Background paper for discussion of air pollution from ships in harbours, Improved fuel quality, Energy from onshore facilities, and other options.
By the North Sea Commission, NSC, August, 2004

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1. Background

<u>1.1 Why focus on pollution in ports?</u>
Compared to other modes of transport, shipping has several environmental advantages. The energy demand is relatively low, counted per unit goods. It has few problems with traffic congestion, noise and use of land. Shipping thus has the potential to become a sustainable way of transportation, but there are some problems to deal with. One of them is the emission of air pollution by ships in or near ports. These are generally quite large, particularly compared to the amounts emitted by vehicles on shore. Such vehicles are often subject to various pollution restrictions, which do not cover the ships.

In-port emissions are of particular interest to local air quality, as they often take place close to areas where people live or work. Consequently, the main focus here is on the health impacts of air pollutant emissions. But reducing in-port emissions also contributes to lowering the overall pollution load, which will benefit health and the environment on a regional scale as well.

One solution to the problem of air pollution from ships´ engines in harbours is mentioned in paragraph 44 iv of the Bergen Declaration 2002: "*convenient and cost effective onshore facilities for energy provision*". The North Sea Ministers "*agree to encourage harbour authorities to examine the feasibility of making [such facilities] available ...*" This option is described in item 2.2 of this paper, including the results of a brand new study in this field.

However, at the 3rd meeting of the IGSS in March 2004, discussions (prompted by an earlier version of this paper) indicated an interest in development of two main options. In addition to shore-side electricity – which may be considered a solution, which is particularly relevant in certain circumstances – there was general interest in discussing improved fuel quality and the reliable supply of controlled quality fuels to the shipping industry. Item 2.1 of this paper therefore sets out to explore this latter option.

Finally, this paper briefly describes a few other options – short term and long term – to address the problem of air pollution from ships in harbours.

1.2 What are the most relevant pollutants in ports?

The combustion of marine fuels results in emissions of air pollutants, such as sulphur dioxide (SO_2), nitrogen oxides (NOx), particulate matter (PM), and volatile organic compounds (VOCs), including polycyclic aromatics (PCAs). The emissions of SO_2 and NOx give rise to secondary inorganic sulphate and nitrate particles, and NOx- and VOC-emissions contribute to the formation of ground-level ozone. These air pollutants can damage human health, vegetation and the built environment, and contribute to acidification and eutrophication, damaging sensitive and important ecosystems.

One important aspect, which has not attracted much attention until recently, is the very high amounts of polycyclic aromatics (PCAs) in the marine residual fuel and sometimes in the marine diesel oil. For this reason the marine residual fuel is classified as Cancerogenic Cat. 2 according to EU classification criteria, and some studies have shown that quite large amounts of polyaromatics are emitted via engine exhaust. Many ships today use marine residual fuel for their auxiliary engines at berth.

There are no regulations as regards how much PCA a marine residual fuel or a marine diesel fuel may contain. Residual fuels may consist of about 20 % PCA whereas the fuel for heavy diesel trucks on shore in Sweden must not contain more than 0.02% PCA (Swedish Environmental Class 1).

Measurements of PAH (polycyclic aromatic hydrocarbons) made in the exhaust from ships using marine residual fuels, reveal that the emission seems to correlate strongly with the amount PAC in the fuel. A rough estimation shows that one large ship entering a Swedish harbour on marine residual fuel may correspond to the PAH emission from about 1200 heavy diesel trucks on shore.

2. Solutions short term

There are a number of measures available today, aimed at reducing in-port emissions, and still more options are being developed for the future. A list can be summarised like this:

Measures aimed at reducing in-port emissions – techniques currently available:

2.1 Improved fuel quality
2.2 Connection to shore-side electricity
2.3 NOx reduction techniques
2.4 SO_2 abatement technology
2.5 Vapour recovery

2.1 Improved fuel quality

As emissions of SO_2 are directly proportional to the sulphur content of the fuel, the simplest way to reduce these emissions is by using low sulphur fuel. The European Commission suggests – in its proposal from November 2002 to amend directive 1999/32/EC regarding the sulphur content of marine fuels – that the sulphur content of marine fuels used by ships at berth in all Community ports shall not exceed 0.2%, and that this limit should be lowered to 0.1% sulphur as from 1 January 2008. According to the Commission, "this approach is proportionate, practical and easily enforceable, and will improve local air quality by reducing ships' emissions of SO_2, PM and NOx in ports." (See also section 4.2, economic benefits, below.)

Recent studies indicate that the emissions of PAHs are ten times higher per unit of energy from the burning of high-sulphur heavy fuel oil than from low-sulphur marine gas oil. Consequently, a major change to low-sulphur gas oils (max 0.2%S) in port areas would also significantly reduce local emissions of PAHs. To get full impact of this measure in densely populated harbour areas however, the cleaner fuel should be used not only at berth but in the whole harbour area. A definition of the harbour area could – for example – be within the points where a pilot is supposed to be on board.

- The North Sea Commission therefore proposes to the IGSS meeting to discuss including the use of low sulphur and low PAH fuel in densely populated harbour areas as an important parameter defining the Clean Ship.

In this context it is essential to emphasise the right of ship-owners to be able to rely on a supply of controlled quality fuels, just like the right enjoyed by any user of fuels on land. This is not the case today. In order to ensure environmental performance and safety of shipping, there is an urgent need to develop and establish mandatory international quality standards for marine fuels along similar lines as the current fuel quality legislation for road vehicle fuels in e.g. the European Union. This would mean that the producer of the fuel is legally responsible for the quality of the fuel. Ideally, binding regulation on marine fuel quality should be agreed and adopted globally, but in order to initiate such a process, the EU should start drafting a directive on marine fuels quality without undue delay.

There are indications from bunker operations in Europe and around the world that sometimes hazardous waste, or waste endangering the ship´s operational safety, finds the way into marine residual oils. This additionally emphasises the need of international fuel quality legislation and also an open control system, where important parameters are included and violation against limits can lead to legal action. A general advantage of changing to environmentally standardised and controlled fuels is that it may contribute to substantially reduced harmful emissions not only in harbours but also at sea.

Parameters of general interest from an environmental point of view are for example sulphur (S), polycyclic aromatics (PCA, PAH), calcium (Ca), phosphorous (P), zinc (Zn), total organic chlorine, density.

- The North Sea Commission therefore proposes to the IGSS meeting to discuss aside of the Clean Ship Approach bringing up the initiative for a directive on marine fuels quality within the EU to the CONSSO meeting in October, as an issue for the Ministerial Meeting in 2006.

2.2 Connection to shore-side electricity

Shore-connected electricity can be used to replace the burning of marine fuel oil in ships' auxiliary engines while berthed at quay, thus reducing both air pollutant emissions and noise. This has positive effects also on the working environment on and near berthed ships. There are examples of shore-side electricity being used in various parts of the world, a.o. at quays for cruise ships and naval ships. For the continued discussion in the IGSS it seems most relevant to first look at examples in the North Sea area.

A recent study[1] on shore-side electricity for ships (attached) – produced on behalf of the North Sea Commission – investigates the practicalities, costs and benefits of such systems. This study has also done some "example calculations" for specific ship services in the North Sea. As shown in this study, the environmental benefit achieved depends on a number of factors, such as the time the vessel is berthed at quay, the fuels used, the performance of the engines, etc.

In brief the conclusions of the study are:
The external costs associated with emissions of air pollutants from ships in port are significantly lower for ships connected to shore-side electricity, even though the land-based electricity was assumed to emanate solely from coal-fired power stations. (The resulting positive effects would be even greater if the electricity supplied were to be generated from renewable sources.)

However, the direct cost for shore-side electricity is 2-4 times higher than the direct costs of generating electricity onboard by auxiliary engines running on heavy fuel oil. (A part of this higher cost consists of energy taxes paid for land-based electricity.)

Finally, a comparison between the estimated external costs and the direct costs of electricity generation shows that the external emission costs for onboard power generation are <u>much</u> higher than the total direct costs for electricity from a shore-side power connection. This illustrates that the benefits associated with shore-side electricity connection clearly outweigh the costs for those systems. It was also shown that shore-side electricity is particularly suitable at quays where the same ships make regular calls. The North Sea has numerous such harbours.

The advantages of shore-side electricity are recognised by the European Commission, which in its Communication[2] from November 2002, on an EU strategy to reduce atmospheric emissions from seagoing ships, urges port authorities to require, incentivise or facilitate ships use of land-based electricity or clean onboard power while hotelling in port.

So far only very few ports have taken such action, and consequently there is an urgent need for action. Co-ordinated action for a sea area such as the North Sea will be useful also to ensure the development of uniform systems between the ports.

Therefore the North Sea Commission would like to propose to the IGSS meeting to:

- Discuss the inclusion of measures that facilitate ships use of shore-side electricity in port as a parameter defining the Clean Ship.

- Discuss bringing proposals that promote ships use of shore-side electricity to the CONSSO meeting in October, as an issue for the Ministerial Meeting in 2006. This would be in line with paragraph 44 iv of the Bergen Declaration.

[1] **"Shore-Side Electricity for Ships in Ports – Case studies with estimates of internal and external costs"**. Report 2004-07-06. By Karl Jivén, MariTerm AB, Gothenburg, Sweden. www.mariterm.se

[2] **"A European Union strategy to reduce atmospheric emissions from seagoing ships."** Communication from the Commission to the EP and the Council. COM(2002) 595 final. European Commission. November 2002.

2.3 NOx reduction techniques

- Selective catalytic reduction (SCR) is a system for after-treatment of the exhaust gases that can reduce NOx-emissions by more than 90%. When retro-fitted it replaces the exhaust silencers.
- Humid air motor (HAM) is a technique for preventing the formation of NOx during combustion by adding water vapour to the combustion air. The method is able to reduce NOx by 70-80%.
- Water injection and water emulsion. Water is injected in the combustion chamber or mixed with the fuel in order to lower the temperature of combustion and hence reduce NOx formation. The potential for emission reduction is around 30-50%.

A general advantage of introducing NOx reduction techniques is that such a change may contribute to substantially reduced harmful emissions not only in ports but also at sea.

2.4 SO_2 abatement technology

Tests of seawater scrubbing as a means of reducing the emissions of air pollutants have recently been initiated. Scrubbing the exhaust gases with seawater brings the sulphur from the gas to the water. After this process, the seawater is filtered to remove particulates, which are trapped and collected for disposal. The seawater is re-circulated back into the sea, where the SO_2 goes into solution as sulphate. It is estimated that this process can cut SO_2 emissions by 95%, and particles by 80%. However, it still remains to be demonstrated if this cleaning technology is environmentally suitable in all types of environments, such as shallow waters, brackish waters, and enclosed port areas.

2.5 Vapour recovery

The loading of petroleum products gives rise to evaporative emissions of VOCs, which can be reduced by more than 95% by the use of vapour recovery systems.

- Example, Port of Göteborg, Sweden.

Emissions of more than 400 tonnes VOC per year are avoided in Göteborg as a result of a collaboration between Preem, Shell, shipowner from the Swedish Shipowners´ Association, The City Environmental Authorities and the Port of Göteborg. In the beginning of the year 2001 a vapour recovery system was installed. Apart from the environmental benefits, the working environment has very much been improved. The costs to reduce the emission is about 20 SEK(€2.2) per kilo.

3. Solutions long term

Measures aimed at reducing in-port emissions – techniques under development:

3.1 Fuel cells, hydrogen powered

Fuel cells can, for instance, be used for the propulsion of ships or to generate the power needed by ships in ports. Fuel cells can be powered by a number of fuels, one promising alternative for the longer term is hydrogen.

Example 1, a development project in Stenungsund, Västra Götaland, Sweden, with the purpose to demonstrate the use of on board fuel cells as an Auxiliary Power Unit (APU) for ships in port. Hydrogen produced as by-product from the petrochemical industry will be used to power the fuel cells. In a future sustainable system the hydrogen has to be produced from renewable sources.

Example 2, similar projects in Norway are an EU supported r&d project, FCSHIP, and a project run by Det Norske Veritas.

3.2 Other energy sources

There are a number of other possible energy supply solutions for APUs and ship propulsion. Examples are methane gas (biogas, natural gas), alcohols (methanol, ethanol), Fischer-Tropsch liquids (synthetic paraffines, more clean-burning diesel substitutes) and battery systems.

4. Discussion

It is clear that a wide range of measures are already available that could significantly reduce in-port emissions of air pollutants. Moreover, in the longer term even more options are expected to become available.

4.1 Incentives for change

A crucial question is how this type of measures can be promoted. Here, too, several options are available, that could be applied either individually or in various combinations:

- Legal requirements (at national, EU, or global level)
- Economic instruments (at local, national, EU, or global level)
- Voluntary agreements
- Procurement demands
- Economic support e.g. for promoting the development and application of environmentally sound techniques and behaviour

Whereas more ”formal” incentives like legal requirements and economic instruments may take a longer time to introduce, voluntary agreements and procurement demands can be introduced relatively instantly by the market forces.

Some cargo owners are eager to show that their whole chain of production and transportation takes careful account of environmental aspects. Therefore they may become more interested in taking responsibility for the environmental standard of their transports – including the environmental and health impacts of emissions to air from ships in harbours. Shipping companies which are ”in the public eye”, such as cruise ships and passenger ferries, may also prefer to take such responsibility.

4.2 Economic benefits

Regardless of which instrument or combination of instruments that is used to promote the implementation of measures to reduce pollution from ships in or near ports, it is quite clear that there is a lot to be gained economically. Reductions in air pollutants have a number of direct benefits to human health and environment. Some of these benefits can be converted into monetary form by attaching a benefit to each tonne of pollutant reduced. Such calculations have a.o. been made in the aforementioned study by MariTerm AB. Methodologies are however not yet available to monetize the benefits to ecosystems.

The monetized benefits estimated by the European Commission, and used to assess its proposal for 0.2% sulphur limit in marine fuels used in ports, take into account effects on human health as well as effects on crops and modern building materials. The values for EU port areas were based on the assumption that half of the ports are in rural areas and half are in cities having 100,000 population. This is a conservative estimate because of the 50 EU ports with the highest emissions, ten have populations of around 500,000 or more. In order of emissions, these are Hamburg, Barcelona, Genoa, London, Amsterdam, Thessaloniki, Naples, Lisbon, Dublin and Copenhagen. Of these, five are EU capitals and four have populations around 1 million or more.

In these densely populated areas the monetized benefit per tonne of SO_2 and PM reduced will be 5 to 15 times greater than the estimated benefit used for the purpose of the general cost-benefit analysis, because more people benefit from the emissions reductions.

The EU cost-benefit analysis demonstrated that the benefits significantly outweigh the costs. In fact, for the in-ports proposal, the fuel price premium for 0.2% sulphur marine fuel would have to rise to 400 euros per tonne before costs would exceed benefits.

(The facts and figures on benefits presented in this section are taken from the Explanatory Memorandum published by the European Commission together with its proposal to amend directive 1999/32 as regards the sulphur content of marine fuels - Document COM(2002) 595 final, Volume II - of 20 November, 2002.)

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