Denmark	4.4-12	5.2-15
Belgium	5.2-14	11-31
Netherlands	6.6-18	13-39
Great Britain	3.9-10	6.6-19
France	7.7-21	8.0-23
EU 25	**4.4-12**	**5.6-16**

It is intuitively quite natural to imagine that emissions at sea give rise to significantly lower damage costs than emissions on land. In general this is correct as well, but not for all areas. Emissions in the North Sea are estimated giving rise to higher damage costs than emissions that occur in several Baltic countries. Emissions in the North Sea give rise to relatively high levels of damage in the densely populated countries along its coasts, resulting in high evaluations. For emissions in the North Sea the damage costs are clearly lower than the damage costs for emissions in more densely populated countries such as Belgium, France, the Netherlands and Germany. It is not self-evident which damage and damage costs are to be included upon analysing how an exchange rate should be determined. The report's opinion is that damage costs should only be taken note of in those countries that are included in the system. This creates in itself an incentive for countries to participate in the system. It is seen to be important that the effects in the form of acidification and eutrophication also are included.

In addition to the discussion regarding the large variations in regional damage costs it is also relevant to discuss more local variations. In principle welfare theory arguments can militate in favour of variations in damage costs between emissions in the open sea and emissions in ports and coastal areas being assessed differently (for example through an exchange rate). Analysis carried out with regard to damage effects of emissions from vessels in port thus show that the local effects are generally small. The reason is that these emissions from large vessels' funnels normally stem at a great height and with strong thermal updraft and therefore affect content and deposit in the adjacent areas to a small degree. This picture is supported by a study that, by means of the so-called ExternE model, theoretically calculated the damage costs from a ferry that operated in three geographically separated Swedish fairways.[49]

A conclusion from this argument is that there is no direct interchangeability between emissions in a local environment where there are problems with high contents of a pollutant and emissions at sea. The interchangeability applies instead to emissions from vessel funnels and emissions from heavy industries' chimneys and the regional effects that these emissions generate. The interchangeability also has a geographic dimension. The damage costs can vary between different regions.

To summarise there is currently no basis for determining how the damage costs differ between emissions at sea and on land and between different regions. The question of interchangeability should be analysed further. A forthcoming IIASA report is expected to show new knowledge within the area and can therefore provide a more certain further basis.

[49] Electrowatt-Econo, 2002.

With an exchange rate it can, with greater certainty, be possible to maintain that the trading that is proposed is also *directly* good for the environment. An interlinkage may be made here to the precautionary principle. At the same time it is important to note that an exchange rate that overestimates real differences in damage costs is running the risk of undermining the system's efficiency. The report adopts no position regarding whether an exchange rate should be introduced in any emissions trading system or not.

According to the conclusions in the report consideration should be given to the possibility to save emissions credits. This creates a certain dynamics. Smaller players can collect credits in order to be able to sell larger lots, which simplify administration at the same time as shipowners can choose the moment to sell and thereby avoid selling at a time when they consider that the price level is temporarily low. One opinion is, however, that a limit should be introduced so as the nominal value of an emissions credit, in terms of kg emissions is deflated in due course. This means, in other words, that a non-utilised emissions credit will totally lose its nominal value in due course. Such an arrangement limits the undertaking that society gives when an emission credit is issued and creates better conditions for development of the system in the medium- and long-term. A mechanism of this kind is regarded as being particularly important if a system is introduced on a trial basis.

A depreciation of the emissions rights' nominal value in terms of kg emissions, also provides increased credibility for players who, outside the areas that are regulated by statute, will voluntarily buy emissions rights in order to be ”emissions free”. It can for example relate to a travel bureau or a power producing company that, as an option, has bought emissions rights in order to be able to offer its customers travels or power free from emission. The travel bureau or power company then buys emissions rights within the statute-controlled system, but sells them outside this system. Without depreciation of the value the credits could remain in an organisation that bought them at one time in the regulated system and gradually build up a concealed value that would invite abuse or purely unlawful trading (that an organisation sells the emissions credits in breach of undertakings to its customers).

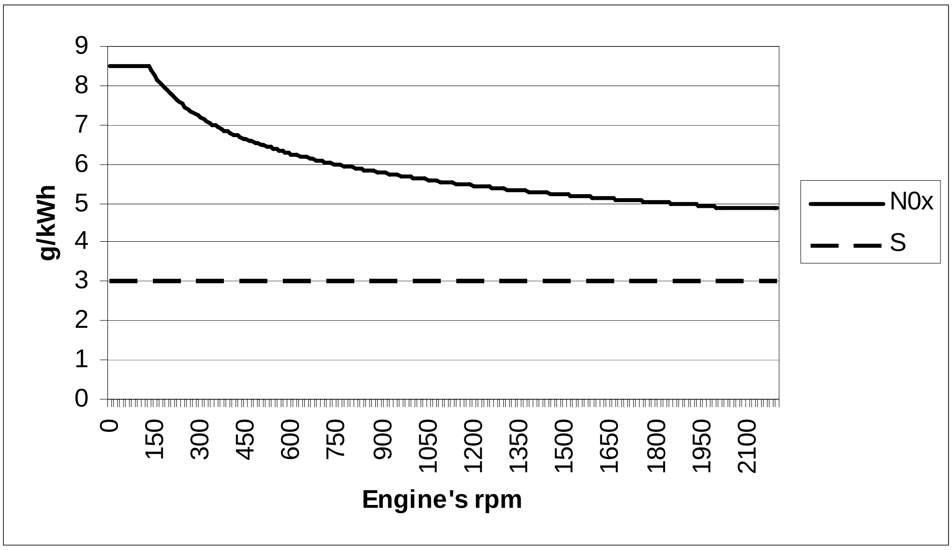
5.3 The closed system

Also in *the closed system*, the reference levels for nitrogen oxide and sulphur emissions respectively, are defined in relation to the levels defined by MARPOL, Annexe VI and, there is a separate settlement for nitrogen oxides and sulphur. In order to bring about a reduction of the emissions of significance, it is necessary for the reference level to be set below the environmental performance that the law defines. A reference level corresponding to the law's requirements regarding sulphur content in bunkers should, by definition, not cause any demand for emission credits in a closed system and, consequently, not give rise to trading or an environmental incentive either. Where nitrogen oxides are concerned it is proposed, as an example for calculation that the reference level in this alternative be set at the IMO curve minus 50 percent. For sulphur it is proposed that the reference level be correspondingly defined in relation to emissions upon the use of fuel with a sulphur content of 1.5 percentage points minus 50 percent, corresponding to 3 gram sulphur dioxides (calculated as SO_2) per kilowatt hour.

A final determination of the reference level should be shown by an analysis of, on the one hand, the need for emission reductions and, on the other hand, the risk of distortions of the ports' competitiveness, primarily in the periphery of the demarcation area. There can also be reasons to study shipping's competitiveness in relation to other forms of traffic in this context. The lower the reference level, the greater the additional cost will be to make landfall at a port within the demarcation area, compared to the cost for other ports and for other forms of transport.

The closed system differs from the open system since trading is taking place exclusively within shipping, that it is obligatory for all vessels calling at ports in the demarcation area and that a settlement takes place at each port of call. A shipowner with a fleet where certain vessels give rise to emissions above the reference level and others that give rise to lower emissions, should be able to ”exchange” emission rights between his ships. Otherwise trading takes place between shipowners.

Figure 6. Reference levels for nitrogen oxides (NO_x) and sulphur oxides (S, calculated as SO_2) in the closed system, according to the alternative that is described.



In principle the same choice is required in this system as in the open system described above. Sulphur and nitrogen oxide emissions are dealt with separately, but no exchange rate is employed.[50] Even if the closed system is developed for trading within shipping, it should not prevent other players from buying emissions rights. It could be a matter of businesses outside the ship owning industry that wish to market themselves as being emission neutral or organisations that wish to create conditions for individuals to ”live emission neutrally”, through compensating emissions from their travels or their housing through measures taking place within shipping. Through such a design of the system it could also, in the longer term, be developed towards an open system. It creates an alternative for society if/when it transpires that the overall emissions need to be lowered further and that further measures are needed. Society can then create regulations that involve emission reductions through demand for emissions rights being created in the maritime sector.

[50] Even in a shorter perspective it can certainly be discussed in principle whether an exchange rate between the North Sea and the Baltic is warranted. In a future developed system ”exchange rates” may very well be applied at a more detailed level provided that it is possible to establish with a degree of certainty that the emissions’ damaging effects differ between different parts of the demarcation area. An alternative to this is that other national or local control means are applied separately in order to deal with such effects. It can be a question of environmentally differentiated port or fairway dues.

5.4 Administrative procedures

Trading systems discussed here require an administrative superstructure. In this present description it is divided into four different procedures: the certification procedure, the settlement procedure, the trading procedure and the control procedure.

Certification procedure for sea-side

A possibility that, in many respects, is attractive and likely close at hand in terms of time from a technical perspective, is actual measurement of emissions in flue gases. Such technology is already developed for land-based plants. Several factors mean however that the technology developed for land-based application not necessarily is suitable for shipping. The primary reason is the vibrations and the temperature stress in a vessel’s funnel. Flue gases from vessels are also often of a different composition and more corrosive than flue gases from land installations. Marine applications are furthermore subjected to sea water and salts in a different manner than land applications. The costs of the actual measurements are also unclear. One possibility that can limit the costs can be the development of systems that measures the emissions in the flue gases approximately and then reckons them up in order to describe actual emissions in a representative manner. In order for solutions of this type to be allowed it is necessary for them to be shown to be verifiable and reliable and that they are certified for their application.

In this context, as a (possibly temporary) solution in the shorter term, it is proposed however that there be a certification and control procedure that is based on and currently employed in the Swedish fairway dues system. Through environmental differentiation of the Swedish fairway dues there is also experience of certifying and controlling the emission of sulphur and nitrogen oxides from shipping. The system that has been developed is deemed to operate satisfactorily and constitutes a basis for the arguments in the report.

The investigation is displaying two main alternatives aimed at how emissions are to be measured and calculated in both systems in the short-term. One alternative is closely associated with the international regulations governing sulphur emission, while the other more closely follows the specification of maximum nitrogen oxide emission from new vessels according to the IMO curve.

The investigation recommends the former case[51], i.e. that the emission calculations and settlement are based on emission factors in terms of kg emission per ton of fuel employed. For sulphur the reference level then lies at 15 kg sulphur per ton bunkers (1.5 % of 1000 kg) in the open system and 7.5 kg per ton in the closed system. This corresponds to 30 kg and 15 kg sulphur respectively calculated as sulphur dioxide. For nitrogen oxides the reference level for low speed engines lies at c. 75 kg nitrogen oxides per ton bunkers in the open system and at half of this in the closed system.

In respect of sulphur no technically complicated certification is required in the opinion of the investigation. A shipowner who wishes to use low sulphur fuel and thereby be able to generate emissions rights concludes a legally binding agreement (sulphur certificate) with the responsible authority. The shipowner certifies that only fuel with certain highest sulphur content shall be used. In this agreement the shipowner also undertakes not to have any high sulphur bunkers on board at all. When this practice in employed in both trading systems it means in effect that vessels that not only ply the demarcation area, but also other waters, may choose whether they wish to use bunkers with a lower sulphur content, despite only being given credits for emission reduction within the demarcation area.

The sulphur content specified in the certificate is expressed in the unit employed in the system (kg/ton bunker fuel) and is registered in a database that is common to the trading system ('s sea-side) and that is referred to as *the emission trading register* below. It is recommended that the sulphur certificate be employed until further notice. The administration should be set up so that it can handle relatively frequent updating of the sulphur certificate. As the market appears the supply of low sulphur oil of a

[51] If, on the contrary, the other alternative should be chosen, the emission factor that forms the basis for emission calculations and the issuing of emissions credits should be expressed in terms of gram emission per kilowatt hour as in the IMO curve, likewise in the Swedish system for nitrogen oxide certificate as a basis for lower fairway dues. For sulphur the reference level in this alternative will be 6 g sulphur oxides per kilowatt hour in the open system and 3 g sulphur oxides (calculated as SO_2) per kilowatt hour in the closed system.

In technical terms it is of course possible to use kg sulphur per ton bunkers as a basis for calculation of sulphur credits and gram per kilowatt hour in respect of nitrogen oxide. The report makes the assessment however that there are appreciable advantages for the administrative procedures to have a common course of action so that either the use of bunkers or the power utilisation form the basis for both calculations.

specific sulphur content will be meagre and unevenly distributed in a region. The system should in principle manage to update the sulphur certificates with a regularity that corresponds to the vessel's bunkering interval.

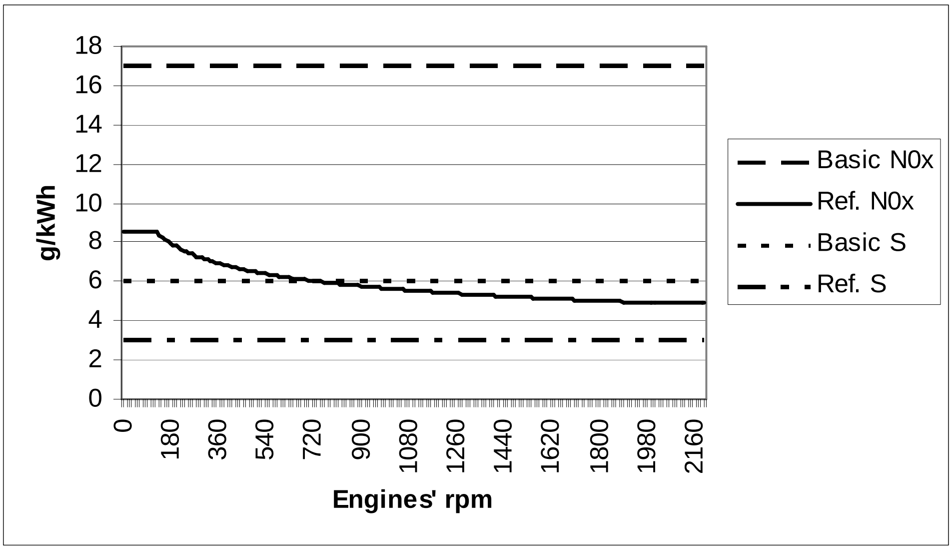
The principle proposal is that credits and emissions according to the basic level in any trading system should be calculated on the overall bunkers consumption. Auxiliary engines are often, for technical reasons, operated on better fuel qualities than the main engines. This means that the system provides a certain over-compensation for vessels that choose to operate on low sulphur fuel at the same time as vessels in the closed system, that are charged according to the basic level, can be charged for somewhat higher emission than they actually emit. In view of the fact that the auxiliary engines' share of the overall energy utilisation is relatively low (typically about 5 percent, somewhat more for ferries) and the desire of simplistic system design, this is regarded as being acceptable however. Any vessels that wish to install so-called exhaust gas scrubbers or other emission reduction technology in order to lower sulphur emissions shall undergo a certification procedure like that described for nitrogen oxides below. If a vessel no longer lives up to the demands specified in the sulphur certificate the shipowner is obliged to report this to the authority. The sulphur certificate is then deregistered and, if relevant, a new sulphur certificate shall be issued that represents the new circumstances.

Regarding nitrogen oxides a technical certification procedure is required. The set-up means that all vessels that wish to generate emissions rights must undergo a certification by an accredited control laboratory. Emissions from main engines and all auxiliary engines are then measured. Nitrogen oxide emission is measured at 75 percent of installed output on main engines and at 50 percent output utilisation on auxiliary engines. The measured emissions for the respective engines are weighted together in proportion to the respective engine's share of the total engine output for all engines. The result will be an overall weighted emission value. This value can be expressed in kg nitrogen oxide emission per ton bunker fuel. This emission is confirmed through the authority issuing a nitrogen oxide certificate and the details being registered in the emission trading register for the joint system. If the conditions onboard alter, e.g. as a result of nitrogen oxide reduction equipment being out of operation, the shipowner is obliged to immediately report this to the authority who, as a consequence of the notification, alters the details in the emission trading register. Certification and the nitrogen oxide certificate is proposed to apply for three years. Thereafter, re-certification will be required.

The open system, where credits that are generated within shipping can be sold to land-based sources, (or the state) only certification of participating vessels is required. This in itself limits the overall administrative burden that the system causes. The system being voluntary and since those who are participating normally achieve net gains in the system, it is reasonable to believe that acceptance of necessary administration is greater than in an obligatory system. On the other hand, this system means that corresponding declaration and verification procedures have to be built up on land in order for regular trading to take place. Verification on land should be able to be carried out in a similar way as in the Swedish charges system for nitrogen oxide emission for larger land based plants. (The matter is analysed further in chapter 7.) If, however, the state enters as the other party and buys credits then no such activity is required on the land-side.

In *the closed system*, where ship to ship trading is taking place, it is required that all vessels (over 300 GT) that call at ports within the demarcation area make a declaration. This design means that the number of vessels that need to be certified is limited through a general basic value (in terms of kg/ton bunker fuel) being applied to vessels as long as it is not shown, through a certification procedure, that they qualify for lower emissions. Such basic values first and foremost create the possibility for all vessels to call at a port in the demarcation area without it being preceded by a separate certification procedure for the vessel. At the same time it provides a possibility to anticipate the cost, without certification, (the actual number of emissions rights that have to be bought) in order to call at a port according to a certain route. To buy emissions rights to the extent that follows from the basic value can correspondingly be an alternative for vessels that visits the demarcation area very rarely. This opportunity makes it possible at the same time for older vessels, for example, that have poor nitrogen oxide performance and thereby have little or nothing to gain from a certification but to make significant investments, to pay through purchase of emission rights to the extent that follows from the basic value but, at the same time, avoid additional costs for certification.

Figure 7. Reference levels and basic values for nitrogen oxides (NO_x) and sulphur oxides (S, calculated as SO_2) in the closed system.



With regard to sulphur it seems suitable for the basic value to be set according to the sulphur emission that is to be guaranteed for bunkers through the existing rule system, i.e. an emission corresponding to a sulphur content of 1.5 percent in bunkers. For nitrogen oxides it is provisionally proposed that there be a basic value corresponding to 17 gram nitrogen oxides per kWh which lies somewhat higher than the normal emission from high nitrogen oxide emitting high speed engines, but simultaneously lower than what high nitrogen oxide emitting low speed engines give rise to. It is in itself an unwanted ”discount” that is thereby built into this system for high nitrogen oxide emitting low speed engines. The disadvantage must be weighed against the advantages of simpler administration. In line with older vessels being replaced with more modern ones, this problem will also be of progressively lower interest.

If the alternative based on consumed volume of bunkers is chosen it is considered to be relatively uncomplicated to also include auxiliary engines in the system. If, however, the alternative is chosen that is based on emissions per kilowatt hour then there are more reasons in favour of letting the system only include the main engines as a first step, and then also include auxiliary engines at a later stage. For technical reasons fuel with different properties and sulphur content is, as mentioned, often utilised for auxiliary engines and for main engines. Moreover it is more difficult to verify how auxiliary engines are operated, given existing technical systems. The information stored by the AIS system provides a good picture of how main engines are operated trough ships’ speed but gives poor information about auxiliary engines.

Settlement procedure

The procedure whereby there is a provisional determination of how many emission rights are to be credited or debited is referred to here as the settlement procedure. The information the shipowner declares forms the basis for the settlement. The control of this information takes place within the framework of the control procedure described below. The procedure comprises:

- Declaration from the vessel, shipowner or his representative (ship's agent).
- The authority or organisation that is responsible for the procedure determines the volume of emissions credits that are generated or consumed.
- Registration of transactions in the emissions trading register.

It may be felt that the model for declaration and verification can be permitted to be somewhat more comprehensive in the open system since it is voluntary and possibly covers fewer vessels. The assessment is made here however that the procedure required for verifying and checking the vessels emissions is the same for the vessels involved, irrespective of system. The economic values that are traded in the open system are not necessarily less than the values that are traded in the closed one. If the demand on the land-side becomes great the traded values may, on the contrary, be greater in the open system.

Under all circumstances an organisation is needed to deal with the procedure. This may be a centralised player or consist of national authorities that act under the same regulations. The task of the settlement organisation will be to:

- Provide certain information about the regulations and procedure.
- Draw up and apply an efficient form for declaration, determination of number of credits and to effect settlement.
- Send settlement notes to the shipowner or his representative.
- Be responsible for the joint (international) emissions trading register where, on the one hand, data regarding vessels' specific emissions, according to nitrogen oxide certificates and sulphur certificates, is stored and, on the other hand, information regarding the emissions credits' owners.
- Have a role in the control procedure (described in a later section).

Vessels are required to make a declaration of the information needed for settlement. In general the declaration and verification should be made as simple as possible while, at the same time, satisfactory security is achieved so that the system can function well and be reliable. In the open system such a declaration is needed only from those vessels that choose to take part, while the closed system requires that all vessels that call at a port in the demarcation area take part and thereby also make a declaration. In the closed system a declaration is, in principle, required per port call, while a declaration in the open system can be made more infrequently. In the open system a periodic declaration is proposed. For vessels that operate in scheduled traffic with high regularity there are good prerequisites for developing a simplified procedure in the closed system as well.

Declarations shall, where appropriate, contain information about specific emissions according to the nitrogen oxide certificate and the sulphur certificate, as well as which vessel and which period of time the declaration relates to. The volume of bunker fuel that it attributable to operation within the demarcation area since the preceding declaration, shall be stated. The information shall also cover bunker fuel for operation of auxiliary engines. In the open system energy consumption is declared, broken down by calendar day in order to facilitate control. (In the closed system, however, the use is not declared in connection with any voyage from ports within the area to out of the area, but only consumption from entering the demarcation area to the port in question.)

In principle a manual declaration can take place e.g. in accordance with the form that vessels currently make their fairway declaration when they call at Swedish ports. The declaration is made via the Internet. In a standard system, however, the declaration should be able to occur automatically. Experiences from the technical development work that took place with regard to road charges should be exploited when a system is developed for trading with emissions rights. The road-side's so-called EFC directive[52] can serve as a model for how a legal framework that ensure functionality and promotes standardisation can be formulated. An automatic unit should store data on specific emission in accordance with any nitrogen oxide certificate or sulphur certificate, respectively, and should be connected to a positioning system (GPS or similar) that indicates when the vessel is in the demarcation area and thereby determines which data from the fuel meter or

[52] Directive 2004/52 EEC.

which data regarding the route shall be registered for declaration. The automatic unit can declare automatically by e-mail. In the open system it occurs with the frequency that is laid down, while in the closed system it can occur when the main engine is closed down and the positioning function ascertains and verifies that the vessel is in a port (a port area) within the demarcation area.

One possibility is to design the system so that the declarations are made directly to authorities in the participating countries. In this case, all countries' authorities must work with a common emissions trading register that e.g. covers certification data and emissions rights. A common register prevents more than one authority issuing credits based on the same activity. In the closed system duplicated transactions can also be prevented through a strict territoriality principle, where each country deals with transactions only for the ports of that country.

According to the report's assessment, a possibility that has significant advantages is when the entire settlement procedure is outsourced to an independent operator. This creates the opportunity to fully benefit from the economies of scale and it creates a guarantee of conformity where shipowners and vessels always encounter the same procedure, irrespective of where the vessel is registered and where the declaration is done place.[53]

With an exchange rate the area where the emission took place shall also be considered in the settlement procedure in a way that all emission rights can be converted to one and the same unit with which the trading takes place.

Trading procedure

The formulation of the system follows the method that applies to the current European carbon dioxide trading. It means that it is up to the market to establish trading places by itself.

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[53] The current administration of the sale of road charges for heavy goods vehicles (Eurovignettes) to driver from third countries may serve as a model. Four of the member states involved in the co-operation (Belgium, Luxemburg, the Netherlands and Sweden) have jointly outsourced an organisation for the sale of road charges to vehicles that are registered in countries included in the system. The fact a vehicle has paid the charge is, however, controlled by the police or corresponding national authority. Stockholm's congestion charge and the German km tax for heavy vehicles (maut) are examples of national tax systems where the collection of taxes has been outsourced.

Each emissions right that changes owner shall be registered in the emissions trading register as described above. Trading in emissions rights can take place at a time other than when they are made over. The experience from the Emissions Trading System of the European Union (EU-ETS) shows that trading takes place bilaterally between individual companies, via brokers or via an exchange. During 2006 something of the order of 1 000 million emission rights were sold in the system for carbon dioxide trading, of which an estimated 75 percent was traded via brokers and the remainder via exchanges.

It is considered likely that several of the currently active brokers of emission rights for carbon dioxide also will offer services for broking credits for nitrogen oxides and sulphur if such a system is established.

Control procedure

The control procedure is designed to ensure that incorrect reporting or attempts at fraud of the system are discovered to a sufficiently large extent in order to control abuse and thereby render the system reliability and to ensure that emission reductions are achieved. The control procedure is divided into two parts where one deals with the control of specific emissions in accordance with nitrogen oxide certificates and sulphur certificates and the other part is designed to ensure that the activity within the demarcation area declared, is correct.

Control and follow up of emissions performance is presumed to be undertaken by the national authority responsible for the shipping inspections. Control is expected to be carried out regularly in connection with port state inspections (not necessarily as a part of them). Another alternative is to allow an accredited control institute to undertake these inspections on assignment and account of the state.

Control of emission performance takes place on board and should encompass examination of bunker invoices for oil[54] and, where appropriate, for urea (upon catalytic reduction). It should also be checked that prescribed verification procedures for sulphur oxide reduction have

[54] According to MARPOL, ANNEXE IV it is required that vessels can show so-called Bunker Delivery Notes (BDN).

been followed. There should also be a random control of the bunkers that remain on board.[55]

According to the Paris Memorandum of Understanding on Port State Control (Paris MOU) further port state inspections shall be avoided for six months after the preceding inspection carried out in a country that is a member of the Paris MOU. If a port state inspection of an event takes place in a country that is a part of the Paris MOU, but not in the system for emissions trading, inspections of emissions performance in connection with a port state control can become very rare and it should be possible to predict that no new inspection will take place during the half year that follows an inspection. In order to create confidence in the system further controls are therefore needed. There are no legal obstacles to a state carrying out separate controls of kind outlined here.

The result of samples and result of controls should be stored in the joint emissions trading register for vessels' specific emissions that is common for the countries included in the system. The history from earlier inspections can constitute a basis for which vessels should be prioritised for inspection.

In the longer term it should also be possible to employ measuring equipment in order to analyse flue gas plumes from vessels and to identify high-emission vessels that can warrant further control. Such equipment can be fitted at fixed positions in fairways, aboard vessels or on board aircraft. At the request of VINNOVA and the Swedish Maritime Administration the Institute for Radio and Space at Chalmers is conducting a project in which existing technology for such applications is being tested and developed. The concept is based on measurement of the ultraviolet spectra of the sun and, from distorsion of these spectra, identifying the amount of sulphur dioxide and nitrogen dioxide along the path of the sun's rays. By measuring the wind can also the amount of sulphur in a cross-section of flue gas plumes be estimated. Against this background it can then be

[55]This is an activity that not only needs to be built up for the systems for trading with emissions rights that are proposed, but the control of quality of bunker fuel is also needed in order to ensure that members states observe Directive 1999/32/EEC (amended through Dir 2005/33/EEC).

calculated how much sulphur and nitrogen oxides the vessel emits per time unit or per nautical mile.[56]

The settlement organisation should be given the task of carrying out a certain examination of the declarations that are received. A system should be constructed where all declarations automatically undergo a certain examination of likelihood. On a random basis a proportion of the declarations should also be subjected to a more detailed control.

By means of the information that the national shipping administrations store in the AIS system (Automatic Identification System) regarding all large vessels (over 300 GT) it can be checked with considerable accuracy what route individual vessels have covered within the demarcation area during a certain period of time. Through the system's information on the vessel's speed and information about the engine output, an indirect calculation can estimate the bunkers consumption with relative accuracy. If such a control gives reason to further follow up, additional information may be requested. Additional information may take the form of printouts from the vessel's voyage data recorder (a non-obligatory piece of equipment that, for example, registers each change of the engine's rpm) or a copy of the vessel's engine log book which is an obligatory document where, at the least, the operating time and power output of the main engine is recorded, as well as the operating time of the auxiliary engines.

The control procedures that are described should be combined with incentive or sanction systems in order to ensure that the rules are observed and followed.

5.5 Legal framework

The open as well as the closed trading system's sea-side is, as formulated above, compatible with current international regulations.

The closed system in particular, as previously described, requires an international legal framework to be developed for the system. It can take the form of agreements between the participating countries, but an EEC directive is preferable. In line with what is stated by Nature Associates regarding its proposal for environmental charges in the Baltic, it can be

[56] Previous efforts within the area have been reported in Mellqvist, et al., 2003.

pointed out that this matter should not be regarded as being a tax issue and that it should therefore be sufficient for there to be a qualified majority for a decision on a proposal in the European Council of Ministers.

In the ongoing work within IMO, associated with the review of MARPOL's Annexe VI, there are proposals for amendments that open the way for trial applications of trading with emissions reductions. The review work is expected to be completed during 2008.

If the open system is trading with land-based plants change to EU law is required, which will be discussed in the following chapter.

5.6 Effects on emissions and economy

The model that is built up to describe the costs for shipping to reduce emissions of nitrogen oxides within the demarcation area, as described in the preceding chapter, does also show that the cost of reducing emissions varies between different vessels. It depends first and foremost on the vessel's traffic pattern. The costs of measures also vary considerably depending on at which point of the lifecycle the vessel is. To a certain extent it also depends on differences regarding varying technical properties of the type vessels.

When the model is used for analysing how the market may adjust itself to the two different systems for emissions trading as described above, it is assumed in the principle alternative that a decision to introduce a system will be made immediately and that the system is introduced in 2010. The ten vessel types are represented in the model at three different stages of their lifecycle, as new buildings, as an existing vessel with a lengthy remaining lifespan (at least six years anticipated remaining lifespan) and as an existing vessel with a shorter remaining lifespan (five years or less). The model thus describes reality by means of 30 vessels. These vessels are then weighed together in relation to an estimate of the different vessel categories' share of the day's emission of nitrogen oxides in the demarcation area. The estimate is based on statistics relating to the number of calls at Swedish ports broken down according to engine output and vessel category. Engine output has, in other words, been used as an approximation for the extent of the emission. For the different vessel types the emissions are then divided between the three age classes in relation to anticipated lifespan. The way in which the emissions are broken down between vessels consequently represents simplifications in many respects, but the precision that is achieved is regarded as sufficient and adequate in this context.

Table 7. The emissions' distribution between vessel types.

Vessel type	**Share, %**
Bulk	3.0
Dry cargo	10.0
Container, over seas	0.5
Container, feeder	2.5
Ro-ro	10.0
Reefer	0.5
Ferry	70.0
Supertanker, over seas	0.5
North Sea tanker	0.5
Coastal tanker	2.0
Chemical tanker	0.5

As seen from the table ferry traffic is very dominant in this context. In the model it is presumed to correspond to 70 percent of emissions. Dry cargo vessels and ro-ro vessels also give rise to significant shares, while the emissions shares from several other vessel types are small.

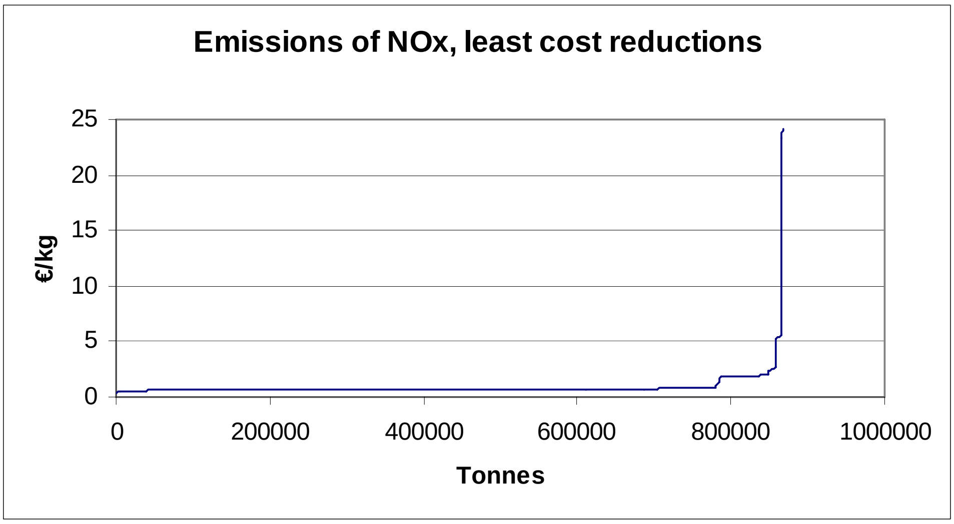
In the North Sea and the Baltic there are currently some fifty vessels that have taken measures to lower nitrogen oxide emissions, the majority of them being ferries. In the application that is employed here no note is taken of this and all vessels are regarded as being state of the art and no measures taken.

In figure 8, the supply curve for emissions credit for nitrogen oxides calculated for the Baltic and the North Sea with the aid of the model, is shown. The curve shows the cost and emission reduction for the least expensive technology for the respective vessels, weighted in relation to the vessel type's significance for the overall emissions.

The supply curve is flat up to c. 750 000 ton per year. In this interval the costs of measures rises from c.0.50 to 0.80 € per kg of nitrogen oxides.

This supply curve is however not quite stable, but varies according to how the instrument of control is formulated. Greater incentives can make it profitable to invest in a technology that is somewhat more expensive per reduced kg provided that it gives rise to greater reduction. An instrument of control that would create a stable incentive of 1 € per kg nitrogen oxides should thus, according to the model, mean that SCR (with 90 percent reduction or more) rather than DWI (with 50 percent reduction) will be the most profitable with new production of several vessel types as well.

Figure 8. Supply of emissions credits for the Baltic plus North Sea according to model calculations.



The model calculations show that a reduction by 50 percent of total emissions of nitrogen oxide from shipping's in the demarcation area (accumulated volume of 500 000 ton in figure 8) can occur at an average cost of barely 0.70 € per kg nitrogen oxides. A general requirement of all vessels to undertake measures in order to reduce emissions would be more costly through vessels that seldom ply the demarcation area, as well as older vessels that are approaching scrapping, being forced to take measures. A regulatory solution would also increase the regulation costs since it might limit the choice of technology. The HAM technique, as well as catalytic reduction, gives rise to a significantly higher degree of reduction than 50 percent and could not be used optimally if a general reduction requirement of a lower level was to be introduced.[57]

[57] A parallel in this respect may be drawn from experiences in USA where trading with emissions rights, in relation to regulation solutions, were identified as an innovation-promoting instrument of control. Ellerman et al., 2003.

By help of the model, the costs for regulating all the vessels' emissions to a level corresponding to halved emissions as in the trading system that has been cost-calculated above has been calculated. The model shows that such a regulation involves an average adjustment cost of almost 2.70 € per kg nitrogen oxide. In the model the choice of technology in this case has consistently fallen on direct water injection, the technology that, according to the model's description of technologies for emissions reduction, gives rise to just a fifty percent reduction.

Differences in costs of measures between regulation and trading illustrate the potential welfare gain that rests in trading rather than regulation. The adjustment costs will be c. 1 billion € per year lower, according to the model, if trading is applied compared to regulation.

An open system that permits trading between land and sea involves also additional potential. So far the cost of measures on land have not been described in all details in this present work. Upon determining what is to be regarded as the best available technology, which is required upon environmental certification of large combustion plants, a guideline value per kg nitrogen oxides of c. 4 € is employed in Sweden. The charge on emission of nitrogen oxides payable in respect of energy production in combustion plants in Sweden, amount to the same figure. From this background a cost for measures of 4 € per kg nitrogen oxides is employed here for land-based plants as a basis for a calculation example and used as a basis for an estimate of the potential welfare gain upon trading between sea and land.

By such trading between sea and land, to an extent corresponding to a 50 percent reduction of ship's total emissions within the demarcation area (500 000 ton NO_x), the adjustment cost according to the model may be lowered by almost 85 percent or by almost 2 billion € per year. Through the cost of measures at sea being less than 4 € per kg nitrogen oxides, up to a reduction of almost 90 percent (or 900 000 ton), the potential for efficiency gains is, at the same time, greater if the trading is made more comprehensive.

The calculation example presumes that there are buyers for emission rights corresponding to 500 000 ton nitrogen oxides per year. The possibilities and ways of creating such a demand are discussed in the following chapter.

6. Land-side in the open system

A key question in the open system is how demand for emission credits can be created. In principle, demand can be developed from land activities or from aviation. Here aviation and road traffic are not analysed further, however. Instead the focus is primarily placed on land plants.

As stated, there are two different directions of principle for the creation of trading with emissions reductions. The first is trading under an emissions bubble. In such a system it is stated how large the emissions may be for the involved land plants taken as a whole. The emissions rights are then apportioned or auctioned out. It should be possible to include shipping in the bubble or for it to remain outside, however able to sell reductions to land plants.

The second kind of system, the so-called credit-based trading, involves a reference level being stated as mentioned. Credits are created through the fulfilment of higher requirements than those prescribed and requirements for purchase arise on emissions above that level.

The activities on land in the countries around the Baltic and the North Sea emitted an estimated 6,600 thousand tons of nitrogen oxides and 4,200 thousand tons of sulphur calculated as sulphur dioxide (assumed 60 % of EU 25, cf. table 2) in 2004. It is estimated that 2,000 thousand tons of nitrogen oxide and 3,200 thousand tons of sulphur dioxide derive from plants covered by the directive for large combustion plants. In 2010 emissions from the large plants may be assumed roughly to fall to the order of magnitude of 1,500 thousand tons of nitrogen oxides and 1,700 thousand tons of sulphur dioxide.

The report has analysed five main alternatives for creating a demand for emissions credits from the land-side. In addition, there are a number of variations on these. The main alternatives are described in this chapter where the conditions for, and consequences of, an envisaged introduction are described clearly. The five described main alternatives[58] are:

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[58] Variations of the alternatives can relate to which land plants are covered, which countries are to take part, how large a demand for emissions credits shall be aimed at, whether shipping's participation should be voluntary or not, whether land plants may sell

1. Uniform system where land activities and shipping take part under the same conditions.

2. Emissions bubble for major plants on land, while shipping takes part voluntarily.

3. Additional requirements upon new licenses for land plants. The further reductions may be bought from shipping.

4. Land plants may claim purchase of emissions credits in proportion to the emissions of preceding year. Shipping takes part as a voluntary selling party.

5. The states around the Baltic and North Sea undertake to buy emissions credits from vessels that ply the North Sea and the Baltic.

Not all of these alternatives can be called emissions trading in the strict sense. The first fulfil such criteria, while the latter does not.

In line with the argument given in chapter 5 there are reasons to consider whether an ”exchange rate” should be applied if trading takes place between land sources and shipping. The exchange rate can be warranted upon trading between two geographical areas. This is the case if an emitted unit from one area generally is resulting in discernibly greater health and environmental damage than the same amount of emission in another area.

Before a more detailed description is made of the four main alternatives, an overall description is made of the regulations that control large land plants' sulphur and nitrogen oxide emissions.

6.1 Current requirements for land installations

During the present year the plants in Europe covered by the directive for large combustion plants shall have adjusted their activity to the requirements of the directive. The licenses normally regulate which limitation values that apply to the relevant activity. The limitation values

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emissions credits and thereby trade with other land plants, whether other existing instruments of control shall remain or not (NO_x charges, sulphur tax, environmentally differentiated fairway dues, requirements for shipping e.g. 1.5 % sulphur in sulphur control areas). Not all variations are described. In certain cases variations for the five main alternatives are commented on.

may be expressed as limit values that are not to be exceeded and target values that, if exceeded, involve an obligation to take measures so that this is avoided.

Conditions in these licenses can regulate one or more of the following aspects:

- The scope of the emissions per time unit, per produced volume of goods or per employed energy unit.
- Which concentration of relevant matter may be in the flue gases and the concentration's level during different periods of time.
- Which type of process and cleansing equipment is to be employed.
- The quality of the energy carriers (the fuels) e.g. sulphur content.
- Highest concentration of relevant ambient pollution as well as any requirements regarding smell (unusual condition).

Many large plants covered by the directive for large combustion plants have been given conditions that state maximum permitted emission of sulphur dioxide and/or nitrogen oxides in the flue gases or per employed or distributed energy volume. Maximum annual emission expressed as ton pollution is, as a principle rule, not regulated.

The requirements for certain plants' highest permitted emission are indirectly controlled by requirements regulated within the EU, e.g. for large plants for energy production. Requirements for sulphur dioxide and nitrogen oxides are regulated in these provisions as milligram per normal cubic metre flue gas as certain output outlets. Stated concentrations may not be exceeded as a mean value for hours (alternatively half-hours), calendar months and calendar years. It should, however, be noted that despite the regulations it will always first be decided upon certification what is the best available technology for the tested plant. In the event of application of what is the best available technology for the individual plant giving rise to a higher emission than the mini directive's value, the latter shall apply. Conditions for existing plants may vary according to circumstances in each separate case and when in time the license was issued.

For example pulp mills can have a maximum annual emission of sulphur dioxide and nitrogen oxides regulated in the conditions as limit values. The activity is always conducted with a certain margin to stated limit values since exceeding these can lead to sanctions. Normally therefore the annual emissions are kept a bit below the permitted emissions. If there is a need for extended or altered production compared to the license, the business must apply for a license for extended or altered activity.

6.2 Uniform trading system for land installations and shipping

In a common system where land installations and shipping take part under equal conditions the land plants are given the same reference level as vessels. In line with the description of the sea-side in the open system in the previous chapter, the level may be expressed in terms of e.g. kg nitrogen oxide emission per ton oil or oil equivalent. With such a system design consideration is given to emission-reducing measures being carried out on land and at sea to different degrees. In terms of principle, this alternative has advantages both from the perspective of efficiency and distribution.

The question of joint reference level does not need to be studied further prior to any introduction. The land-side's heterogeneity regarding energy carriers and technical conditions for emission-limiting measures, must be considered.

Upon comparison with the development in USA, where emission trading for land plants has partly replaced regulations, this alternative is seen as being particularly interesting. It is stressed that trading in USA has shown itself to be a more effective instrument of control from an administrative perspective than regulations. However, this investigation has not had the means of opportunity in respect of this point to follow up the American experiences to a desired extent.

In the short and medium-term it is, however, not deemed to be possible to introduce such a system in Europe. As previously stated the current international regulations on the sea-side as well as on the land-side, constitute obstacles to a standard system that also covers shipping that only passes through the demarcation area without calling at ports in the area.

6.3 Emissions bubble for land – voluntary for shipping

This alternative means that large land plants' license conditions for sulphur dioxide and nitrogen oxides are adjusted or revoked. The conditions are replaced by an emissions bubble. The bubble may, for example, be set 10 percent narrower than the current overall annual emissions for the relevant emissions sources covered. The emissions bubble may subsequently be reduced further. Trading between the plants is permitted and shipping is involved on a voluntary basis. Participating vessels may sell achieved and qualified reductions below a stated reference level as described in the previous chapter. One variation could be that shipping became the subject of project-based mechanisms, e.g. similar to CDM and JI in the existing trading system for carbon dioxide.[59]

Upon emissions trading within a bubble the emissions rights are distributed through auction or are also distributed free of charge to the plants e.g. in proportion to previous years' emissions or in proportion to the plant's production volume, so-called efficiency-based targets. There is also an intermediary position with regard to the allocation of emissions rights. A separate rules system is created for how emissions rights are to be apportioned and calculated.

The need for emissions rights for plants on land will be a function of, on the one hand, emissions per employed energy unit or production unit, and on the other hand, the extent of the activity. Since all plants that are covered by the directive for large combustion plants shall fulfil the requirements in the directive in October 2007 for, e.g. best available technology, the land plants' production will, in the short-term, be decisive for the need to buy emissions rights. In the longer term, innovations and new technology may also influence the need.

A surplus of emissions rights for land plants may arise if there is a downturn for the relevant industry or if there is a transfer to alternative energy carriers or altered process stages. If so, these plants then compete with shipping in selling emissions rights.

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[59] CDM (Clean Development Mechanism) and JI (Joint Implementation) are the Kyoto protocol's project-based mechanisms. They allow countries with obligations to credit themselves with emission reductions in a project form, via transfer of technology, in transition countries and developing countries.

This alternative is roughly estimated to create a demand for emissions rights of c. 150 000 tons of nitrogen oxides and 170 000 tons of sulphur dioxide from plants that are covered by the directive for large combustion plants in the countries around the Baltic and the North Sea. This is provided the bubble is set at 10 percent less than what the emissions as a whole would be without the introduction of the trading system for involved plants on land.

How this alternative would affect regulated industries' competitiveness is a central aspect. It can take a relatively long time to investigate and alter the requirements for an emissions bubble for large plants in Northern Europe. Extensive amendments to the EU's environmental legislation will be required.

6.4 New license for land – voluntary for shipping

This alternative is based on stricter requirements being imposed upon testing of new plants and upon re-testing of existing plants, e.g. plants that are covered by the directive for large combustion plants, than would otherwise have been imposed upon the activities.

This alternative can impose that the emission is conditional upon a stated amount per year irrespective of the throughput of the activity. It must also be regulated whether permitted emissions volume can be sold even if the throughput drops as a result of a downturn in the industry or if the procedure is altered so that nitrogen oxide or sulphur dioxide emissions fall sharply. Another possibility can be that emitted volumes are made conditional upon employed or produced energy unit and then also energy carrier (fuel) per year.

How long it could take to introduce such a system depends on how extensive the amendments that are required in the EEC directive and in the legislation of the participating countries will be, e.g. depending upon whether changes are needed in respect of the principle of best available technology in the directive for large combustion plants.

Upon an introduction it will still take some years before a more considerable demand for emissions credits will be built up. The need to buy emissions rights increases over time when more and more plants are being subjected to re-certification.

Some years after the introduction of the new rules the demand for emissions reductions can amount to around 30 000 ton nitrogen oxides and sulphur dioxides respectively, in the countries around the North Sea and the Baltic. The calculation example is based on the estimate that 5 to 10 percent of the large plants will be re-certified or be given licenses for new activity per year and the requirements are assumed in the example to be set to about 10 percent stricter for nitrogen oxides and sulphur dioxide than what is corresponding to the best available technology. A side-effect that probably arises, witch is not considered in this calculation example is that those carrying out the activity are likely to try to delay re-certification for altered production in order to avoid increased costs. This can as a consequence also delay changes that are desirable for other reasons.

6.5 Land requirements for purchase of emissions credits – voluntary for shipping

One way of circumventing the need for major changes to the current regulations is to prescribe that all large land plants, e.g. plants that are covered by the directive for large combustion plants, are annually required to buy emission credits corresponding to e.g. 10 per cent of the preceding year's emissions of sulphur dioxide and nitrogen oxides. Voluntarily participating vessels may sell reductions below the stated reference level.

If a system like this were to be introduced this also requires amendments in legislation, but to a far lesser extent. Either it is ruled within the EU that certain plants on land in the states around the North Sea and the Baltic must buy credits in proportion to the preceding year's emissions or national requirements are introduced in the states concerned. If major plants (plants that are covered by the directive for large combustion plants) are forced to buy emission credits some years after 2010 corresponding to 10 percent of the preceding year's emissions, then a demand for emissions credits corresponding to around 150 000 tons of nitrogen oxides and 170 000 tons of sulphur dioxide shall be created. If the buying requirement does not grow gradually then the annual demand for emissions credits will also probably decrease when the process of reduction measures and enhancement of efficiency at plants on land continue.

To place further economic strain on major land plants in Northern Europe in this way may seem unjustified and to be in conflict with the of the polluter pays principle since land plants become forced to directly or indirectly finance the emissions-reducing measures within shipping. It can also damage the efficiency of the economy in that it involves plants being priced out of the market from being subjected to economic burdens that are above the socio-economic costs the activity causes. Production that is socio-economically justified can then be discontinued and/or moved to countries where corresponding impositions do not occur. The alternative is estimated to cause an annual cost increase for the land plants in the countries around the North Sea and the Baltic of around 200 to 300 million €.

This alternative does not constitute any direct trading with emissions rights.

6.6 Governments buy emissions credits from shipping

One way of avoiding directly increased costs for the land plants is for the governments concerned to absorb the reduction costs by means of buying emissions credits from shipowners taking measures and whose vessels sail in the Baltic and in the North Sea. Halving the emissions of sulphur dioxide and nitrogen oxides in the Baltic and the North Sea would cost about 650 million €. The undertaking of buying from each country could be in proportion to the population, GNP or emissions. The countries' prerequisites for fulfilling the EU's ceiling directive should also constitute grounds for a buying requirement.

The difference between forecasts for EU-15 and its obligations for 2010 in accordance with the ceiling directive, amounts to some hundred thousand tons of nitrogen oxides and somewhat less for sulphur dioxide.

An alternative that is not based on the regulating of the countries' obligations could be for individual states to voluntarily buy a certain volume of emissions reductions. Selling ”vessels” should be able to be all vessels that call at ports in the participating countries irrespective of flag or possibly restricted to vessels flagged in EU member countries. On the other hand it is unlikely to be legally possible to strictly aim the ”support” only at vessels that sail under own national flag.

Who may be a vendor shall be decided by participating states, but the support should be reported to the Commission in accordance with the EU's state support legislation. If such purchase of emissions credits is to be regarded as state support, the extent should not exceed existing guidelines for state support.

6.7 Verification of emissions

A central question is how the emissions from the activities are to be regulated and controlled. Should the system be based on the undertaking's own environmental accounts or on information from a separate control instance? Ideas may be gathered here from the EU's trading system for carbon dioxide, but also from the Swedish system for nitrogen oxides from fixed combustion plants[60]. The accounting from the verification of the vessel's emissions, as described in the preceding chapter, are in major respects relevant also to the land-side.

In 2005 the Swedish charges system for nitrogen oxide emissions covered about 400 boilers for electricity and heating production. The overall emissions amounted to about 14 000 tons of nitrogen oxides per year. The charge is barely 4 € per kg sulphur oxides irrespective of fuel. The overall charges, minus the Swedish Environmental Protection Agency's administration costs, are repaid to those required to pay the charges in proportion to the production units' share of the overall exploited energy production. This imposes control requirements.

It is the instance carrying out the activity that measures and registers emissions in accordance with the Swedish Environmental Protection Agency's regulations and general advice[61] and may base its payments on these measurements. The rules states, for example, that measurement may be omitted for a maximum of 5 percent of the operating time. The emissions shall then be estimated in accordance with stated rules. In the event of a greater break the emissions shall be calculated at 1.5 times the previously measured average. If the measurement of the emissions does not take place the emissions shall be calculated on the basis of a temp[late? for the respective fuel.

The Swedish Environmental Protection Agency is a tax-imposing authority and those liable for tax shall be registered and shall submit a special annual declaration for each production unit. The declaration also constitutes a claim for repayment. With the declarations as a basis, the Swedish Environmental Protection Agency gives the government proposals regarding how great the return amount shall be (SEK/kWh). The overall nitrogen oxide charges amount to almost 65 million € per year and the

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[60] SFS 1990:613.

Swedish Environmental Protection Agency's administrative costs amount to about € 540 000 per year. The state's administrative costs amount to barely one percent, which must be regarded as very moderate in this context. Added to this are the costs for the companies of control and administration. The relatively large similarities between administration of the nitrogen oxide charges and a system for emissions trading indicate that the costs can be held at a moderate level.

Verification of emissions regarding trading with emissions rights for carbon dioxide is controlled by national law. Swedish businesses that are covered by trading with emissions rights shall, for example, submit a verified emissions report for the previous no later than 31 March each year. The verification imposes that the emissions reports shall be examined and approved by an independent accredited controller. This so-called third party control shall, in turn, guarantee that the companies' reporting is effected in an impartial and equal manner in all the EU's member states. [62]

6.8 Conclusions

Introducing an emissions bubble for major plants in northern Europe, and thereby removing the present regulations in stated conditions for those plants, requires extensive changes to a number of fundamental environmental laws in Europe. Where the involved plants are concerned there will be a need for changes and exemptions from fundamental principles and rules in, e.g. the directive for large combustion plants and the directive for coordinated measures for preventing and limiting pollution. With retard to the present supervision of the directive for large combustion plants the question of trading with nitrogen oxides and sulphur has been taken up and the question of opening up the way for trading with emissions rights is one of the aspects that the commission brought forward in an Internet consultation during the spring of 2007.

Prior to a possible introduction of emissions trading, in accordance with the discussion in chapter 5, an exchange rate should be considered that approximately reflects the various damage costs depending upon from where, geographically, the emissions originate.

[61] NFS 2004:6.
[62] SFS 2004:1194, NFS 2005:6.

With a too generous allocation of emissions rights and if trading is permitted between land plants, the risk for increased emissions locally grows, in addition to local environmental effects, this can also be in conflict with the EU's air quality directive. How great the initial demand will be for emissions credits will depend on how large a bubble is permitted to be and how the initial distribution of the emissions rights will be carried out. Theoretically a large demand for emissions rights can be created and, thus, heavy trading with substantial reductions from shipping will occur.

The alternative of imposing somewhat stricter demands on land-based plants when they are to be given conditions because the plant is new or when it is re-examined upon e.g. extension of the activity, does not require equally comprehensive changes to existing regulations. This, however, creates considerably less demand for emissions credits since relatively few plants are added or re-certified.

To introduce demands upon land plants to buy emissions credits from vessels that correspond to a certain percent of the emissions previous year is not likely to require changes to fundamental European environmental legislation. A separate European regulation for the countries involved, or rules in each participating country, could be introduced with these requirements. For this, as with the above alternative, it is however necessary to have a regulation that controls how emissions are to be quantified and controlled. As previously pointed out, however, reasons of efficiency as well as distribution (the equity perspective) militate against this alternative. The alternative conflicts with the polluter pays principle through land industry having to directly pay for the reduction measures on vessels.

Even in the shorter term it can be possible to apply the alternative that involves the states buying emissions credits from shipping. However this variant also conflicts with the pollution pays principle. Industry is not affected directly, however, and the states and the populations that are exposed to the pollution may pay for the reductions via the tax return. It is possible that the EU's guidelines for state support to shipping will need to be reviewed as the space for many states may already have been pledged.

Summarised below are different ways of creating demand for emissions credits according to the descriptions in this chapter.

Table 8. Summary of the different alternatives' potential and properties. Stated buying and selling quantities as well as reduction, do not take the occurrence of an exchange rate into consideration.

	Buy 2010-15 1000 ton NO_x/SO_x	**Sell 2010-15 1000 ton NO_x/SO_x**	**Reduction 2010-15 1000 ton NO_x/SO_x**	**Need for rule change**	**BAT principle**	**PPP principle**	**Adm. cost €/kg**
0	300/125	300/125	600/250	Medium	OK	OK	Medium
1	Follows from formulation of system			Very large	No	OK	Medium
2	150/170	>600/250	150/170	Very large	No	No	Medium
3	30/30	>600/250	30/ 30	Large	No	No	High
4	150/170	>600/250	150/170	Medium	OK	No	Medium
5	600/250	>600/250	600/250	Small	OK	No	Low

0. Compulsory trading for shipping only within the Baltic and North Sea
1. Joint bubble for shipping and land plants.
2. Compulsory bubble for large land plants in countries around the Baltic and North Sea. Voluntary for shipping in these seas.
3. 10 % stricter conditions for all new large land plants and upon re-examinations. The stricter requirements are met of bought on the market where shipping also takes part.
4. Large land plants in states around the Baltic and North Sea are forced to buy emissions credits from vessels in proportion to the previous year's emissions. Voluntary for shipping in the North Sea and the Baltic.
5. Stats around the North Sea and the Baltic buy emissions reductions from vessels.

7. A comparative policy analysis

The instruments of control adopted to limit shipping's emissions of sulphur and nitrogen oxides and that have been of the greatest importance, are technical regulation. In Sweden, as stated, economic instruments of control are also applied in the form of environmentally differentiated charges.

7.1 Regulations

The sulphur content of bunker fuel has, as stated, been regulated globally to a maximum of 4.5 weight percent, a regulation that is so generous that it can hardly have any practical significance. In the so-called sulphur control areas that the Baltic and North Sea, respectively, constitute, the limit value of 1.5 weight percent sulphur applies as of this year. It is certainly a high limit value compared with other sectors, but it still contributes towards lowering the sulphur dioxide emissions. For certain niches, such as oil used in port, decisions have been taken in the EU that are considerably more ambitious.

The regulation that exists regarding new vessels' emissions of nitrogen oxides and that are described in the so-called IMO curve reproduced in figure 5 in this present report, is very moderate. It almost confirms the technical development that has occurred. Within shipping, regulation according to the model that is represented on the land-side by best available technology in accordance with the EEC legislation, does not occur within shipping nor, as far as is known, has been discussed.

As a basis for an analysis of regional regulation initiatives, within the nitrogen oxide area as well, the Swedish Environmental Protection Agency is financing a study of environmental gains and other consequences that could arise if Sweden, as a port state, were to require passenger ferries to meet certain emissions requirements.

The regulating of fuel quality, as well as engine performance, will be developed. With the decision model that applies within global shipping, there is considerable slowness in the system. Inherent in this is the risk that regulations will continue to be technology-confirming rather than technology-promoting. The market for new, innovative, low-emissions solutions, without further instruments of control, will be weak.

Complementary instruments of control that contribute towards driving the market, are important. If small markets can be created for new technology that affords such solutions the opportunity to show that they work, they can not only contribute towards environmental improvements but also create better conditions for a more successful regulating work. The Swedish environmentally differentiated fairway dues have been of importance in this respect.

7.2 Economic instruments

In the light of what has been said regarding regulations within shipping, the economic instruments of control for shipping should be regarded as being complementary rather than instruments of control that compete with regulations. The corresponding logic should also apply on the land-side. Regulation based on the best available technology shall not, in the first instance, be regarded as an alternative to emissions trading and other economic instruments of control. On the contrary there can be strong reasons for applying them as supplementary instruments of control in order to drive environmental requirements still further.

Environmentally differentiated shipping charges

Sweden has regarded it to be a matter of urgency to spread the use of environmentally differentiating fairway dues. If other countries create similar systems the overall incentive grows. In the EU Commission's White Book from 2001 the Swedish fairway dues are stressed as representing an interesting possibility.[63] The foreign followers within the sector are, however, still almost non-existent. One explanation for this can be that national shipping charges only are applied in a few countries.

The primary objective of the Swedish fairway dues is to finance a significant part of the Swedish Maritime Administration's activity, including e.g. fairway development, hydrographic information, ice-breaking and maritime search and rescue. In order, at the same time, to stimulate environmental adjustment these fairway dues have consequently been environmentally differentiated. The extent of the incentive that can be created is ultimately limited by the Swedish government having limited the overall extent of the fairway dues at the level that exists at present. To a

[63] COM(2001) 370, p. 83.

certain degree the differentiation potential is also limited by the Swedish Maritime Administration’s ambition of stability in the system so that the income can be predicted and activity planned accordingly. Taken as a whole this means that the fairway dues incentive at present, for the average vessel, is well under 0,1 € per kg for sulphur and for nitrogen oxides. With the institutional conditions that apply the fairway dues, with the current costs of measurements, can never provide an incentive by themselves that fully justify measures for emissions reductions for shipping. Environmentally differentiated port dues can help, but the efforts made to date are, to a large extent, expressions of local opinion pressure and market requirements from Swedish ferry passengers, Swedish industry and international cruise tourists.

To summarise, the environmentally differentiated fairway dues are important through the incentive they provide, but perhaps first and foremost through them clearly defining a development that is desirable from a social perspective and that is regarded by many players as being a clear indication of the technical requirements that can be imposed in the future. Given the current institutional frameworks in Sweden, as well as in other countries in northern Europe, the development potential for this instrument of control is regarded as being limited however.

Nitrogen oxide tax according to the Norwegian model[64]

The nitrogen oxide tax, or charge, that was introduced in Norway on 1 January 2007 has a significantly greater instrument of control potential than the Swedish fairway dues. It is a pure tax that does not have the institutional limitations of the Swedish system. The nitrogen oxide charge amounts to NOK 15 per kg and is thus at a level that fully justifies far-reaching emissions reduction for the vessels that spend a lot of time within the chargeable area.

There is, however, a limitation in this aspect. The charge is only imposed on traffic in Norwegian territorial waters, as well as domestic traffic even of parts of the routes are outside Norwegian territorial waters. The actual emissions limitations are therefore to be expected from a restricted market segment. The system’s incentive effect is enhanced by vessels and plants

[64] http://www.ssb.no/emner/01/04/10/agassn/ and http://www.toll.no/templates_TAD/Subject.aspx?id=105536&epslanguage=NO

being compensated through contributions to nitrogen oxide-reducing measures. Taken as a whole an income of c. NOK 500 million is expected, while c. NOK 400 million is expected to go to various compensatory measures.

Both the transport policy's striving towards ”fair and efficient pricing”, and the environmental policy's polluter pays principle are in line with the Norwegian application. Fifteen NOK does not need to exceed the actual emissions costs. The problem is, instead, in applying a national tax on shipping. In the same way that the discussion regarding possible trading with emissions credits, in accordance with this report, should take place in an international perspective, then international taxation should be regarded in the same way. In the short and medium-term it may appear to be almost impossible to achieve a European unanimity of view regarding an international tax of this kind.

Emissions trading

As with the Norwegian nitrogen oxide tax, trading with emissions rights, as discussed in this present report, has a potential to create significant incentives for emissions limitations within shipping. One prerequisite that remains to be cleared up is, however, that there is actually interchangeability between emissions on land and at sea. Regarding nitrogen oxides it seems, however, to be clear that the second prerequisite for trading to have potential has been met, i.e. that the costs of measures vary between different players at sea and on land. One question that needs to be studied further, however, is how possible allocation of auction of emissions rights is to be conducted. Emissions-reducing measures have generally been adopted to a significantly greater extent on ”land” than at ”sea”. Similar prerequisites should be present in order to benefit from emissions-reducing measures that have already been adopted

Emissions trading primarily has an environmental and efficiency potential if it can be introduced more quickly that regulations and taxes. This can be the case, on the one hand, through the international legislative procedure that is required, being easier within the transport and environmental areas, respectively, than within the taxation area and, on the other hand, through the extensive IMO procedure that precedes regulation, not being required.

The analyses in this work further show that the flexibility of the emissions trading can make an adjustment to a certain emissions level of nitrogen oxides be less expensive through the trading stimulating measures for which the adjustment costs are lowest. According to model calculations this may mean, with the current fleet of vessels, annual costs savings of some billion € per year for the Baltic and North Sea. When regulations of nitrogen oxide emissions are introduced, the potential diminishes.

Emissions trading for nitrogen oxides can generally be expected to be less costly for those players the control is aimed at:

- In a tax system the tax-liable person not only pays the costs that are associated with the emissions reductions that the taxes lead to, but also pays tax for the remaining emissions.
- Pure regulation does not afford the opportunity for companies with high costs of measures to buy emissions rights instead, but forces more expensive adjustments through.

From this background it is not surprising that resistance to trading is less than that to taxes and regulations in order to achieve a corresponding effect.

While costs of measures for reducing emissions of nitrogen oxides vary considerably between different vessels, as well as between sea and land, the situation is somewhat different with regard to sulphur. The costs of measures within shipping are generally speaking the same, since the primary measure is that of using low-sulphur oil. Sulphur emissions are directly proportional to the sulphur content (apart from in the individual marine scrubber plants that occur experimentally) and the additional cost of low-sulphur oil is, in principle, the same for all.

Other economic instruments of control

In terms of pure principle environmental differentiation can also occur in respect of other charges or subsidy systems. The Swedish Environmental Protection Agency and the Swedish Maritime Administration have jointly commissioned a study of possibilities of environmentally differentiating the shipping aid. The aim of the project was to provide a basis for answering the question of whether an environmental differentiation of the aid can be a possible and suitable way of suiting shipping environmentally.

The study concluded that a possible environmental differentiation should be aimed at nitrogen oxide, that the instrument of control is powerful but that it controls on a somewhat incorrect basis as the extent of the aid, according to the model examined by the study, is determined by a combination of the personnel force on board and the engines' specific emissions of nitrogen oxides rather than the actual emissions volumes. To introduce a unilateral national environmental differentiation in accordance with the studied alternative would, according to consultants, bring about decreases in the nitrogen oxide emissions from merchant shipping, but could also risk leading to significant change of ship registration to other flags. The extent of the flagging out is difficult to estimate.[65]

Other instruments of control that, viewed as a whole, may be deemed to have less potential than regulations and economic instruments of control. As examples of these, mention may be made of research and development and environmental requirements upon purchase.

In both the short and long-term the regulation of vessels and fuels are seen to be a principal line to follow. Economic instruments of control are, at the same time, important complements in order to promote the development of new technology, stimulate the employment of existing technology and create the conditions for a more aggressive regulation policy. Economic instruments of control also possess the potential for stimulating special efforts in specific areas where the environmental problems are worse or where the environmental ambitions are greater than in other quarters.

[65] Swahn, Swahn, 2007,

8. Summary and conclusions

- Shipping's emissions of sulphur and nitrogen oxides are considerable and further measures for reducing emissions from the sector are urgently needed.
- It is technically possible to formulate satisfactory administrative procedures for an emission trading system for sulphur and nitrogen oxides in which shipping is included.
- The question of the extent to which there is interchangeability between emissions of nitrogen and sulphur oxides, respectively, on land, at sea and between different regions, is of fundamental importance in this context and requires further analysis.
- Provided that there is interchangeability between emissions from different emissions locations, the emissions trading system has, to different degrees, at least in the short and medium-term, a theoretical potential for contributing towards significant improvements in efficiency.
- Systems for trading with emissions rights for sulphur and nitrogen oxides, in which shipping is included, should be dealt with in an international context.
- In the short-term, international law constitutes significant restrictions with regard to how emission trading systems can be formulated.
- The report does not adopt a position regarding whether any system for trading with emission rights should be introduced or how, in such an event, it should be formulated.

The emission of nitrogen and sulphur oxides in Europe and at sea in its vicinity, causes health and environmental problems. Significant measures have been taken on land. In Europe, land-based companies' emissions of sulphur and nitrogen oxides are still greater than those of shipping but, according to current forecasts based on decisions taken to date, it is anticipated that shipping's emissions of these pollutants will be greater than land-based sources' emissions within a fifteen year period, unless further measures being taken.

As a consequence of the measures on the sea-side being small in comparison with the land-side, the costs of further emissions reductions, especially for nitrogen oxides, are – at the same time – considerably lower at sea than on land. There is no reason to expect that an adjustment, of the desired rate and extent, will occur spontaneously within shipping. It is therefore highly important that further instruments of control are introduced in order to limit shipping's emissions of these pollutants.

It is probable that problems with shipping's emissions of air pollutants shall, in the longer term, be able to be solved efficiently and at low costs through making use of the technical development and technical requirements relating to vessels and fuels. The development may then be likened to what we see on the roads. In such a world the value of other instruments of control, such as emissions trading or environmental charges, are significantly lower than at present. All experiences indicate, however, that the development within shipping proceeds very slowly. The industry's global nature and a decision system in international forum that is based on consensus, severely inhibits the rate of development. When possible instruments of control for limiting shipping's emissions are discussed, it is therefore important to try to formulate these in such a way that they can have the means of achieving faster acceptance than the international technical requirements that can be expected. Instruments of control that can be introduced relatively quickly can bridge the period between the present and the future when technical requirements, followed by technical development and innovation, have more or less eliminated the shipping problem of sulphur and nitrogen oxide emissions. If a system for trading with emissions rights takes as long to introduce as international technical regulation, then it has a limited potential for contributing towards environmental adjustment of shipping, compared with a system that can be introduced earlier.

One conclusion is that a system for trading with emissions rights for sulphur and nitrogen oxides, where shipping is included, should be discussed and decided upon within an international context. The environmental problems in question are trans-national. Shipping is an international industry at the same time that the trading system's potential grows with the size and number of sources that are included. Any emissions trading system should, right from the start, be formulated so that the administrative systems can also be employed for trading systems in respect of other substances and also make it possible for other countries or regions to be involved.

In this present report a perspective is constructed that involves a system being introduced for shipping in the Baltic and the North Sea at the same time as it covers all countries that lie around the coasts. This demarcation applies to both the systems that, according to the commission, are to be examined: both the open, cross-sector trading system and the closed system where only shipping is included. A focus on the Baltic and the North Sea does not, however, mean that analysis and conclusions are irrelevant for a more restricted introduction, e.g. in only the North Sea or the Baltic

In order for trading with emissions to have the prerequisites for justification, it is generally required:

- That there be an interchangeability between relevant emissions from different sources, and
- that the costs of measures vary between different sources.

The question of the extent to which there is interchangeability between emissions of nitrogen and sulphur oxides, respectively, on land, at sea and between different regions has been accorded considerable attention in this work. The report does not, however, arrive at any final assessment of the matter. A strong recommendation is, therefore, for the matter to be given priority if the government wishes to proceed further with an analysis of a trading system of this kind. It would be interesting to theoretically analyse, with existing emission dispersion models, how the environmental loading (deposits, background counts) affects different regions' dependence upon where a certain emission production is undertaken.

In the report it is stated how emissions trading systems for sulphur and nitrogen oxides that cover shipping, can be formulated and administered. It is noted that, in technical terms, it is fully possible to formulate fully satisfactory administrative procedures for such systems.

The model built up to describe shipping's costs for reducing emissions of nitrogen oxides within the demarcation area shows, for example, that the costs of measures vary considerably within shipping. It depends primarily on the vessels' traffic patterns. Investments in cleansing equipment on vessels that always ply within the demarcation area contribute to emissions reductions in the area during all operating hours, while the situation is quite different for vessels that are in ocean-going trade. For these vessels the corresponding investments have an effect in the form of decreased emission within the area for only a small part of the overall operating time.

The costs of measures per ton emissions reduction also varies considerably depending on where in its life cycle the vessel finds itself. Measures are cheaper with newbuilding and with retrofit while retrofit also has, to some extent, to be depreciated over fewer years. The latter applies in particular to older vessels that approach the time for scrapping. To some extent differences in vessels' costs of measures also depend to separate technical properties and individual formulation.

The model calculations indicate that a halving of shipping's emissions of nitrogen oxide in the demarcation area (500 000 tons per year) can be achieved at an average cost of c. 0.70 € per kg nitrogen oxides. A general regulation for all vessels, with the intention that they shall halve their individual emissions, is correspondingly calculated to require an average adjustment cost of almost 2.70 € per kg nitrogen oxides. The difference in costs of measures between regulation and trading illustrates the potential social benefits that are inherent in an internal trading system for shipping. The cost differences are due to the regulation alternative also forcing through measures for vessels where the costs of measures are very high, e.g. as a result of vessels plying within the demarcation area for only a short while. The social benefits may, according to the model, amount to c. 1 billion € per year.

An open system (trading within an emissions bubble or credit-based trading) that permits trading between land and sea has, compared with an internal shipping industry system, further theoretical potential, which can be illustrated by means of a calculation example. If the costs of measures on the land-side are deemed to be 4 € per kg nitrogen oxides and trading to an extent of 500 000 tons nitrogen oxides a year can be achieved, the adjustment costs of a reduction of the nitrogen oxide emissions in the demarcation area can be lowered by almost 85 percent or 2 billion € a year if future emissions reductions can be moved from land to sea.

Regarding the potential of different systems in terms of efficiency and emissions reduction, the report primarily analyses nitrogen oxides. The current trading with emissions rights for sulphur appears to have a lower potential in an internal shipping system as a consequence of the costs of measures between different vessels varying to a lesser degree. To take the most obvious and competitive measures – to employ low-sulphur bunkers – costs, in principle, is the same per reduced ton for all vessels. For an open system the costs of measures between the sectors can, on the other hand, be greater as can also the potential social benefits.

The closed emissions trading system that is outlined in the report is more completely described than the open one in the sense that it describes both the system's supply and demand side. The system requires the development of a common view between the demarcation area's coastal states. The closed, internal shipping system, has advantages in that it does not require changes to international legislation, that it corresponds to the polluter pays principle and that its reduction potential should be relatively considerable. A disadvantage is that distortion of competition can be expected, primarily to the disadvantage of ports on the periphery of the demarcation area. The theoretical potential for social benefits is considerable. The closed system is probably associated with fewer problems connected to the emissions' damage costs varying between different sources that are covered by the system, compared with the open system.

As reported, the demand side in an open, cross-sector system, can be structured in different ways.

The alternative that lies closest to economic theory is probably that of creating a system where both sectors take part on the same premises. They are given the same reference levels in terms of, e.g. emissions of nitrogen oxides per employed ton of oil or oil equivalent if they are formulated as a system for credit-based trading. At least in theory it should also be possible to formulate a corresponding system with trading within a common emissions bubble. Such a system's advantages lie primarily in it fulfilling the principle of the polluter paying, that the reduction potential is considerable and also that the potential social benefits are considerable – greater than in the closed system. As with other open systems this should, in principle, be able to contribute towards evening out any costs of measures on the land-side and thereby give rise to establishing more equal competition conditions between land industries. The alternative requires, however, an extensive legal development work. Common views are required at the EU level since several EEC directives need to be amended in order to clear the way for the system's land-side. A standard system that also covers transit shipping, that does not call at ports in the demarcation area, also requires changes to the international maritime law convention.

An open system may, in principle, be formulated so that shipping takes part voluntarily and trades in relation to a ”bubble” on the land-side that is created through land plants, upon reconsiderations of licenses, being permitted to trade with a certain proportion of the reduction level that is determined according to the principle of best available technology. Such an alternative does not equate with the polluter pays principle and the reduction potential is smaller. The alternative has the advantage of not requiring complicated regulation on the sea-side. On the other hand it is necessary to create a common view around the proposal at the EU level. In this alternative, too, it is necessary for several EEC directives that regulate emissions on the land-side to be amended.

In the report the possibility is also discussed of creating demand for emissions credits in an open system by raising the requirements for regulated industry on the land-side. The alternative does not satisfy the polluter pays principle and should not be regarded as an emissions trading system but be seen, instead, as an activity for the financing of subsidies for another one. The alternative has the advantage of not requiring changes to the EEC legislation. As with the closed system for shipping it is enough for a common view to be achieved between the demarcation area's coastal states.

The possibility of creating demand for emissions credits by states buying these has an advantage in the simple legal superstructure. It is required that the participating countries achieve a common view, but it is unlikely that any change to international law will be required. The system has a disadvantage in that the polluter pays principle is not achieved and that it constitutes a burden on the respective countries' state budgets. In addition such a system has to be formulated in such a way that it does not come into conflict with the EEC's state aid rules.

The report does not adopt a position regarding how any system for trading with emissions rights should be introduced or how, in such an event, it should be set up. On the other hand it is noted that there are important aspects that remain to be resolved and certain circumstances that need to be accorded special attention. It would probably be appropriate for countries around the Baltic and the North Sea to be involved in further analysis of the area.

The interchangeability between emissions at sea and on land, as stated previously, needs to be studied further. Is it satisfactory in this present context to assess relevant emissions on land in different regions and in the North Sea and the Baltic, respectively, alike or should a system include an ”exchange rate” in order to deal with the emissions' differing damage costs?

Existing regulations constitute, in the short and medium-term, limitations to how a trading system for emissions can be set up. The current European legislation imposes, for example, requirements governing the use of the best available technology for emissions from many land plants and provides small or no possibilities of permitting emissions on land against emissions reductions at sea. In order to create an efficient trading system that also encompasses the land-side, three EEC directives need to be amended, as stated. It is necessary to achieve a common view regarding the basic thinking behind a trading system throughout the entire circle of member countries, not merely the coastal states around the North Sea and the Baltic. A theoretically shortest time to achieve such amendments is assessed as being 3 to 4 years. Such amendments would thus not be able to be carried out before year 2012 at the absolute earliest.

The UN's convention on law of the sea prevents impositions on vessels that pass through a nation's waters without making port calls. For vessels that call at a port a state has a greater opportunity of introducing instruments of control such as the Swedish environmentally differentiated fairway dues.

At the same time as international law represents a moderating factor on opportunities for introducing systems for trading with emissions rights there are currently discussions regarding emissions trading being conducted within the EU and IMO.

Emissions trading for sulphur and nitrogen oxides can potentially replace other instruments of control for reduced emissions, but will probably never be able to constitute the only instrument of control in this area. Special regulations will, with great certainty, be required in the foreseeable future in order to guarantee environmental quality locally. It cannot be precluded, for example, that even with the introduction of emissions trading there will still be a rationale for environmentally differentiated port and fairway dues in Sweden.

A theoretically natural alternative to trading with emissions rights may be to introduce a standard system for environmental charges for shipping's emissions of sulphur and nitrogen oxides. In technical terms the difficulties are largely the same as for a trading system. Vessel emissions must be certified and controlled and knowledge is required in order to determine whether the charges are to be differentiated between different areas in a manner that, in a trading system, is reflected in an exchange rate. The big difference lies more in how costs and resources are to be distributed.

With a charges system the shipping industry would, on the one hand, pay the adjustment costs relating to environmentally-friendly technology that are made, including the administration and, on the other hand, an environmental cost (charge) for the remaining emissions. Such an arrangement is reasonable, viewed from an environmental policy and transport policy perspective. It may, however, be presupposed that the shipping industry will be negative. An important question would also be how the income from an international charges system would be distributed. Is it to be passed back to those who are affected by the emissions, to the participating countries according to the extent of the traffic within their territorial waters or within an economic zone, or shall it be fed directly back to the industry? If the charges system is set up so that the income from it is paid back to the industry then the consequences of that are similar in character, compared with a closed internal shipping trading system.

With an open system of the type outlined in the report, there is no reason to anticipate any opposition from shipping. They take part voluntarily and can, through selling emissions credits, have all their costs of adapting their vessels environmentally, covered. If such a system is formulated in a way that involves further requirements, over and above those imposed under existing legislation, this involves further requirements for land plants and opposition form land-based industry can be expected.

If, on the other hand, it is possible to introduce a system that means that land-based industry can compensate costly measures relating to their installations through buying emissions credits from shipping, then both sides can emerge as winners. This means, however, that expected emissions reductions on land will be absent.

It is important for any trading system for emissions rights to be set up so that it does not jeopardise adjustments aimed at environmental targets but, on the contrary, accelerates a development in this desirable direction.

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Annexe 1. Vessels with nitrogen oxide discount in the Swedish fairway dues system

Vessels with a nitrogen oxide certificate, type of measure and calculated reduction of emissions. The Swedish Maritime Administration, which does not pay fairway dues, has been tinted in blue in the table. Source: The Swedish Maritime Administration.

Name of ship	Type	First approval date	Emission level g/kWh		Reduction in tonnes/ year compared to a conventional ship	Measure
			Before	After 1st certifi-cation		
Atle	Icebreaker	1999-06-03	15,00	2,00	Variable	SCR
Aurora	Pass	2003-01-07	14,50	3,71	612	SCR
Balder Viking	Icebreaker		14,50	3,50	Variable	SCR
Baltic Press	Ro-ro	2005-12-28	14,50	8,60	104	EIM
Baltic Print	Ro-ro	2005-12-05	14,50	8,50	104	EIM
Balticborg	Ro-ro	2004-09-01	14,50	2,50	802	SCR
Birka Exporter	Ro-ro	2003-12-03	14,50	1,30	541	SCR
Birka Paradise	Pass	2004-11-10	14,50	0,40	2127	SCR
Birka Princess	Pass	2002-05-13	14,50	0,54	1393	SCR
Birka Shipper	Ro-ro	2001-11-28	14,50	1,30	533	SCR
Birka Transporter	Ro-ro	2002-11-18	14,50	1,20	537	SCR
Bothniaborg	Ro-ro	2005-02-22	14,50	1,90	842	SCR
Cellus	General cargo	2001-11-27	14,50	1,30	358	SCR
Forester	Dry cargo	2003-08-26	14,50	1,90	235	SCR
Gotland	Ro-pax	2003-12-18	14,50	1,60	3107	SCR
Gotlandia II SKWR	Pass	2006-05-09	14,50	1,57	2125	SCR
Hamlet	Pass	2006-10-25	14,50	0,30	472	SCR
HSC Gotland_SJLC	Pass HSC	2002-12-05	14,50	0,80	1781	SCR
Mariella	Ro-pax	2001-07-03	15,00	4,40	1070	HAM
Mercandia IV	Pass- and car	2007-01-09	14,50	1,30	145	SCR
Mercandia VIII	Pass- and car	2007-01-09	14,50	1,10	147	SCR

Navigo	Tanker	2002-07-03	15,00	7,80	301	Magnetizer
Obbola	Ro-ro	2004-11-03	14,50	1,00	818	SCR
Ortviken	Ro-ro	1999-12-15	14,50	0,80	818	SCR
Scandica	Work vessel	1994-12-19	12,00	0,80	Variable	SCR
Schieborg	Ro-ro	2003-08-26	15,00	2,00	1156	SCR
Sigyn	Nuketrpship	2002-08-20	14,50	1,10	Variable	SCR
Silja Europa	Ro-pax	2003-05-23	15,00	2,60	2216	SCR
Silja Festival	Ro-pax	2001-05-23	14,50	4,20	1552	SCR
Silja Serenade	Ro-pax	2002-08-29	14,50	5,94	1652	Waterinj + SCR
Silja Symphony	Ro-pax	2002-09-23	14,50	5,51	1685	Waterinj + SCR
Slingeborg	Ro-ro	2000-11-20	14,50	1,80	1132	SCR
Spaarneborg	Ro-ro	2000-12-06	14,50	2,50	1117	SCR
Stena Jutlandica	Ro-pax	1998-12-22	14,50	1,30	1915	SCR
TransPulp	Ro-ro	2007-03-15	14,50	0,40	1806	SCR
Thjelvar	Ro-pax	2001-12-10	14,50	0,60	1054	SCR
Timbus	General cargo	2003-03-21	15,00	1,60	375	SCR
Tor Viking	Icebreaker		15,00	3,50	Variable	SCR
Transpaper	Roro	2006-11-06	14,50	0,40	1806	SCR
Tycho Brahe	Pass	2006-12-05	14,50	0,30	612	SCR
Vidar Viking	Icebreaker		14,50	3,50	Variable	SCR
Viking Cinderella	Pass	2003-10-02	14,50	0,40	2420	SCR
Viktoria I	Ro-pax	2004-06-24	14,50	3,90	1548	SCR
Visby	Ro-pax	2001-12-10	14,50	1,60	3107	SCR
Östrand	Roro	2004-11-16	14,50	1,20	806	SCR
Total, excluding icebreakers and work vessels					45326	

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