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MERENKULKUALAN KOULUTUS- JA TUTKIMUSKESKUKSEN JULKAISUJA

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SHIP ORIGINATED AIR EMISSIONS, SOLID WASTE AND WASTEWATERS - a Feasibility Study of the New Hansa Project

Kalli Juha, Alhosalo Minna, Erkkilä Anne, Åkerström Jari & Sundberg Pekka

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SUMMARY

The drainage area of the Baltic Sea is densely populated with heavy urban, industrial and agricultural centres having vivid traffic from and to the Baltic Sea Region. This causes heavy environmental loading and environmental problems in the Baltic coastal and sea areas. The Baltic Sea is an extremely sensitive shallow brackish water basin with unique coastal regions and archipelagos, which exacerbates the effects of the environmental loading. Therefore, the environmental management following the principles of sustainable development is crucial for the successful regional development of the Baltic Sea area.

Marine transport traffic is increasing in the Baltic Sea, thus increasing concerns over ship-generated atmospheric emissions, solid waste and wastewater management. Management of environmental issues in international shipping is regulated by international conventions by International Maritime Organization (IMO) and within the Baltic Sea by the European Union (EU) and the Helsinki Commission (HELCOM). However, a need to develop more sustainable port policies for the Baltic ports has emerged among the Baltic cities, the aim being the developing of successful methods and improvement of the environmental management and co-operation between ports, cities and shipping companies in the Baltic Sea region. From this starting point, the New Hansa of Sustainable Ports and Cities project was introduced.

The project aimed at developing ports (practices and policies) as parts of sustainable transport corridors for improved spatial integration in the Baltic Sea region. This will be achieved by harmonising a number of environmental management practices with regard to ships in ports and by speeding up the implementation of sustainable port policies in all main ports of the Baltic Sea region. The problems addressed have economic, social and environmental aspects as well as considerable territorial impacts calling for integrated solutions. These solutions necessarily need to be developed in strong co-operation of ports, port cities and stakeholders on all sides of the Baltic Sea. Specifically, the project concentrated on harmonising and strengthening the policies and practices to reduce air emissions, wastewater discharges and solid waste generation and to improve reception practices of ship-generated wastes in ports.

The project included a feasibility study that comprises basic information about the emissions of shipping, their effects on ports' operating methods and spatial planning and recommendations for ports and ship operators in forms of best practises and harmonization proposals. The results and recommendations of this study have been taken into account when the joint policy document - Baltic Memorandum of understanding on sustainable port and maritime policy in the Baltic Sea region - has been written. This study is part financed by the European Union (European Regional Development Fund) within the BSR INTERREG III B programme and within the project "New Hansa of Sustainable Ports and Cities".

The conclusions and recommendations of the feasibility study are based mainly on the data collected from the project partners and the topics discussed in project meetings and visits. Following are the recommendations for ports to improve and harmonize the environmental management of ship-generated atmospheric emissions, waste and wastewaters:

1. Introduction of economic incentives and co-operation between ports in developing them
2. Introduction of shore-to-ship electricity wherever possible
3. Harmonization and improvement of waste collection and management in ports
4. Encouragement to discharge sewage ashore to prevent the discharges on the open sea
5. The active promotion of the environmentally sustainable best practices (promoting the sustainable development as a competitive advantage, co-operation with the stakeholders)
6. Gaining the knowledge about ambient environment for harmonization of the environmental management of the ports in the Baltic Sea region.

Key words

Environmental management, shipping, sustainable development, ports, atmospheric emissions, wastewater, solid waste, Baltic Sea, coastal regions

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2. THE AIMS AND IMPLEMENTATION OF THE PROJECT

The drainage area of the Baltic Sea is densely populated with its hundreds of millions of habitants. There are large urban, industrial and agricultural centres and vivid traffic from and to the Baltic Sea region. Human activities with variety of industries and increasing traffic cause heavy environmental loading, environmental problems and risks in the coastal and sea areas. On the other hand, important recreation areas and globally unique archipelagos are situated in the Baltic Sea region. The Baltic Sea is an extremely sensitive shallow brackish water basin, which exacerbates the effects of the environmental loading. Therefore the environmental management following the principles of sustainable development is crucial for the successful regional development of the Baltic Sea area.

Several years of co-operation of port cities and ports within the Union of the Baltic Cities (UBC) have shown that there is a common need and a wide interest to develop sustainable port policies in the Baltic Sea region, which led to the establishment of **The New Hansa of Sustainable Ports and Cities** project. The project started in 2003 and ended in the end of 2005. It was a joint project of 18 ports, cities and other partners from all parts of the Baltic Sea. Following were the partners of the project: Stadtwerke Lübeck GmbH (as a lead partner), Hanseatic City of Lübeck, Baltic Energy Forum e.V. (BEF as a coordinator), City of Stockholm, City of Helsinki, Port of Helsinki, City of Malmö, City of Turku, City of Pori, City of Mariehamn, Port of Kolding, Port of Rostock, Ports of Stockholm, Port of Turku, Ports of Szczecin and Swinoujscie, the Centre for Maritime Studies (CMS) of the University of Turku, Union of the Baltic Cities (UBC) and Finnlines Plc.

2.1 Aims of The New Hansa of Sustainable Ports and Cities project

The project aimed at developing the ports (practices and policies) as parts of sustainable transport corridors for improved spatial integration in the Baltic Sea region. This will be achieved by harmonising a number of environmental management practices with regard to ships in ports and by speeding up the implementation of sustainable port policies in all main ports of the Baltic Sea region. The problems addressed have economic, social and environmental aspects as well as considerable territorial impacts – and they call for integrated solutions. These solutions necessarily need to be developed in strong co-operation of ports, port cities and stakeholders on all sides of the Baltic Sea. Specifically, the project concentrates on harmonising and strengthening the policies and practices to reduce air emissions, wastewater discharges and solid waste generation and to improve reception practices of ship-generated wastes in ports.

2.2 The Memorandum of Understanding (MoU) on Sustainable Port and Maritime Policy in the Baltic Sea Region

On the Baltic Sea regional strategic level the most important outcome of the project will be the joint policy document – the Memorandum of Understanding (MoU) on Sustainable Port and Maritime Policy in the Baltic Sea Region. Through the Union of the Baltic Cities (102 members, 12-year-record of East-West co-operation), wide support and commitment will be sought to the MoU among the port cities, the ports and all stakeholders.

2.3 The four Work Packages of The New Hansa of Sustainable Ports and Cities project

In practice, the project is divided in four Work Packages (referred hereinafter also as WP). The Work Packages 1 - 3 will produce environmental data, analysis of environmental, socio-economic and territorial impacts, as well as information on the relevant national, European and international legal frameworks, and best practices with regard to the issues of ship-generated atmospheric emissions, wastes and waste waters and their management practices and regulations in the different ports. These Work Packages will form a basis for the Work Package 4, where the development of shared strategies, policy options and joint commitment for implementation will be carried out. The impacts of the project will be further ensured by well-targeted dissemination and continuous liaison with the stakeholders and policy-makers.

3. INTRODUCTION TO THE FEASIBILITY STUDY

Increasing marine transportation has led to growing concern on ship-generated air, waste and wastewater emissions. There are many reasons to the increased attention such as calculations of sulphur emissions from land based sources and road vehicles compared to the emissions from shipping. The calculations show that in the coming years shipping will be the biggest source of sulphur emissions in Europe. Among the non-road sources, marine engines are the least regulated and fastest growing source of air pollution.

There are provisions to regulate the waste and wastewater management onboard ships but flexible, harmonized and sustainable practises to manage and receive them in the port facilities are still to be achieved. The practises vary in different ports. Sorting of the ship-generated waste to decrease environmental load is in some cases difficult because of different practices in ports. Sustainable methods of waste management exist, but the implementation and harmonization on international shipping is a complex task. This is due to varying background and resources on which the waste management is built in ports.

The hazardous nature of oily waste and wastewaters have been recognised in the middle of the 21st century and regulated by the international conventions. Untreated sewage from ships is still allowed to discharge into the sea with certain limitations. Large passenger vessels produce black and grey water in substantially large magnitudes. Ports generally play an important role in environmentally effective management of wastewaters.

Thus, even if many environmental regulations have been steps towards the decreasing of the environmental loading, there is still need to examine and introduce more efficient methods and practices of the sustainable environmental management. This need is an especially current topic in the Baltic Sea area, as the increasing shipping traffic increases the environmental loading. This feasibility study contributes the topic by describing and investigating the environmental management of the ship-generated loading in ports and their surrounding areas. In addition this study as a whole considers the socio-economic and regional aspects of the environmental management in ports.

3.1 The work packages of the feasibility study

The feasibility study includes three main sections concerning the Work Packages 1, 2 and 3 of the New Hansa project. The Work Packages deal with atmospheric emissions, noise and vibrations and ship-generated wastes and ship-generated wastewaters, respectively. The study consists of background data of the participating ports and the general information and theory of environmental issues concerning the topics of the Work Packages.The study and the results are based mainly on the data provided by the project partners.

The general aim of the feasibility study is to analyse the data concerning WP1 (ship-generated atmospheric emissions), WP2 (ship-generated waste) and WP3 (ship-generated waste water), in order to produce information for developing a joint policy, the Memorandum of Understanding (MoU) on Sustainable Port and Maritime Policy in the Baltic Sea Region.

The specific aims were to:

- evaluate the existence and availability of the data regarding WP 1 - 3 topics
- compare different practices applied in the participating ports regarding the topics of WP 1 - 3
- compare legal frameworks regulating operations in the participating ports
- compare the environmental impacts observed and reported by the participating ports in the questionnaire (exclusively based on the existing reports and studies that concern or include the participating ports)
- compare the socio-economic and spatial consequences observed and reported by the participating ports in the questionnaire (exclusively based on the existing reports and studies that concern or include the participating ports)
- study how the legal framework and regulations support integrated planning and solutions in the participating ports
- draw up a synthesis of the feasibility studies for a joint policy paper.

This study provides:

- general information about ship-generated air pollution, waste and wastewater,
- their effects on the environment,
- data about the management of atmospheric emissions, waste and wastewater,
- recommendations for ports, cities and responsible parties of the vessel use.

This document is a result of a feasibility study conducted by the Centre for Maritime Studies, Pori Unit of the University of Turku (hereinafter referred as UTU/CMS) and a part of the implementation of the New Hansa of Sustainable Ports and Cities project.

4. MATERIALS AND METHODS

The study is based on the data collected from the partners of the project via questionnaires, the literature, the Internet and other study references that include information about shipping and related environmental topics. Supporting research work was performed by excursions to and interviews in the partner ports and other related interest groups. The partner meetings of the New Hansa project have been acting as a forum where the partners have had a chance to give their contribution to the development of this study.

The questionnaires were the main method to collect the data from the ports. Thus, it proved to be a flexible method that suited for every partner and gave an opportunity for the ports to individually contribute to the study. Literature, scientific articles and the Internet references were used to collect data about the best available technology and practises concerning the subjects of the study.

The first questionnaire concerning the issues of WP 1 - 3 was sent via e-mail to the partners in April 2004. The second questionnaire including only legislative issues of WP 1 - 3 was sent to the same receivers in May 2004. The data from the answers is collected in the Appendix 1 of this study. The additional statistical information was gathered from official web pages of the ports and directly by interviewing the ports' personnel.

The general nature of the questions gave an opportunity for the answerer to formulate the answer in one's own words. This made the nature of the collected data along with other data (the interviews and conversations with the partners) qualitative. Despite of this, in order to have some quantitative approach to the subjects, the results have been tabulated and presented in graphs when possible.

The references of the environmental issues concerning shipping have been collected from the literature, scientific research articles and Internet sources. The data from these sources were collected to survey the available environmental technology and methods to compare with the results of the questionnaires and to give the reader an overall description about the field of the study. The scientific literature directly concerning these topics is scarce, but was used as sources when possible. The Internet has proven to be a very efficient source of information of the current situation in the environmental field of study. However, the reliability of the Internet and other non-scientific sources had to be verified. Therefore, in this study, the Internet sources have been revisited very critically and data concerning certain subjects have been collected from different sources in order to get a neutral and versatile view on the subjects.

A problem to overcome when creating this study was to pick up the essential parts of the vast amount of information. The subject areas of the Work Packages are very wide, which led to a situation where the authors had to concentrate more to certain aspects. These highlighted issues are mainly subjects raised up in the discussions in the partner meetings and thus support the partner’s interest and contribution to the study

The authors of this study have excluded the answers of the questionnaires not having any useful information. On the other hand, some of the answers not directly answering the question gave otherwise important information which was used in the context. The ports also have varying practices to collect data and create statistics, which makes the comparison between the ports in some cases very difficult or impossible.

Some of the practises presented in this document might be already outdated at the time of publication. This is because of rapid development in the environmental field and continuous development of national and international regulations. To compensate this deficiency, the Internet was used to check the tenability of the literature sources. However, the main results and recommendations are in more general level, and future techniques complement them.

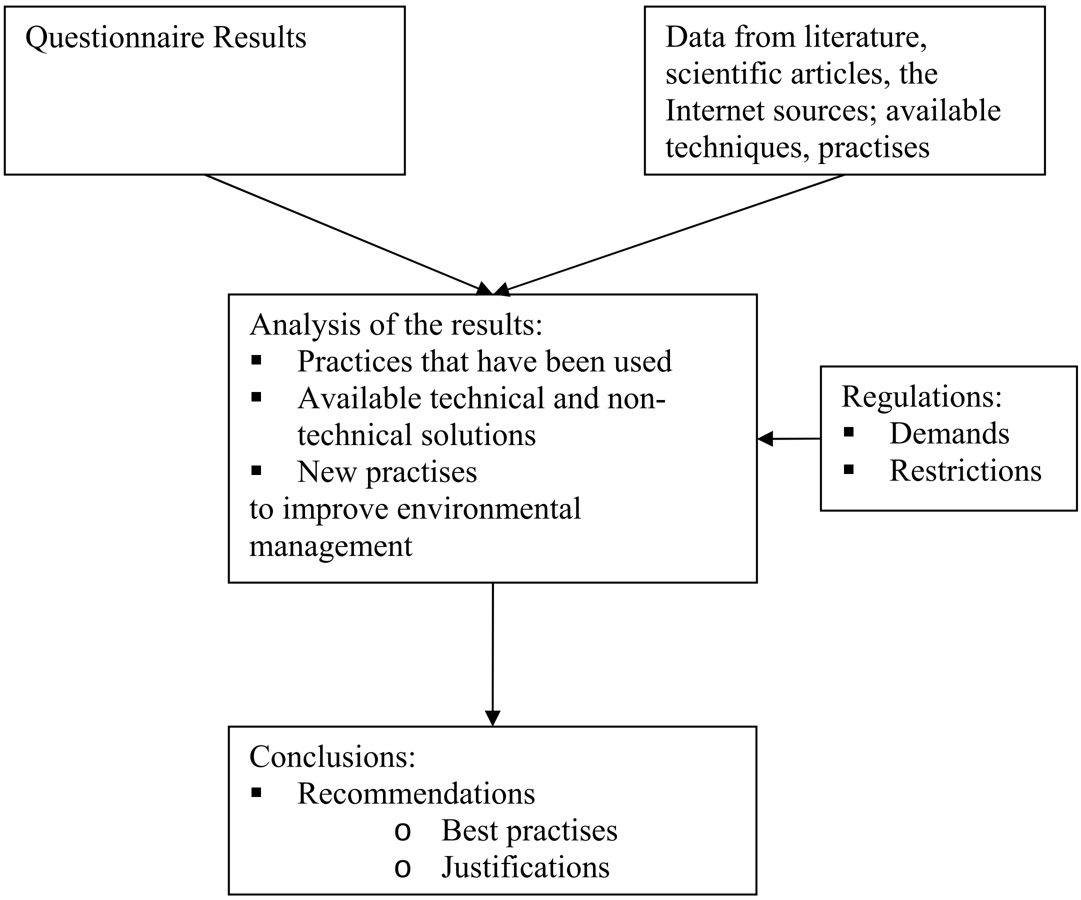


Figure 1. Flowchart describing the construction of the study

5. THE PORTS STUDIED

The partners of the New Hansa project sent information about the ports they are representing. To demonstrate the difference between the studied ports some general information has been collected in this document. The web pages of the ports have been used as source references to support the text.

On the basis of these descriptions it is possible to comprehend the different starting points of the ports concerning the environmental issues. Some are mainly passenger ports whereas others are cargo ports. The amount of cargo volumes and types are different in each port. In relation to the surrounding environment and urban population centres, the locations of the ports also vary: some are situated practically in the city centre and others tens of kilometres from the nearest city. These characteristics make ports individual and highlight certain environmental issues that are important for the participating ports. Solutions to improve environmental performance are not always the same for all these ports. This is a significant challenge, when joint practices should be developed. It widened the scope of this study, and forced to examine the topics from different standpoints.

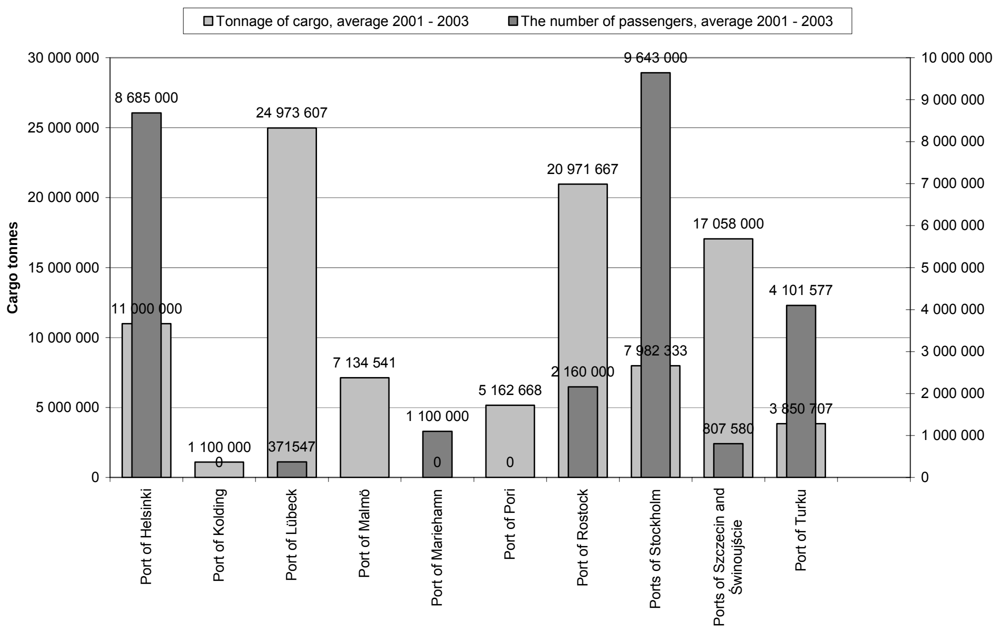


Figure 2. Cargo tonnes and passengers. The Port of Mariehamn has no statistics from the particular period for cargo. There is no comparable data about passengers for the Port of Malmö due to restructurings in passenger line traffic in the shown time period.

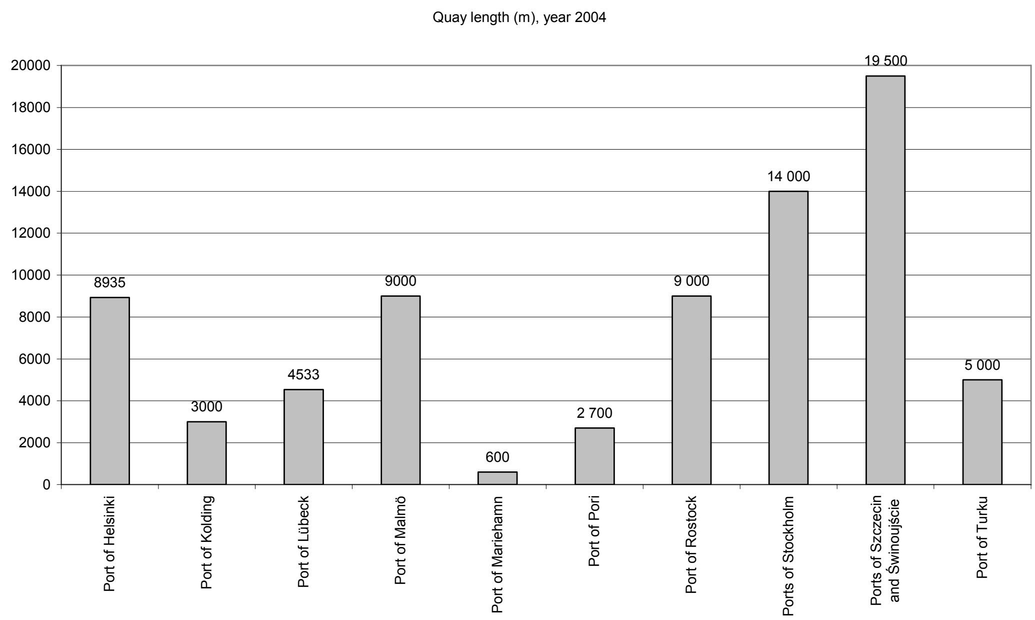


Figure 3. Quay length

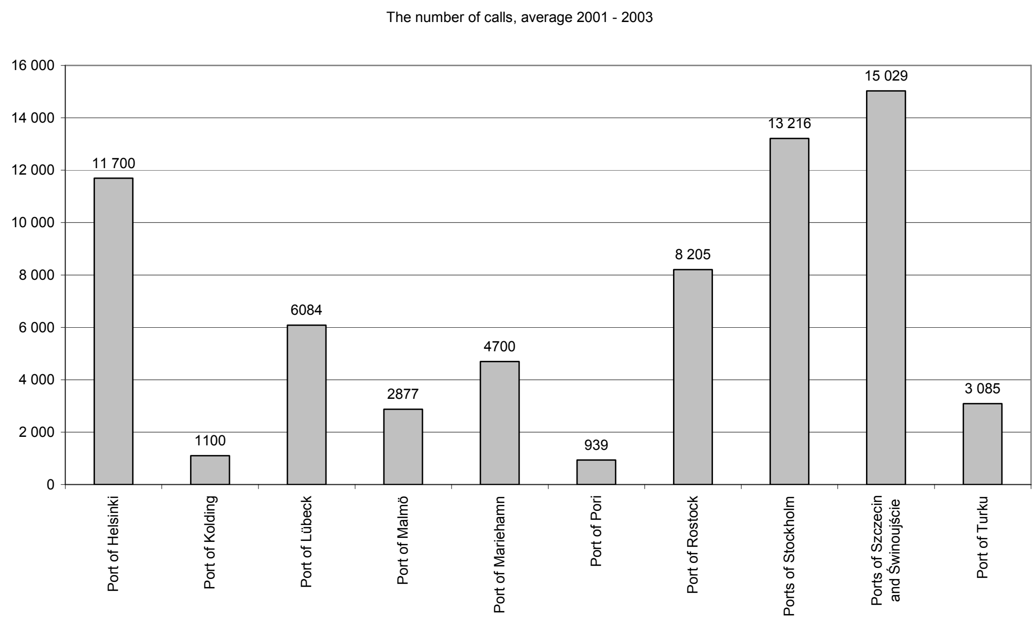


Figure 4. The number of ship calls in the Port of Malmö, an average of 2002 - 2003.

5.1 Port of Helsinki

The Port of Helsinki is a municipal enterprise including the West, South and North Harbours. The Port of Helsinki is primarily a unitized cargo and passenger port handling about 11 million tons of cargo and 8.7 million passengers yearly. Helsinki is the largest city and the capital of Finland with over 500.000 inhabitants and the harbours are located in the city area. A modern Vuosaari Harbour is under construction, away from the city, and it should be in operation by the year 2008, when the cargo traffic from the West and North harbours will be transferred there.

Picture 1. Port of Helsinki, South Harbour (Photo: Port of Helsinki)

Picture 2. Port of Helsinki, West Harbour (Photo: Port of Helsinki)

5.2 Port of Kolding

The Port of Kolding is a municipal self-governing industrial- and traffic port, which handles 1.1 million tons of cargo per year, 90% is dry and liquid bulk while 10% is general cargo. There is no passenger traffic in the port.

Picture 3. Port of Kolding (Photo: Port of Kolding)

5.3 Port of Lübeck

The Ports of Lübeck handles forest products such as paper and cellulose. The company "Lübecker Hafen-Gesellschaft mbH" (LHG) runs the public ports of the Hanseatic town of Lübeck. There are also private port operating companies.

The Ports of Lübeck include terminals Skandinavienkai, Nordlandkai, Konstinkai and Schlutup. The terminal Skandinavienkai, located in Lübeck-Travemünde, is to be substantially extended and located near the widely known recreation area. The terminal Seelandkai is under construction. Private quays such as Lehmannkai 1-3 and the Container Terminal Lübeck are becoming more and more important for the Port of Lübeck.

Picture 4. Terminal Skandinavienkai (Photo: Lübecker Hafen-Gesellschaft mbH)

Picture 5. Terminal Schlutup (Photo: Lübecker Hafen-Gesellschaft mbH)

5.4 Port of Malmö

The Port of Malmö is a part of the CMP AB (Copenhagen Malmö Port), which is a Swedish registered limited liability company. The harbour itself is situated about 2 km from the city centre of Malmö, closest to the port there are offices, industrial and residential areas. Main cargos in the port are floating bulk, dry bulk, containers and new cars. The number of cars has increased in the last years since a new car terminal was built.

The passenger ferry traffic was closed down in 2003. The port expects passenger traffic to grow in the future. A new passenger line was opened in the summer 2004, and a growth in cruise ship traffic is also expected.

Picture 6. Port of Malmö (Photo: CMP AB)

5.5 Port of Mariehamn

Mariehamn is the capital of the Åland Islands. The Islands are situated in the northern Baltic Sea, between Sweden and Finland. The Port of Mariehamn is located in a bay with sheltering islands around it. The passenger traffic is heavy and there are approximately 4.700 port calls per year.

Picture 7. Port of Mariehamn (Photo: Port of Mariehamn)

5.6 Port of Pori

The Port of Pori is one of the biggest Scandinavian timber harbours and a growing container harbour, its infrastructure is suited for the needs of oil and chemical harbour and a project shipment harbour. The 15,3 - metre draught makes the Port of Pori the deepest port in the Gulf of Bothnia, thus giving an advantage in large-scale bulk shipments. The large port area provides facilities for port operations and the industry. The Port of Pori comprises three separate harbours: the Mäntyluoto harbour, the Tahkoluoto deep-water harbour and the oil and chemical harbour. The Port of Pori is owned by the Pori Town.

Picture 8. Port of Pori (Photo: City of Pori)

5.7 Port of Rostock

The Port of Rostock is located on the Warnow River estuary where the river meets the Baltic Sea on a site away from residential areas. The port works by the so called "Landlord Model". This means that Hafen-Entwicklungsgesellschaft Rostock mbH (HERO) owns and provides the infrastructures and offers the service providers (handling, storage, distributing etc.) in the port. The company is owned by 74,9 % by the Hanseatic City of Rostock plus 25,1% by the Land Mecklenburg Vorpommern.

The port area is 7.5 million m^2. There are 43 ship berths on more than 9 km of quays. 25 of the berths are equipped with special facilities for ferries, Ro-Ro ships, ore and coal, cement, grain, fertilisers, liquid cargo, and chemicals. In 2003, a total of 2.3 million passengers and 21.1 million tonnes of cargo were transported.

Picture 9. Port of Rostock (Photo: Rostock Port/nordlicht)

5.8 Ports of Stockholm

The Ports of Stockholm Group consists of the parent company Stockholms Hamn AB, subsidiaries Nynäshamns Hamn AB, Roslagshamnar AB and Stockholms Hamnentreprenad AB. The Ports of Stockholm Group comprises three different ports: Port of Stockholm, Port of Kapellskär and Port of Nynäshamn. Kapellskär is located 90 km north of Stockholm and Nynäshamn 60 km south of Stockholm.

The Port of Stockholm has harbours around the city of Stockholm, and it is a central port for freight and passengers. Due to the close contact with people living in the city the port must face various environmental challenges. Being the biggest port of the group the Port of Stockholm handles more than 8 million passengers and 5.5 million tons of cargo every year.

The development of the Port of Kapellskär has been fast in the past years. The port offers Ro-Ro traffic to and from Estonia and Finland, including Åland, having passenger traffic more than 1.4 million in 2004. The Port of Nynäshamn concentrates in Ro-Ro and passenger traffic and in 2000 more than one million passengers passed by the port. In 2004, the amount of passenger was 1.3 million.

Picture 10. Port of Stockholm (Photo: Port of Stockholm)

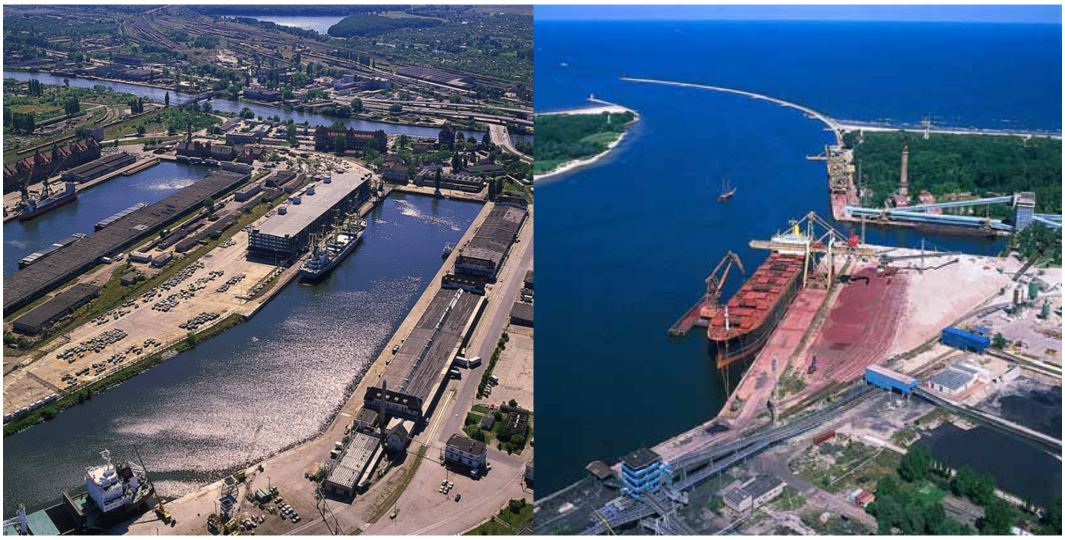
Picture 11. Port of Kapellskär (Photo: Port of Stockholm)

Picture 12. Port of Nynäshamn (Photo: Port of Stockholm)

5.9 Ports of Szczecin and Swinoujscie

The ports of Szczecin and Swinoujscie are one of the largest port complexes on the Baltic and the closest seaports for a big portion of western Poland, for the Czech Republic and Slovakia. Due to improving economy and active marketing the traffic in both harbours is on the rise. A railway network links the ports of Szczecin and Swinoujscie; Berlin is 135 km from Szczecin, Prague - 533 km, Vienna - 805 km. The share of rail transport in 1998 was over 80 percent. The ports are connected with their hinterland by a river.

Authority of Szczecin and Swinoujscie Seaports is a joint stock company having a jurisdiction over both port complexes with responsibilities that include management of the port and infrastructure, support services for port service companies and setting of port dues. In 2003, the Seaports of Szczecin and Swinoujscie handled 15.6 million tonnes of cargo and 867.000 passengers. The main cargo flows consists of coal, ore, other bulk and general cargo.



Picture 13. Port of Szczecin (on the left) and Port of Swinoujscie (Photo: Szczecin and Świnoujście Seaports)

5.10 Port of Turku

The Port of Turku is the second largest port for general and unitised cargo in Finland after Helsinki. It is also the only train ferry harbour in Finland. Four million people travel between Stockholm and Turku every year. There are six to and from departures on the route daily, two of which are train ferries that also carry passengers and four passenger/car ferries. More than 300.000 vehicles pass through the passenger harbour annually.

The Port of Turku is situated close to the city centre. Pressure to success in environmental efforts is not only created by nearby inhabitants but also by the Natura 2000 area in the island of Ruissalo very near the port.

Picture 14. Port of Turku (Photo: Port of Turku)

6. SPATIAL PLANNING AND MONITORING OF THE PORT ENVIRONMENT

Spatial planning covers all issues dealing with land use and physical planning. It involves planning related to the geographical side of the economy, land use and environment. Spatial planning is defined in the EU Compendium of Spatial Planning Systems and Policies as: "**public policy and actions intended to influence the distribution of activities in space and the linkages between them. It operates at all levels of decision-making and embraces land use planning and regional policy.** "

Spatial planning is implemented by laws concerning physical plans, by land-use planning and by projects that improve the quality of development plans. In general cities, authorities and citizens are actively interested in environmental aspects related to spatial planning. Public attention is increasingly paid to the environmental issues. The fact that environmental aspects have to be taken into consideration in the planning stage supports the sustainable use of natural resources and the environment. The environmental impact analysis must be performed before a plan is introduced.

It should be possible for the inhabitants to participate in the planning procedure. The success depends both on the inhabitants' activity and the attitude of the developer as well, that is, how the opportunity to express one's opinion is organised. Especially at the local level, public participation enhancement is prioritised. The idea of the public participation is to encourage it from the very beginning of the planning procedure.

Preventing of the dispersion of the regional settlement structure is a goal based on the principles of sustainable development. For example development of urban centres in relation to the region's traffic arteries, the important role of good infrastructure for public transport and other regions like port areas plays important role in spatial planning (Terra project 1999).

This study presents the basic types of possible impacts concerning air emissions and noise, solid waste and wastewaters of shipping, and some methods to solve the environmental problems. The study describes different types of emissions of shipping and problems that can incur. The study also presents the emerged problems within ports concerning spatial planning and the environment, and describes how those problems are solved in particular ports. The results of this study aim to follow the principles of sustainable development from the point of view of socio-economical and regional planning.

6.1 The interaction of ports and shipping with regional spatial planning

Ports and cities are traditionally closely linked together. To provide their services, ports need a large area of land for port operations. Depending on the type of services, the land use varies from quays and small terminal buildings to vast areas of open dry bulk fields.

The development and enlargement of the ports versus the eagerness of residential areas to get closer to coasts and ports create a conflict concerning the demand of land. Shipping produces variety of impacts to the environment in areas with heavy ship traffic, especially in the ports. All the potential environmental impacts of shipping cannot totally be defeated, but the effects can be prevented or diminished with the help of proper spatial planning.

The development of ports and cities is a continuous process where both are trying to fulfil the needs they meet. The questions in the questionnaires sent to the partners also concerned the enlargement plans of the ports and the management of ports in co-operation with cities. This chapter analyses the spatial planning concerning the participating ports.

All of the participating ports work in co-operation with the near-by city in spatial planning. The co-operation has various forms. Generally, however, groups with representatives from the port and the city have discussions of the needs of the city and the port. Supporting parties, for example environmental and health protection administrators, give their contribution. The answers showed that the ports generally are interested in enlarging their operations, and they have ongoing enlargement projects. On the other hand, the cities also need more land and they have established, for example, residential areas near the port. The land with sea view is a valuable residential area. This affects the development of the ports. It is also a source of possible conflicts because port operations and traffic to and from ports may cause disturbing effects to the near-by residential areas. Generally, cities are developing their structure and ports need to take that into consideration. However, the answers did not reveal any problems in the co-operation between ports and cities.

All of the ports have prepared to expand. Some of the ports still have room for new operations within their area, whereas others do not, for example, the Port of Helsinki building a new harbour in Vuosaari to transfer the West and North Harbours farther from the city centre. The old harbours are planned to become new housing areas. However, moving the operations to totally new area, even if the place is carefully chosen, may produce new environmental challenges. An environmental impact of the planned port area should be well analysed beforehand. The surrounding areas with its nature and inhabitants as well as logistical issues affect the construction and location of a new port. The truck traffic to and from the ports is generally heavy. New traffic routes of thousands of trucks may cause serious problems also on the roads farther off the port's neighbourhood. This is an aspect that should be remembered also in local road planning.

One solution to expand is to create new land areas from shallow water areas near the port. In Malmö it has been decided to get more land for port's use by filling 1 million m^2 of sea at the northern part of the port. The soil material required for the filling process is transported from the tunnel construction site in the city.

Efficient land logistics serves the environmental aspects. Heavy truck traffic creates problems with traffic and road design in the city, and often some special arrangements must have been done, e.g., restricting heavy vehicle traffic and transport of dangerous goods in certain city areas. For example, the role of road traffic has been carefully taken into consideration in designing of the Vuosaari Harbour. In the planning process of the Vuosaari Harbour, the location of the harbour has been considered also from the point of view of road and rail transport. Generally, efficient road and rail connections to ports have to be taken into account when planning new port areas, because they have long-term environmental effects to surrounding regions.

Rail transport is a very important part of cargo handling in many harbours. Some of the studied ports have a possibility to serve train ferries. When developing rail infrastructure, different technical demands have to be considered than in road design, for example, sharpness of turns and steepness of hills, rail width and bearing capacity of the railroad. The rail width problems in the Port of Turku have been solved by building a large hall where cargo is unloaded and loaded further on to train with another rail width. Using of rail transport is generally thought to be more environment friendly than road transport. In the Port of Lübeck, whole trailers of trucks are loaded on trains with a special crane.

6.2 The monitoring and modelling of the environment

It is very important to have information about the surrounding environment of the port (Wooldridge et al.1999). Both past and present environmental information is needed to understand impacts of different actions and to predict the future conditions. Efficient monitoring also shows possible changes in the environment, giving an opportunity for the managers to find the polluting source and to take actions to prevent the effects.

Ports generally do not have continuous monitoring programmes or systems, although many have conducted some surveys about air quality in and near the port area. The monitoring of air quality is usually performed by the local authorities. Thus, the nearest air quality measuring point may locate far from the port area, and, therefore, there is few data about the emissions of port operations. This means that the effects of the changes in port operations have to be estimated theoretically in order to predict the risks threatening the environment and the ambient air. There are, e.g., models to estimate the atmospheric dispersion and hydrodynamic and water quality models to predict and understand the currents and water quality. These models are possible to be utilised when the effects of shipping and port operations are estimated or predicted, although they may need to be modified for small regional scales.

6.2.1 Modelling and calculations of atmospheric emissions

The ports have studied the atmospheric emissions of the ships in and near the port area by modelling or calculating the emissions based on measured values.

In the studied ports, the emissions from ships have been estimated by different calculation methods (e.g., in the Port of Mariehamn and the Port of Malmö), which have the similar principle idea. The following parameters are taken into consideration in the calculation: number of calls, at berth time, engine types and loads, ship types, fuel quality and consumption, manoeuvring, etc. Using these parametres the atmospheric emissions are calculated with the emission factors of different engine types.

The Lloyd's register and ENTEC studies provide emission factors and values that are widely used ("Quantification of emissions from ships associated with ship movements between ports in the European Community, Entec UK Ltd, July 2002"). In Finland, MEERI is a simple calculation model for waterborne transport developed in VTT Communities and Infrastructure in Finland (Mäkelä et al. 2000). It calculates the amount of exhaust emissions and energy consumption caused by waterborne transportation. MEERI is a sub model of the calculation system LIPASTO, which covers four modes of transportation, and is the first annually updated waterborne calculation model in Finland.

The previously mentioned calculations estimate the amounts of emitted pollutants, but not the spatial distribution. Studying of spatial distribution of air pollutants requires specialized dispersion models. Meteorological and physical/chemical factors contribute to the dispersion of pollutants, which is taken into consideration by the models. The results of the distribution of pollutants and evaluated concentrations can be used for various purposes, for example, in spatial planning of port and town areas and in estimating the impacts of shipping and port operations on ambient air.

The Port of Lübeck has used the German TA Luft dispersion model AUSTAL2000 to determine the level of air pollution in the Lübeck-Travemünde harbour area concerning maritime activity (LAIRM CONSULT GmbH 2004). The effect of road traffic as a major source of pollutants has also been examined, as well as the estimated effects of both ongoing and future plans in the port area.

The information about atmospheric pollution of shipping is useful data for a port in terms of environmental management. The influence of shipping should be possible to be compared with the total air quality of the surrounding area. The air pollutants to be studied should include the compounds emitted from marine diesel engines (United States Maritime Administration 2003): NO_x (NO and NO_2), SO_x (SO_2 and SO_3), PM (PM_{10} and $PM_{2.5}$), CO_2, CO, HC, Benzene, carbonyls and trace metals.

Diesel engines are one of the potential sources of fine particles. Therefore, it is recommended to include PM_{10} and even $PM_{2.5}$ to the studied components of air pollutants. Studying only the particulate matter as a mass is not enough. The limit values for PM_{10} and $PM_{2.5}$ concentrations are not defined. WHO announces that the available information does not allow a judgement to be made regarding concentrations below which no effects would be expected (World Health Organization 2000). That is why they do not give any limit values. In some cases, the origin of measured particles is necessary to be determined to be able to direct the efforts to the appropriate emission sources.

Handling of dry bulk materials can lead to considerable dusting. Fall-out of dust on the sea and surrounding land areas should be diminished. There are technical solutions to prevent dusting while loading and unloading, for example the Advanced Grab Drive control system (Sirjola, 1999) in cranes which optimizes the operation of the grab and prevents dusting and human errors (in use at the Port of Pori). The boxed conveyors diminish dusting but also noise of loading operations.

6.2.2 Marine environment near the port

Ports generally do not perform continuous monitoring of surrounding water quality. The ports studied carry out their own monitoring programmes and surveys mostly when implementing dredging operations, applying environmental permits or spatial enlargements.

The information about the water quality in the port area or in the surrounding coastal waters comes mainly from monitoring programmes carried out by the environmental authorities or obligatory monitoring programmes performed by the polluters. The monitoring programmes have been started circa in the middle of the 20th century because of the pollution problems observed and suffered from the biggest cities. However, these monitorings have not produced any separate information about the effects of shipping or port operations.

Shipping causes several effects on marine environment, e.g., air emissions of ships cause nutrient loading in open and coastal waters, dredging and erosion due to ships' waves cause resuspension of sediments in shallow waters, antifouling paints contain heavy metals and chemicals that are dissolved to the sea water. Discharged sewage and ballast water are also examples of threats to marine environment. The effects are especially harmful in the exceptionally sensitive and unique coastal areas and archipelagos of the Baltic Sea.

Contaminated sediments are a threat for marine life. Dredging and disposal of dredged material are environmental concerns that the ports have confronted with. Anything that stirs up the water, such as a storm or vessels' propellers, can resuspend some sediment. Resuspension may lead into all fauna (not just the bottom-dwelling organisms) being directly exposed to toxic contaminants. TBT (tributyl tin) is a substance that has been discussed a lot in the recent years. Findings of TBT can interrupt or aggravate dredging operations, because TBT is a toxicant for marine life, and in dredging operations it is resuspended from sediments.

7. WP 1: ATMOSPHERIC EMISSIONS, NOISE AND VIBRATION

Ports are multifunctional areas with various sources of air pollution. The size, location and commercial profile of the port affect to the amount, quality and distribution of generated pollution. This part of the study will concentrate on the emissions in the air. The major air pollutants related to port activities are particulate matter (PM), nitrogen oxides (NO_x), sulphur oxides (SO_x), carbon oxides (CO_x), ozone, heavy metals and hydrocarbons, including volatile organic compounds (HC and VOCs), dioxins and pesticides (Bailey & Solomon 2004). Most of these pollutants originate from burning of diesel fuels in engine operations onshore and offshore. Handling of dry bulk cargo, accidental leakages and storing of liquid fuels are sources of other types of air pollution.

7.1 Emissions of marine transport compared with other transport modes

The exhaust emissions from shipping are largely due to burning of fossil fuels (Corbett & Fischbeck 1997). The main engines, primarily used for propulsion, are the most significant source of ships' emissions. Studies in general have shown that marine sources are a significant factor in tropospheric air pollution. If the increase in demand for shipping services and market requirement for increased speed and availability continues, technical measures alone will not be able to prevent a total growth in emissions from ships.

The world's ships are primarily powered by diesel engines and they will dominate the markets far to the future (Corbett & Fischbeck 1997). The total world fleet in the middle of the 1990s included approximately 55% slow-speed diesel, 40% medium-speed diesel and 5% other engine types. Oil tankers and bulk carriers are by number not dominant but due to their size, they are of significant importance regarding to air emissions (International Maritime Organisation 2000). Ship emissions affect global background pollution levels of nitrogen and sulphur (NO_x and SO_x), which are the two major pollutants from shipping (Corbett & Fischbeck 1997). Other significant pollutants to be mentioned are particulate matter (PM), hydrocarbons (HC) and carbon oxides (CO_x).

Marine-, rail- and road transport modes are to some extent competitors to each other, but on the other hand, these transport modes together form a door-to-door transport chain. Which mode of these is the most environmental friendly depends from numerous variables. One factor is the load capacity factor determining how full a particular vessel or truck is loaded. Oil tankers and bulk carriers have proven to be more efficient than the other vessel types in terms of used fuel per mass of transported cargo. Energy consumption affects directly to CO_2 emissions. In general, with the same energy consumption marine vessels transport cargo considerably longer distances than heavy trucks. From this point of view marine transport is an environmentally favourable option (International Maritime Organisation 2000).

When considering NO_x emissions per mass of transported cargo from marine vessels and comparing them with emissions from trucks and rail, ships still perform better (International Maritime Organisation 2000). The difference is not as clear as in case of CO_2, however. The main reasons for this is that there is more efficient technology and developed regulations decreasing the NO_x formation considering road transport.

SO_x emissions from marine transport are much higher than from other transport modes (International Maritime Organisation 2000). This is because of higher sulphur content in marine diesel fuels. SO_x emissions per mass of transported cargo can be 6 - 26 times higher than in road transport.

Generally, it can be concluded that marine transport can compete well with other transport types in terms of environment and air emissions. When comparing different transport modes and their emissions with each other, there are clear differences between pollutants. The emissions also vary significantly between ship types. However, marine transport still has more potential for emission reductions than other modes of transport.

7.2 Major air pollutants

This chapter presents the air pollutants that are the main compounds produced from shipping. Some aspects on regulations concerning pollutants are also presented in order to clarify the importance of a particular compound. In addition, some general aspects of reducing the air pollution are considered.

7.2.1 Sulphur oxides, SO_x

The main sources of SO_x emissions are the burning of coal and oil. The burning of fossil fuels containing sulphur leads to SO_2 and SO_3 emissions that are collectively referred as sulphur oxides, SO_x (The European Pollutant Emission Register 2005; Elvingson & Ågren 2004). Power stations, oil refineries and other large industrial plants contribute the majority of the total mass released. The contribution from road traffic is small due to the strict regulations on sulphur content of fuels.

Sulphur emissions dissolve easily in water. Once released into the air, SO_x combines with water droplets to form sulphuric acid, or with other particles in the air to form sulphates. SO_x can travel thousands of kilometres from where it was emitted. When absorbed in land, SO_x is mainly sulphuric acid and may cause acidification of soil and freshwater ecosystems (Elvingson & Ågren 2004).

In diesel engines all sulphur entering the combustion chamber is oxidized to form SO_x and emitted to the air with exhaust gases (Hellén 2003). This means that in practice the SO_x emissions are directly proportional to the sulphur content of fuel and the fuel consumption. Sulphur dioxide emissions follow an empirical relationship (Corbett & Fischbeck 1997): SO_2 per ton of fuel = 20 x (S%), where S% is the percent of sulphur contained in the fuel. The only way to affect the SO_x emissions in diesel engine technology is to make more fuel-efficient engines. The sulphur content in heavy fuel oil produced in Europe is approximately 2,9%.

Shipping is a significant source of global sulphur pollution (Corbett & Fischbeck 1997). The International Maritime Organization estimates that sulphur emissions from ships' exhausts are from 4.5 to 6.5 million tons per year, which equals to 4% of total global sulphur emissions. It has also been estimated that SO_x emission from ships will increase by 11 - 13% by the year 2010.

The MARPOL Annex VI of the International Maritime Organization specifies "SO_x Emission Control Areas" with more stringent control on sulphur emissions. In these areas, the sulphur content of fuel oil used in ships must not exceed 1,5% m/m alternatively; ships must fit an exhaust gas cleaning system or use any other technological method to limit SO_x emissions to less than 6 g/kWh. The Baltic Sea area is designated as a SO_x Emission Control Area in the Protocol. The annex VI has entered in force on 19.5.2005 (International Maritime Organization 2004d).

The EU regulates the sulphur content of marine gas oil and marine diesel fuels in Directive 1999/32/EC in the EU territorial waters up to 12 nautical miles from shore. Due to the lack of any sulphur limits for heavy fuel oil, the Commission's proposal for revision of the Directive is put forward. New sulphur limits are the same as in the Marpol Annex VI. The Directive, however, includes extension of the 1,5% sulphur limit to ferries to or from any Community port. In addition, when a ship is at berth in a port, the limit of 0,1% should not be exceeded.

Calculations show that if the average sulphur content of about 2,7 - 3,0% of the marine heavy fuel oil in all European sea areas would lower to 0,5%, the total sulphur emissions from international shipping would decrease more than 75%. The effects of the Marpol Annex VI and forthcoming EU regulations concerning the Baltic Sea will not give reduction values as high as this because of the enforcement of 1,5% sulphur limit. (Ågren 2005; Swedish NGO Secretariat on Acid Rain 2005)

It is estimated that even after the enforcement of the Annex VI, the emissions of SO_2 are expected to increase by 45% between 2000 and 2020. This means that sulphur emissions of shipping will surpass the total emissions from all land-based sources in the 25 EU countries by 2020 (Swedish NGO Secretariat on Acid Rain 2005).

Shipping is a significant source of sulphur emissions due to the high sulphur content in marine fuels even when using so called low sulphur fuels (less than 0,5% sulphur). Fuel containing 3% or 0,5% of sulphur has the sulphur content of 30.000 ppm and 5.000 ppm respectively. When comparing these figures to the maximum allowable sulphur content of 50 ppm in road transport it can be seen, that the marine fuels contain much more sulphur.

7.2.2 Nitrogen oxides, NO_x

The major man-made releases of nitrogen oxides are primarily from fuel combustion, biomass burning and some production processes. Combustion processes emit (among many other releases) a mixture of nitrogen oxide (NO) and nitrogen dioxide (NO_2). The nitrogen oxide reacts with other chemicals in the air and formates nitrogen dioxide. On the average, 57 kg of NO_x is released per ton of fuel by medium-speed engines and 87 kg NO_x per ton by slow-speed engines (Corbett & Fischbeck 1997).

According to HELCOM, approximately 25% of total nitrogen load entering the whole Baltic Sea originates from airborne inputs. The emissions of nitrogen oxides (NO_x) from international shipping traffic were estimated to account for approximately 10 - 20% of the total nitrogen deposition entering the Baltic Sea in 1990. However, there are data on nitrogen oxides emissions from international shipping traffic in the Baltic Sea region only for this particular year 1990 (HELCOM 2003; HELCOM 2005).

The increased use of low sulphur fuels in shipping has led to a situation, where the significance of NO_x has been increased as one of the major air pollutant. Currently, different interest groups (from engine builders to authorities) are more and more concentrating on NO_x emissions. This can be seen in the development of international regulations concerning shipping and in focusing of the environmental studies reported by the ports. Every port that has studied air quality has measured the NO_x levels in their ambient air (Appendix 1).

7.2.3 Particulate matter, PM

Particulate matter in port areas originates mainly from burning of fossil fuels and handling of dry bulk or road dust resuspension. When considering the emissions of shipping, particulates are formed by diesel engines. The development in diesel engines and combustion processes has decreased the total particulate mass, and nowadays the focus is more on the particle size and number distribution (Lepperhoff 2001). Particulate matter is still one of the most significant emissions from marine diesel engines.

Particles can be classified as primary and secondary particles (Elvingson & Ågren 2004). Primary particles are directly emitted into the air from a source. The source may be a combustion process, but may also consist of dust, soot flakes and pollen. Secondary particles are formed in the air from nitrogen oxides and sulphur dioxide. These particles consist mainly of sulphate and nitrate salts. Ship emissions are estimated to contribute between twenty and thirty per cent of the airborne concentrations of secondary inorganic particles in most coastal areas.

Particles are alternatively classified by their size. Three categories are used: coarse (from PM_{10} to PM_1), fine (from PM_1 to $PM_{0.1}$) and ultra-fine (smaller than $PM_{0.1}$). Particles under 10 µm (PM_{10}) are usually measured in monitoring programmes, but due to recognition of a more harmful effect of fine particles to human health $PM_{2.5}$, PM_1 and $PM_{0.1}$ are also used. (Elvingson & Ågren 2004)

The soot formed in the combustion process that is not oxidised easily absorbs hydrocarbons from fuel and lubricating oils. Burning of heavy fuel oil, due to the fuel quality, leads to greater particulate emissions. The particulate emissions from burning of diesel fuels can be affected by exhaust treatment, engine technology and good maintenance and by choosing high quality fuels and lubricants (Hellén 2003).

7.2.4 Reducing SO_x, NO_x and PM

The best way to reduce SO_x emissions is to pay attention to selecting the fuel quality. Another potential method is a seawater scrubbing (The Marine Exhaust Solutions 2005). This technology is in a testing phase. The Marpol Annex VI and EU regulations concerning sulphur content in marine bunker oils still give the possibility to use an exhaust gas purification method instead of low sulphur oils.

The NO_x and PM emissions together create a challenge for engine building, because reducing one increases another. When a new diesel engine comes to the market, the result is a compromise between different pollutants. Environmental aspects have contributed greatly to the engine design and development of different techniques to decrease NO_x emissions. Some of the new techniques can be installed to new engines, or as retrofits to old ones.

The concern about the health risk caused by particulate matter and especially the role of fine particles in ambient air has risen. Particle traps or filters are already installed in many light vehicles with high efficiency of exhaust purification. Questions have been raised about the possibility of installing the same technique in vessels’ stacks. The reason for a more environmental friendly technique installed in road vehicles is the quality of fuel. By using fuel containing as small amounts of sulphur as the provisions demand for road vehicles, it is possible to use much more advanced technology than in marine applications. Particle filters have been tested in ships with good experience, but the quality of heavy fuel oil restricts the use of the best available technology, and that way the environmental efficiency of abatement technology.

The MARPOL Annex VI (International Maritime Organization 2004d) requires that diesel engines over 130 kW installed on ships, constructed after 1.1.2000, or engines over 130 kW that undergo a major conversion after 1.1.2000, must meet NO_x emission standards and be certified under the NO_x Technical Code.

The new provisions in the MARPOL Annex VI regarding diesel engine's NO_x emission limits can be reached quite easily when a new engine is concerned because of the rapid development of engines. This leads to a situation where provisions have no effect on ships with new engines, and if the best available abatement technology is to be taken in use, voluntary investments must occur.

7.2.5 Hydrocarbons, HC

Hydrocarbons are chemical compounds containing only carbon and hydrogen. These straight-, branch-chained or cyclic molecules represent about 95% of crude oil. Burning of petroleum (a collective term for hydrocarbons, whether solid, liquid or gaseous) in engine operations lead to emissions of unburned or partially burned hydrocarbon compounds. Hydrocarbons in exhaust gas are in a form of gas, droplets, or bound in tiny particles. In typical urban areas, a very significant fraction of HC comes from cars, buses, trucks, and non-road vehicles and boats. Hydrocarbon pollution results also when fuel evaporates directly into the atmosphere. (Global Marine Oil Pollution Information Gateway 2005; United States Maritime Administration 2003).

Operational discharges of hydrocarbons in marine operations are able to be effectively controlled and avoided (Global Marine Oil Pollution Information Gateway 2005). Good knowledge about physical behaviour of hydrocarbons, installed technical solutions and attitude are in key position in the abatement of HC pollution.

Polycyclic aromatic hydrocarbons, PAHs are natural constituents of oil and occur as outdoor and indoor air pollutants. Environmental releases of PAHs result from human activity or natural sources such as forest fires. The majority of PAHs are released by incomplete combustion of fossil fuels and wood. PAHs occur both in gaseous form and bound to particles (soot). Recreational vessels are one of the most common source of PAH emissions due to inadequate fuel combustion in two-stroke engines. (Global Marine Oil Pollution Information Gateway 2005; The European Pollutant Emission Register 2005)

Volatile Organic Compounds, VOCs are a mixture of propane, butane and several other gases given off through the vaporisation of crude oil and refined products, such as petrol (Global Marine Oil Pollution Information Gateway 2005). VOCs are usually divided into non-methane (nmVOCs) and methane. As soon as petroleum is handled in the open air, vapours escape if it is not prevented. These hydrocarbons in a gaseous form can be emitted into the atmosphere from platforms (extraction of oil), tankers (transportation of oil), terminals (loading and unloading of oil), filling stations (petrol tanking) refineries (processing of oil), pipelines (leakages of oils and gas), and aircraft (refuelling and fuel dumping).

Hydrocarbon vapours can be recovered and "recycled" as liquid fuel (Global Marine Oil Pollution Information Gateway 2005). They are collected and condensed when petroleum products are being loaded and unloaded at terminals, refineries and petrol stations. When crude oil is unloaded from a tanker, the cargo tanks will contain a mixture of gases, including VOCs. When the tank is filled again with crude oil, the gases are vented to the open air. However, with a new technology the VOCs can be condensed and recovered and used as tanker fuel. Onboard emissions of VOCs can be controlled by allowing a slight overpressure in tanks.

Ground-level ozone is created by a chemical reaction between nitrogen oxides and volatile organic compounds in the presence of heat and sunlight (The European Pollutant Emission Register 2005). This means that ground-level ozone is a secondary pollutant, which is not emitted directly into the air from any source but it is a product of reactions between primary pollutants related to burning of fossil fuels. Therefore, the sources of NO_x and VOC emissions are responsible for the formation of ozone. Sunlight and hot weather in a reaction equation show that the ozone formation in urban and rural areas is more problematic in warm weather. This is why ozone is known as summertime air pollutant. Ozone drifts from the areas it was formed and causes transboundary pollution problems that need international attention (European Environment Agency & World Health Organization 1999).

7.2.6 Carbon dioxide (CO_2)

Shipping is globally a minor contributor to the total CO_2 emissions; 1,8% of world total CO_2 emissions in 1996 (International Maritime Organisation 2000). This means that a 10% reduction in emissions from shipping represents less than 0,2% reduction of the world total CO_2 emissions. However, ships are known for the high efficiency of marine diesels (United States Maritime Administration 2003).

CO_2 is not considered as a pollutant or toxic gas. As a natural component of air, carbon dioxide is also known to be a green house gas contributing to the warming of atmosphere. Carbon dioxide and water presents the largest share of exhaust gas flow from diesel engines. Almost all carbon in diesel fuel oxidises to CO_2, but a small part oxidises to CO depending on the excess amount of oxygen in a combustion process (Hellén 2003). The emitted amount of CO_2 can be simply calculated (United States Maritime Administration 2003). Fuel normally contains about 86% carbon by weight, the emitted mass of carbon is the burned fuel multiplied with 0.86. A carbon dioxide molecule is 3.67 times heavier than a carbon atom. Thus, the total mass of emitted CO_2 is 3.67 multiplied with the mass of emitted carbon.

The emissions of carbon dioxide can be reduced by improving fuel economy, burning fuels containing less carbon, still providing the same amount of energy, and by removing CO_2 from the exhaust gases (United States Maritime Administration 2003). Fuel economy is the most effective mean to reduce CO_2 emissions. Switching of fuels and removing of CO_2 are not yet used in practice, but the applications are under investigation.

When reducing GHG emissions, the NO_x, SO_x and PM emissions should also be taken into account. The reduction of one of the previous compounds may increase the formation of another. This is why it is difficult to build a system to regulate a specific compound.

7.3 Air quality standards

Air quality standards given by different organizations define the limits of certain pollutants in outdoor and indoor conditions. These limit values are based on the facts known about human health and tolerance. In monitoring, the measured values and trends should be compared with the limit values and decide if any actions should be taken to provide sufficient air quality.

In 1987, WHO published the first edition of "Air quality guidelines for Europe" (World Health Organization 2000). Since the publication of the first edition, there has been development and knowledge has increased, and the Second Edition has been published with updated guidelines. Starting in 1993, the Bilthoven Division of the WHO European Centre for Environment and Health undertook this process in close cooperation with WHO headquarters and the European Commission. As seen globally, national standards may differ between countries. This is due to the political nature of decision-making.

The EU has set limits for certain air pollutants. These limits are generally target values that the EU countries should meet by a specific date. The Table 1 is based on the following Directives:

- 2000/69/EC carbon monoxide
- 1999/30/EC sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter
- 2002/3/EC Ozone.

Table 1. Air quality limits of WHO and EU

Quality standards for ambient air					
Substance	Averaging time	Limit value WHO	Limit value EU		Date by which the limit value is to be met (EU)
CO	15 min	100 mg/m^3	-	-	-
	30 min	60 mg/m^3	-	-	-
	1 hour	30 mg/m^3	-	-	-
	8 hours	10 mg/m^3	10 mg/m^3	-	1 January 2005
NO_2	1 hour	200 µg/m^3	200 µg/m^3	not to be exceeded more than 18 times a calendar year	1 January 2010
	Calendar year (health)	40 µg/m^3	40 µg/m^3	-	1 January 2010
NO_x	Calendar year (vegetation)	-	30 µg/m^3	-	19 July 2001
O_3	8 hours	120 µg/m^3	120 µg/m^3	not to be exceeded on more than 25 days per calendar year averaged over 3 years	Target value for 2010
PM_{10}	24 hours	-	50 µg/m^3	not to be exceeded more than 35 times a calendar year	-
	Calendar year	-	40 µg/m^3	-	-
	24 hours	-	50 µg/m^3	not to be exceeded more than 7 times a calendar year	-
	Calendar year		20 µg/m^3	-	-
SO_2	10 min	500 µg/m^3		-	-
	1 hour	-	350 µg/m^3	not to be exceeded more than 24 times a calendar year	1 January 2005
	24 hours	125 µg/m^3	125 µg/m^3	not to be exceeded more than 3 times a calendar year	1 January 2005
	Calendar year	50 µg/m^3	20 µg/m^3	-	19 July 2001

7.4 Impact of shipping on the ambient air in the studied ports

Besides shipping and port operations, the air quality in port areas is greatly affected by the local road traffic. Emissions from various sources and dispersion make it difficult to specify the effect of ship-originated emissions. Difficulties in defining the emissions from different sources are noticed in studies considering air emissions near ports (Appendix 1). Achieving an environmental permission for ports has been a common motivator to perform studies about air pollution.

The importance of the effects of shipping on the air quality varies between ports. Shipping in Lübeck-Travemünde is the most significant source of air pollution. In case of Lübeck-Travemünde, the shore-to-ship electricity connection can decrease air emissions of hotelling ships and is evaluated as being an efficient solution for emission problems in Travemünde. In other ports studied, the atmospheric emissions (excluding particles) are not recognised as major problems.

7.5 Solutions to reduce air emissions of shipping in ports

The air emissions caused by shipping originate from burning of different quality fuels in engine operations. Beside technical solutions onboard, there are non-technical methods to make shipping more efficient and to adjust the operations on an environmentally favourable level. This study considers the possibilities of ports to affect the environmental management. Therefore, in this chapter, the focus is on the methods that ports are able to implement.

Public ports, as ports included in this study, have a duty to provide berths for every ship that obeys the international regulations. Thus, they cannot restrict or ban ships that can be assumed to emit large amounts of air pollutants. The technology in use, operation, construction and maintenance of ships is in the hands of ship owners and shipping companies, which means that they are in a major role in reducing of atmospheric emissions of shipping.

However, ports are not totally without tools when reducing the atmospheric emissions of ships. Regulations, recommendations, limit values and economical incentives are efficient methods to be used in order to affect the environmental behaviour of vessels. The following methods are presented and discussed in this chapter:

- economic incentives to reduce pollution by shipping: environmentally differentiated harbour and fairway dues
- shore-to-ship energy
- building of environmental image through better performance
- possibilities of ports to affect the optimizing of ships' speed by port operations.

There are many technical methods available to reduce emissions from ships. The following methods are presented in the appendices.

- seawater scrubbing, (reduces SO_x and PM)
- common rail engine (reduces visible smoke)
- fuel water emulsion (reduces NO_x)

- humid air motor (reduces NO_x)
- direct water injection (reduces NO_x)
- exhaust gas recirculation (reduces NO_x)
- CASS (reduces NO_x)
- selective catalytic reduction, SCR (reduces NO_x)
- NO_x traps (reduces NO_x)
- selective non-catalytic reduction (reduces NO_x)
- low sulphur fuels
- biodiesel
- diesel engine and NO_x emissions
- non-thermal plasma (reduces NO_x)
- methods to reduce CO_2: hull design and maintenance, propeller design
- dual fuel engine (reduces NO_x)
- gas turbines (alternative for diesel engine)
- fuel cells (alternative for diesel engine).

7.5.1 Environmentally differentiated fairway and port dues

The Swedish Maritime Administration, the Swedish Shipowners' Association and the Swedish Ports' and Stevedores' Association made a principle agreement in April 1996 to employ measures in order to decrease ship-generated air pollution, particularly in the form of emissions of nitrogen oxides and sulphur (The Swedish Maritime Administration 2005a). The parties agreed to apply economic incentives in forms of environmentally differentiated fairway and port dues.

Fairway dues in Sweden

The differentiated fairway dues consider the portion of fairway dues levied on the basis of gross tonnage of a ship (The Swedish Maritime Administration 2005b). The number of calls per calendar month and a ship type also affect to the levied due.

Nitrogen oxide discount is given for all ships that prove their emission amount according to the Table 2. There are some changes when comparing new fairway dues to the previous ones. Due to technological progress, a reduction in the upper limit for discounts from 12 g/kWh to 10 g/kWh was made. Changes have also been made in the lower levels to encourage and promote SCR in auxiliary engines.

Table 2. Nitrogen oxide discount in 2005 is given according this table (The Swedish Maritime Administration 2005b) (information given in the currency SEK, 1 Eur ~ 9.5 SEK)

Emissions level, gram NO_x/kWh	Passenger vessels, SEK	Cruise vessels, SEK	Oil tankers, SEK	Other vessels, SEK
0 – 0.50	0.60	0.38	1.00	0.90
0.51 – 1.00	0.70	0.44	1.10	1.00
1.01 – 2.00	0.90	0.50	1.30	1.15
2.01 – 3.00	1.08	0.60	1.48	1.33
3.01 – 4.00	1.17	0.65	1.57	1.42
4.01 – 5.00	1.26	0.70	1.66	1.51
5.01 – 6.00	1.35	0.75	1.75	1.60
6.01 – 7.00	1.44	0.80	1.84	1.69
7.01 – 8.00	1.53	0.85	1.93	1.78
8.01 – 9.00	1.62	0.90	2.02	1.87
9.01 – 10.00	1.71	0.95	2.11	1.96
10.01 –	1.80	1.00	2.20	2.05

Vessels also get a discount from fairway dues depending on the sulphur content of fuel. Marine diesel oil (MDO) or marine gas oil (MGO) are not allowed to be used in Swedish territorial waters if their sulphur content exceeds 0,2%. This is based on the EC Directive 1999/32/EC. The Directive does not cover heavy fuel oil (HFO) or fuel in ships' tanks passing borders between the EU and non-EU countries. If the ships using MDO and MGO do not receive discounts, there is a risk of these vessels switching to HFO. That is why the ships using MDO and MGO are still given a low sulphur fuel discount. The Table 3 shows the sulphur-related dues in Sweden per unit of vessel's gross tonnage.

Table 3. Sulphur content of a bunker fuel affect to the amount of fairway due. Dues are presented as per unit of the vessel's gross tonnage (The Swedish Maritime Administration 2005b) (information given in the currency SEK, 1 Eur ~ 9.5 SEK)

Sulphur content, percent by weight	Passenger vessels, SEK	Other Vessels, SEK
0 - 0.2	0	0
0.21 – 0.5	0.30	0.20
0.51 – 1.0	0.60	0.40
1.01 –	0.60	0.60

Environmentally differentiated harbour dues

Environmentally differentiated harbour dues are introduced in many Swedish ports and in the Port of Mariehamn. The idea for the discount concerning the nitrogen oxides emissions is the same as with the previously presented fairway dues. The limit value for discount in the Ports of Stockholm and Malmö was 12 g/kWh of the engine's output in 2004. When a ship proves that the emissions are less than that, it will get discount at every call of port.

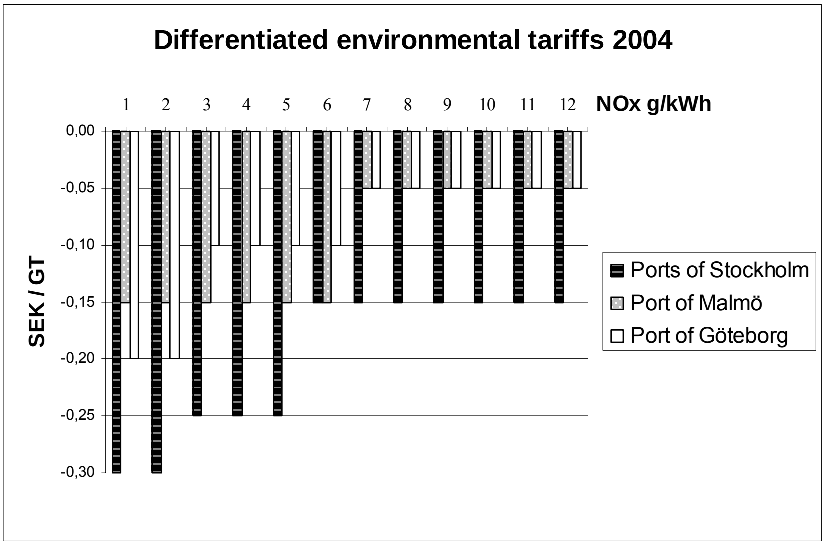


Figure 5. Differentiated harbour dues based on the NO_x emissions in Ports of Stockholm, Malmö and Göteborg (information given in the currency SEK, 1 Eur ~ 9.5 SEK).

In Mariehamn the vessels with engines performing less than 10g NO_x/kWh at a power level of 75%, including all the engines of the vessel, are granted discounts on the harbour fee. Engine performance from 1 to 10 g NO_x/kWh gives a 1% discount. At a performance level less than 1 g/kWh, an 8% discount is given.

Ports are able to contribute to the sulphur content of marine fuels used in ships by economic incentives. Lowered harbour fees for ships using low sulphur fuels have been taken in use in several Baltic ports. The NO_x-reducing SCR-system (selective catalytic reduction) is the most efficient method to reduce NO_x emissions from ships, and the system has proven to work very well in practice (method descriptions in Appendices). Thus, encouraging the use of SCR systems via incentives decreases sulphur emissions, because the adoption of SCR demands the use of fuel with sulphur content less than 2% (G. Hellen, Senior Performance Expert, Emission Control, Wärtsilä Engine Laboratory, personal communication 9.12.2004). When using the SCR systems, a port may give an opportunity to allow ships to use main engines also at berth (this is the case in the Port of Stockholm).

While at berth with constant load of the main engine, the functional SCR system reduces emissions considerably, even more than 95%.

In the Port of Mariehamn the sulphur content of bunker fuel affects the harbour due. Vessels using low sulphur oil only, with a sulphur content of less than 0,5%, are granted a 4% discount, and those using fuel with less than 0,1% are granted an 8% discount. Vessels having engine performance less than 1g NO_x/kWh and using bunker oil with less than 0,5% sulphur are given an additional discount of 8%.

In the Ports of Stockholm passenger ships, passenger ferries and train ferries will be levied a surcharge per GT, for each call into port, when the sulphur content of the fuel for the vessel's operation exceeds 0,5% per weight. For vessels other than named previously, a surcharge will be levied when the sulphur content exceeds 1,0% per weight. The additional charge will amount to SEK 0.20/GT. In the Port of Malmö the harbour due will be reduced by SEK 0.10/GT when using bunker fuel that contains less than 0,5% per weight for passenger ships and 1,0% per weight for other vessels. Since 1991 the Port of Helsinki has granted a 40% reduction in harbour fees for the passenger vessels operating according to the published timetable if the sulphur content of the vessels fuel does not exceed 1%.

7.5.2 Shore-to-ship energy

It is possible to reduce emissions at berth by a shore-to-ship connection, a process where shore power is provided to a vessel allowing it to shut down its auxiliary generators. This technology has been used by the military at naval bases for many decades in cases when ships are docked for long periods. At present, there are currently no international requirements that would mandate or facilitate a shore-to-ship connection of marine vessels (Port of Long Beach 2005). However, the MARPOL Annex VI seeks to address emission controls for hotelling vessels, but it does not mention a shore-to-ship connection separately.

There has been a shore-to-ship connection since 1987 in the Port of Stockholm. This system is still operative and used by passenger ferries in liner traffic. Within the New Hansa project, a new concept has been developed for on-shore power supply in Lübeck. The developed system would be capable of offering electricity in specific frequencies and qualities confirmed by initial data exchange between ship and shore. The system in Stockholm and the system developed in the New Hansa project are both designed for providing electricity source sufficient even for large passenger ferries. The other New Hansa partner ports do not have similar operative shore-to-ship power supplies but they do have some more specialised systems, e.g., in the Port of Kolding and in the Port of Helsinki for high speed catamarans.

The concept of shore-to-ship power supply developed by the Stadtwerke Lübeck GmbH in co-operation with Siemens AG is technically different compared to the connection in the Port of Stockholm. The new system is automated to a high degree with safety measures and electrical on-shore connections designed according to the IEC 60298 standards (LAIRM CONSULT GmbH 2004). The plug-in process is reasonably quick, requiring mere minutes to connect. The high degree of automation in the system provides a low toll on workload to the port authorities, and only standard superficial observation is required concerning the ship. The Port of Lübeck plans a 10 kV on-shore connection for its ferry and passenger terminals, and therefore it would be recommendable for ships arriving in the port to have a 10kV at 60Hz electricity grid. The efficiency of the system would rise if electricity grids in ships became more standardized, although the new systems are capable of offering electricity in specific frequencies and qualities.

The commercial applications under current usage also include the Los Angeles 60 Hz power supply to a ship through a 440 V plug-in connection consisting of 9 plug-in systems and the Göteborg/Zeebrügge 50 Hz power supply to a ship through a 10 kV plug-in connection (LAIRM CONSULT GmbH 2004).

The effects of the introduction of the shore-to-ship connection have been estimated in the Agenda 21 project "Implementation of Agenda 21 in the German Seaports: Model Calculations for the Prediction of Air Pollutant Levels considering Lübeck-Travemünde as an Example" (LAIRM CONSULT GmbH 2004). The starting point of the project was that The Port of Lübeck is adjacent to the widely known Lübeck-Travemünde spa area - "Seeheilbad" Travemünde. However, because of the steady growth of the port traffic and the planned expansion of the Skandinavienkai, an increase in shipping is expected, which endangers the classification of the Travemünde as a spa, and other plans for new tourist attractions. The results of the project show that supplying power from the wharf and the use of low sulphur fuels are appropriate means to reduce the level of air pollution. If all ships were connected to a wharf, the reduction of the sulphur content of fuel would give only little improvements, because the engines are not in operation. However, because it is not possible to connect all ships to a wharf, the reductions of the sulphur content of fuels may considerably contribute to the reduction of the atmospheric pollution. In a general level, the project of constructing a shore-to-ship connection is evaluated to be mutually beneficiary for all participants, i.e., the city, port operators, ship owners and power supply companies (LAIRM CONSULT GmbH 2004).

When introducing a shore-to-ship connection, the produced air emissions are on the responsibility of the producer of electricity. If the power is generated, e.g., from fossil fuels in a power plant, the environmental load is taking place elsewhere than in the port area. The overall environmental benefits would thus be lesser, but if power is generated from renewable sources (e.g., wind energy), the environmental benefits are clear through the whole energy production process. A shore-to-ship power connection may be an attractive alternative for shipping companies if the offered power is cheaper than electricity produced onboard. The efficiency of shore-to-ship power connection increases when berthing time is rather long, energy usage of a ship is high, and the ship has relatively frequent port calls (Port of Long Beach 2005). These aspects affect the cost efficiency and profitability of shore-to-ship power supply making the system more favourable for certain ports.

There is no data available about comparing the environmental efficiency of shore side energy versus abatement technology, e.g. SCR, installed in ships. However, the abatement technology works all the time as the engines are running, both offshore and at berth. This means that abatement technologies have more extensive spatial effects in terms of emission reduction whereas the shore-to-ship power is a local solution. On the other hand, the need for emission reduction is emphasized in the port areas often surrounded by dense housing and urban areas.

7.5.3 Building of environmental image through better performance

During the last years the environment has been constantly in the public gaze. This is especially true in the Baltic Sea region, because the open sea and coastal areas suffer from serious eutrophication and other environmental problems. The public attitudes and buying behaviour affect the company politics and that is why nowadays the environmental performance is regarded as an important part of entrepreneurship. For example, shippers may demand shipping companies to provide environmental efficiency throughout the whole supply chain. This can be already seen in some cases in the field of forest industry where these companies have started to demand environmental performance from the ships that transport their products.

The use of low sulphur fuels and environmental technology onboard ships has a great influence on the emitted air pollution. Low sulphur fuels and technology to reduce NO_x emissions as solutions are the most attractive means for good environmental performance for passenger ships. High environmental performance has a positive influence on the environmental image of a ship, the shipping company, and the product being transported by the ship. Shipping companies have taken environmental issues as one of their commercial assets.

As a critical node in the chain of transport, ports have an opportunity to promote companies' environmental performance as a part of their own high quality environmental management. The Port of Stockholm has established an annual environmental prize, the winner of which will be awarded an Environment buoy. The prize has gained a lot of publicity and is a fine example about how ports could promote the importance of environmental management and environmental image in the field of shipping.

7.5.4 Possibilities of the port to affect the optimizing of the ships' speed by port operations

The general rule of thumb states that the fuel consumption per distance sailed will approximately increase proportionally with (at least) the square of the speed (International Maritime Organisation 2000). Increased fuel consumption increases the exhaust emissions. A diesel engine's optimal operation (economically and environmentally) is normally configured on a high load range. If a ship is forced to drive with a low speed and, thus, with a low load of the engine, the impurity of the burning process causes higher particulate and greenhouse gas (GHG) emissions.

From an environmental aspect, it would be ideal if ships could keep their speed at emission-optimised load of the engine. In addition, the hull design and the weight of cargo affect the optimal speed of a ship (International Maritime Organisation 2000). An optimal speed from an economical (ship owner's) point of view is not always the same as the optimal speed of the ship. The cargo type, the demand of the present and future markets, and fleet planning are factors that affect choosing of a speed of a particular ship. The limiting of ships' speed would be favourable from an ecological point of view only when a ship is travelling with a maximum speed and, thus, at a high fuel consumption rate.

The time saved in a port as a result of more efficient cargo handling, mooring, berthing and anchoring may be used to lower the speed at sea accordingly, and gain savings in fuel costs (International Maritime Organisation 2000). Efficient cargo handling may (among other options) be used to reduce ship speed at sea and to save fuel and GHG emissions in a range of 1 - 5% of total fuel consumption compared to normal practice. Reductions in GHG emissions up to 1 - 2% may be achieved by efficient mooring, berthing and anchoring compared to normal practice. The role of the port facilities in reducing emissions, by means of logistical decisions such as requiring the use of low-emission tugboats rather than having large ship engines running in ports, may provide significant contributions.

7.6 Noise in port environment

7.6.1 The definition of noise

Noise by its definition is unwanted sound. Noise pollution is announced in decibels, which are usually measured with a filter that emphasizes sounds in certain frequencies. The "A" filter (dBA) is the one most frequently used. The "C" filter (dBC) puts more weight on low-frequency sounds such as the bass in amplified music (Noise control & research laboratories 2004).

“Low-frequency noise is noise within the 10 third-octave bands from 10 to 80 Hz. Low-frequency noise is almost exclusively an indoor problem. It occurs when the difference between the C-weighted equivalent sound level and the A-weighted equivalent sound level exceeds 20 dB, measured indoors” (Health Council of the Netherlands Committee on Uniform environmental noise exposure metric 1997).

The intensity of noise diminishes with distance. Outdoors, and in the absence of any close reflecting surface, the effective decibel level diminishes at a rate of 6 dB for each factor of two increases in distance. For example, a sound measuring 100 dB at 10 metres would be 94 dB at 20 metres, 88 dB at 40 metres, and so on (Noise control & research laboratories 2004).

If there are two uncorrelated sound sources - for example, a sound level of 62.0 dB and another one producing a sound level of 73.0 dB - then the total decibel sound level is a logarithmic sum (Campanella Associates 2005), i.e.,

combined sound level $\Rightarrow 10 \times \lg (10^{(62/10)} + 10^{(73/10)}) = 73.3$ dB

Note: for two different sounds, the combined level cannot be more than 3 dB above the higher of the two sound levels. However, if the sounds are phase related ("correlated") there can be up to a 6dB increase.

7.6.2 The solutions for noise abatement

Of the aforementioned facts can be deduced some interesting points when port areas are concerned. In a port area there are commonly several sources of noise pollution, each producing individual decibel levels of noise. According to the arguments above, the sum of these is not directly cumulative and merely slight increase in overall noise level occurs when several noise sources are added up as illustrated in the example. In port areas the efforts to reduce overall noise pollution should be targeted towards the highest decibel level sources in the area. Significant results can be achieved when the noise pollution peaks are eliminated.

The main and auxiliary engines are inevitable sources of noise from ships. Main engines are switched off at berth and auxiliary engines producing energy are switched on while staying at port. Besides the type of silencers the amount of produced noise of an engine depends also on the engine type and design for example, on the rotation speed and whether the engine is a row engine or V-engine (T. Viitala, Design manager JTK-Power Oy, personal communication, 30.8.2005).

Low-frequency noise from the auxiliary engines can be a problem near a berthing vessel. Measured decibels can be well below the limit level but still it is possible to hear a disturbing low-level sound. This low-frequency noise may also resonate with different structures, for example, large windows of offices and flats. In designing new ships the noise is taken into account better than in older ships. Mufflers need comparatively lot of space, which is always expensive in ships, making shielding of noise difficult in existing ships. Low-frequency noise problems from individual ships can be solved in many cases with investigation of ignition frequency of the engine and applying a proper resonator to diminish the problem (T. Viitala, Design manager JTK-Power Oy, personal communication, 30.8.2005).

Depending on the type of ships, the energy is used for various purposes, e.g., loading, warming, ventilation etc. Noise sources are the fans used for ventilation of cargo space while unloading and loading or the actual loading equipment. Warning sirens and horns are often reasons of complaints, as well.

The level of noise in loading, in many cases, depends on the driver of a loader. Collisions of containers produce clangs that can be heard from far away. The best available technology (BAT) may be introduced in order to reduce noise levels. Noise abatement technology is available for use in ports, e.g., innovations of spreaders' hydraulic dumping in container handling diminishes unwanted clangs in loading. Other noise pollution sources are the engines of the equipment, equipment warning sirens (the auto-backing-beeper), screechy chains and wires, slamming truck ramps, etc.

The noise generated by ships and port operations is one of the major environmental issues discussed in marine forums today. In ports operating on 24-hours a day basis, in particular, the noise and intensive light are polluting the neighbourhood. See Appendix 1 for detailed information on the project partners' answers concerning noise problems in ports.

Spatial planning plays a major role as a pre-emptive means to reduce noise pollution; the noise levels in the areas around the port can be roughly calculated per distances. The layout of the port area can then be made noise dampening oriented by placing the most noisy units as far away as possible from the locations where noise level is to be kept minimal, placing them behind other units, building structures designed for dampening in between, etc. Although it is more sustainable development to reduce noise sources, sometimes it might be practical to build noise walls, i.e., office buildings, terminals and storage areas in such a way that they isolate the neighbourhood from noise sources. In a constructing phase of a port, railway and road traffic can be directed into tunnels.

Improving the efficiency and developing of port operations will reduce emissions overall, but not necessarily the noise. Noise emissions should be taken into consideration when developing the infrastructure or planning the port operations. Replacing of noise sources with other applications is often comparatively expensive, but, e.g., replacing diesel power with electric power may have other environmental advantages as well, apart from noise reduction. The disposition of vessels at berths may be a practical solution - moving the source of noise further away from sensitive areas.

In a port area, a proper maintenance and use of the equipment with safe working environment would give a good starting point for noise management. Driving routes, rails and rail switches, bridges, ramps and ports should be kept in good condition as well as engines and mufflers. Loose metal in rails and ramps produces noise when driven over. These kinds of defects may be comparatively easy and cheap to repair. Idling restrictions of all engine operations at port areas will reduce noise as well as other pollutants in the air. It might be favourable if the restrictions and operations varied depending on the time of the day. At night some of the noisiest machinery could be banned and the volume of warning sounds could be reduced or replaced with strobe lights. Training of the employees is an efficient method to reduce noise as well as to improve safety at work. The co-operation between port authorities and ships is essential in the noise abatement process.

8. WP 2: SHIP-GENERATED WASTE MANAGEMENT

8.1 Regulation of ship-generated wastes

There are various provisions set by different authorities to control ship-generated waste. International conventions and the European Union regulate the ship-generated waste management. The European Union directives are implemented by adopting them to the national legislation of the member countries.

According to the International Convention for the Prevention of Pollution from Ships (International Maritime Organization, International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978, MARPOL 73/78) the discharge of oil, noxious liquid substances and garbage into the sea has been prohibited or restricted since the 1980s. The Baltic Sea has been designated as a Particularly Sensitive Sea Area (PSSA), which means that it is a specially protected area. In addition, the Helsinki Convention regulates the pollution from ships in the Baltic Sea area (Convention on the Protection of the Marine Environment of the Baltic Sea Area, 1992). Ships have to keep cargo, oil and garbage record books that can be used to check compliance with regulations, and to be used as evidence in possible legal proceedings.

The discharge of waste throughout the Baltic Sea is prohibited, with the exception of food wastes, which may be discharged more than 12 nautical miles offshore. The legislative system that regulates the waste management of ship-generated waste is based on Directive 2000/59/EC of the European Parliament and of the Council on port reception facilities for ship-generated waste and cargo residues. The Directive is consistent with the Helsinki Convention and the HELCOM recommendations. Animal based food waste from international shipping has its own regulations based on Directive 1774/2002/EC. Otherwise, food waste is not strictly regulated and it is allowed to discharge into the sea within restrictions concerning the distance from coastline.

The MARPOL 73/78 requires the States Parties to ensure the provision of adequate reception facilities in ports. That is also required in the Directive 2000/59/EC. According to the Directive, "An appropriate waste reception and handling plan shall be developed and implemented for each port."

8.2 Solid waste from shipping

For centuries it was believed that discharging waste into the marine environment was not harmful, because the oceans were thought to be so huge in terms of volume that the capacity to absorb waste was infinite. Discarding waste in the ocean was seen as complementary to the disposal on land, when many coastal communities legally barged waste to be disposed to the sea (Marine Board & Commission on Engineering and Technical Systems 1995).

The waste that was thrown overboard disappeared to the sea, but the problems emerged along with increased shipping. Accumulation of waste as well as its harmful effects on marine environment came up as a problem in the 1970s (Marine Board & Commission on Engineering and Technical Systems 1995). Debris on the surface of the oceans and the deposition of floating waste on the shorelines was clearly seen by the mariners and by people living at coastal areas.

The garbage generated in ships consists of household wastes such as glass and plastic bottles and containers, cardboard boxes, tins and food waste. Hazardous wastes come from maintenance of a ship, such as certain light bulbs; fluorescent lamps, batteries, paints and empty paint containers are also often received by the ports.

In the past, the waste thrown overboard was mainly food waste and other biodegradable substances or heavier substances that sank to the bottom of the sea. However, the composition of waste has changed along with durable materials and waste containing synthetic materials such as plastic packages, nets and fibre fishing lines. Plastics are problematic in many ways, because they can travel long distances and accumulate on certain shorelines decreasing the aesthetical and recreational value of beaches (Marine Board & Commission on Engineering and Technical Systems 1995).

Solid wastes as well as wastewaters dumped and discharged from the domestic and industrial sources onshore, makes the evaluation of the amount of ship-generated waste very difficult (Marine Board & Commission on Engineering and Technical Systems 1995). All waste appearing ashore is not necessarily from the ships, but, for example, carried by the rivers from mainland sources. To study the material discarded from ships on beaches or sea-bottom sediments, the location of sampling must be taken into consideration in order to eliminate the impact of sewer outfalls and recreational activity.

The costs of marine debris are difficult to calculate (Marine Board & Commission on Engineering and Technical Systems 1995). Lost tourism, beach cleanups, maintenance and repairs of damaged vessels and losses in fishing are examples contributing to unknown total costs. Beach-clearing operations have been carried out for example along the Polish coast since 1992, removing 50 - 100 m^3 of waste each year.

8.2.1 Plastics and other persistent material

The MARPOL Annex V covers prevention of pollution by waste from ships: according to the MARPOL Annex V, no plastics may be discarded overboard (International Maritime Organization 2004c). Thus, plastics must be stored onboard for disposal in port reception facilities or incinerated with certified system. The most obvious solution to treat the plastic waste problem on the ships is to reduce the amount of plastic materials brought onboard.

Plastics dominate the debris found on beaches and in the sea-bottom sediments. Plastic is persistent and abundant (Marine Board & Commission on Engineering and Technical Systems 1995). In addition, many other waste materials originated from shipping are persistent, e.g., glass, cement, brick and metals. Even timber, hemp, sisal and cloth can persist for a long time in water. The waste illegally discharged from commercial ships typically includes waste from cargo holds, medical and sanitary items. Sunken items may not be observed immediately, but the long-term and perhaps most insidious effects emerge only after a long time period.

8.2.2 Food waste

Food waste is often the largest single fraction of the total waste in ships (Polglaze 2003). Despite of that, a quite little attention is given to the food waste. This may be explained by the fact that disposal of food waste inside Special Areas (MARPOL 73/78), e.g., in the Baltic Sea, is forbidden nearer than 12 nautical miles from the nearest land.

There are possibilities to manage food waste if the disposal into the sea is prohibited (Polglaze 2003): incineration, diversion of food macerator output to a suitable sewage treatment plant, diversion of food macerator output to a holding tank (possibly after dewatering) for later discharge to the sea or shore (common in cruise liners) or retention of untreated or partially treated food waste onboard (e.g., in bins or in refrigerated storages). In the open sea areas where dumping is allowed, the food waste is usually only simply macerated before discharge.

Effective management of food waste is needed particularly in ships with many passengers onboard. Large quantities of ship-generated food waste may deteriorate seawater and sea-bottom sediment quality, affect marine biota and raise nutrient levels in the water column (Polglaze 2003). Regular and sufficiently large load to a certain area may cause clear changes in aquatic and littoral ecosystems, such as alterations in community species composition and diversity. The nutrient input resulting from the disposal of food waste from ships is relatively minor, especially when compared with inputs from other sources, such as industrial and municipal sewage outfalls and diffuse loading from rivers.

8.3 Oily wastewater from ships and from port operations

8.3.1 Operational discharges

Operational discharges of oil from the ships are originated from engine room waste (oily bilge water and fuel oil sludge) and oily ballast water from fuel tanks.

In Special Sea Areas as the Baltic Sea (defined by the MARPOL Annex I) (International Maritime Organization 2004a), it is forbidden to discharge oil, oily sludge and oil-contaminated residues or ballast waters into the sea. It is necessary to provide the facilities for ships to handle the oily waste. Thus, all oil loading terminals and repair ports located in a Special Area must have adequate reception facilities to receive dirty ballast water and tank washings from oil tankers. Furthermore, all ports must have adequate reception facilities to receive other oil residues and oily mixtures from all ships.

Fuel oil sludge is originated from pre-treatment of fuel before injected in the engine. Impurities of fuel are separated onsite, and the sludge formed is one of the basic ship-originated oil wastes. Sludge in ships is pumped into the sludge tanks that are emptied into the port reception facilities. Oil sludge usually contains only small amounts of water. A ship can produce sludge from onboard separators 0.5-1 m^3/day (Global Marine Oil Pollution Information Gateway 2005).

Bilge water is water that collects and stagnates in the bilge or bottom-most areas of a ship. Leaking cooling water, oil, lubricant oils and other substances from the ship's machinery spaces often contaminate bilge water when they are cleaned. Vessels produce various amounts of oily bilge water. Oily bilge water normally contains only a few percent of oil and a ship may produce it 2 - 3 m^3 a day (Global Marine Oil Pollution Information Gateway 2005). Large ships often have an equipment to separate oil from bilge water, and the sludge formed is pumped into the sludge tank and water into the sea.

With appropriate equipment on board, dirty bilge water can be processed in a way that separates most of the oil from the water before it is discharged into the sea (Global Marine Oil Pollution Information Gateway 2005). Discharged water is allowed to contain no more than 15 mg of oil per litre (15 ppm). However, it has been emphasized that bilge water also contains traces of detergents. These detergents can seriously complicate the treatment of oily waters, because oil and detergents form an emulsion of another density than pure oil.

8.3.2 Cargo related discharges

Cargo related discharges are tank-washing residues and oily ballast water. These discharges are basically related to operation of tankers. Tanker not fitted with segregated ballast tanks may need to discharge oily ballast waters to reception facilities. The amount of oily ballast water may be 30% of ships death weight tonnage (DWT).

According to the MARPOL Annex I, all new crude oil tankers of 20,000 DWT and above, and all new product carriers (30,000 DWT and above) must have segregated ballast tanks (SBT). The existing tankers over 40,000 DWT must be fitted either with SBT or with COW (Crude oil washing systems).

8.3.3 Oily waste in port operations

Ports focused in general cargo and containers produce comparatively small amounts of oily waste, whereas ports having oil terminals produce large amounts of oily waste (Olson 1994). Even if the operations in the oil harbours are secured and leakages minimized, the amount of accidental spills and waste oil is considerable. Cumulative amounts and effects of leaked oil are easily underestimated and difficult to totally prevent. Oil degrades in soil and water; the degradation rate depends on the type of oil. In harsh environment and cool climate, the degradation of oil is slow.

Drip trays are recommended to be used to prevent operational leakages (Olson 1994). When needed, the capacity of a drip tray can be multiplied by connecting it to a separate tank or special drainage system. The sewer system in the area where oil leakages are expected should be able to be closed when needed. It is also possible to install oil-detecting devices to monitor leakages.

Concrete endures oil products better than asphalt, which softens in contact with oil (Olson 1994). This is why oil-durable materials should be used as construction materials when expected the direct contacts with oil are expected (for example, oil loading areas, quays and pump wells).

8.4 Sorting and recycling of waste

Ships generate many waste fractions that can be recycled. Glass and glass bottles (coloured and uncoloured), paper, cardboard, electrical waste and some plastics etc. can be separated from the received waste. Sorting of waste is not difficult in ships because different types of waste are produced in different parts of a ship (Olson 1994). Many of the ships calling the studied ports sort their wastes.

International regulations do not include standards for waste sorting. Recycling of waste is easier when waste is sorted in a proper manner. Regulations regarding sorting include wastes that need special treatment such as hazardous wastes or waste dangerous due to its foreign origin. Household waste can be sorted in ships.

8.5 Port facilities in handling the solid and oily wastes

8.5.1 Port facilities for solid waste produced in ships

Ports are obliged to build reception facilities for wastes that are not allowed to be discharged overboard. Reception of waste should not cause undue delays for ships. Ports need to ensure that the reception of waste is easy and quick, which encourages ships to leave waste ashore. Categories of waste that are to be received at ports are mentioned in the six annexes of the MARPOL (see Table 4). Ports should have a waste management and handling plan. Directive 2000/59/EC complies with the MARPOL. Treatment and disposal of ship-generated solid waste in ports should follow the national and local regulations of the port.

Table 4. MARPOL 73/78 Categories of waste

MARPOL 73/78 Annex	Category of waste	Entry in force
I	Oil	2.10.1983
II	Noxious liquid substances in bulk	2.10.1983
III	Harmful substances carried by sea in packaged form	1.7.1992
IV	Sewage	27.9.2003
V	Garbage from ships	31.12.1988
VI	Air pollution from ships	19.5.2005

8.5.2 Waste from purification of exhaust gases

Waste reception facilities regarding the Annex VI means the facilities to receive waste from purification of exhaust gases, for example, sludge produced in seawater scrubbing process, which is considered as hazardous waste due to contamination of hydrocarbons and trace metals. For example, the producer of EcoSilencer (seawater scrubber) estimated that the ports that are used by ships with their technology might need to build a separate tank for collection of sludge to minimize the costs of transporting waste to further treatment (C. Skawinski, Marine Exhaust Solutions Inc., personal communication, 13.6.2005).

8.5.3 No-special-fee system

A no-special-fee system is created to standardize the feeing systems in ports. Ports need to assure that the costs for ships encourage using of their facilities instead of discharging waste into the sea. In the no-special-fee system all ships calling at port participate in the coverage of the port reception facility costs by paying fees each time they call at port. The idea is that ships will use the facilities they have already paid for. This feeing system also stimulates ports to use the best available technology for reception and treatment to reduce their costs.

A ship is obligated to notify the port of ship-generated waste before the ship is calling the port. The notification in a specified form should be made 24 hours before the ship is calling at port, with certain exceptions. A vessel is obligated to leave ship-generated waste to the port before departure. Exceptions to these regulations can be granted to the liners in regular liner services.

Many ports have notification and disposal instructions concerning ship-generated waste on the Internet, as well as maps of the waste stations. Integrated maritime management systems have been established; for example, in Finland there is a nation-wide PortNet system that covers data of all port calls in Finnish ports. One part of the system is an electric notification of ship-generated waste.

The HELCOM Recommendation 26/1 defines the scheduled traffic, thus defining the vessels that may be excepted from obligatory delivery of wastes and paying of waste fee. By implementing the Helcom recommendation 26/1 in the national legislation, the burden of accumulation of wastes to certain seaports is expected to diminish due to a more accurate definition for ships that are excepted concerning mandatory delivery of wastes. Including of sewage and solid waste into the no-special-fee system encourages ships to discharge all the waste ashore.

The policies and principles of collecting fees affect to the performance of waste management operations. That is why the no-special-fee system has been built up. Reduction in fees intensifies the positive effects of the system. According to Directive 2000/59/EC, fees may be reduced due to the decreased quantities of ship-generated waste, for example, because of better equipment and environmental operations.

The no-special-fee system is generally used in the Baltic ports. This feeing system includes all waste generated in a ship (sludge, oily bilge water and other waste). The amount of ships using the no-special-fee system varies between ports. If the ships calling a port are mainly liners, the amount of excepted ships may be very high (e.g., in the Ports of Lübeck, Stocholm and Helsinki).

The costs of discharging waste vary between the ports, because the ports define their fee according to their definition of the waste amount and costs of building and maintaining their waste reception facilities. The price of the delivery of waste affects greatly the usage of a port's reception system. The waste is delivered in ports where the price is cheapest.

Many ships in regular liner traffic are excepted from a generally used no-special-fee system, which means that they manage their own waste using mostly the services of private companies. If the port authority is responsible for granting of exceptions, they are recommended to follow the principles described in the Helcom Recommendations. Ships that use a no-special-fee system are discharging waste to ports' reception facilities. These vessels include various ship types and differing practices and equipment to handle waste onboard. This affects the fractions and amount of waste discharged from ships. The variability of waste handling should be taken into consideration by ports when planning their reception facilities: the ports should design the facilities according to the ship types usually calling the port.

8.5.4 Waste stations in ports

It has been recommended to have a permanent waste disposal stations in quays to ease the procedure for waste disposal from ships (Olson 1994). This practise allows some flexibility regarding for example working hours in ports. However, permanent waste stations may be problematic in quays, where space is needed for port operations. Thus, the location of permanent waste stations should be chosen carefully. Movable facilities of waste collection are still often needed. Waste stations should include containers for all the waste fractions delivered from ships.

Due to local provisions and instructions of waste collection, ports have different colours and methods to label their waste containers. In addition, containers are different type and size depending on the manufacturer. To prevent unnecessary mixing, containers should be designed for each waste fraction collected, and they should be marked properly. Containers for food and other similar waste need to be well sealed to prevent birds and other animals from spreading garbage around. Special waste, e.g., food that possesses risk due to its foreign origin, should be collected separately in containers that are well marked. Food waste containers must be emptied more frequently in hot and warm weather. It is also recommended to use markings for dry garbage only when containers are not suitable for wet substances.

8.5.5 Treatment of waste collected from ships

The actual reception of waste in practice is not a problem for ports, but further disposal and treatment of received waste may be a difficult task. Waste should be treated and disposed by using environmentally sustainable methods. Ports do not have waste incinerators or other methods to treat waste by themselves. This means that other parties play an important role in building a waste management system in a port. Hazardous waste is handled and treated by certified companies. Household wastes, excluding fractions that are recycled, are delivered to incinerators and landfills near ports. The municipal waste management systems in the studied areas are generally able to provide treatment for various fractions.

Ships are increasingly sorting their waste at the source. Thus, mixing of waste already sorted in ships is frustrating. However, it may often be the most environmental friendly way to treat the waste, because, for example, the specialized treatment facilities may locate far from ports, and transportation may be nor a cost-effective neither an environmentally sustainable way to handle the waste. This contradiction of principles and practices should be solved in the future.

The local municipal waste management and regulations affect waste handling and treatment. Waste should be reused and recycled when possible. Ports usually receive comparatively small amounts of waste, which is why it is often rational to integrate a port’s waste system with the municipal system. Using of incinerators of the municipality or other parties often provides a better solution than establishing a separate incinerator in the port area. If there are no incinerators available for use of a port, a small incineration plant could be built to treat special waste. When building incinerators for ports, the regulations and exhaust gas purification must be considered and taken into account.

The integration of waste management in a port area (that is, waste from ships and waste produced from other companies operating in the port area) has been considered as an effective practice and implemented in many ports. This practice is also recommended in literature (Olson 1994; Marine Board & Commission on Engineering and Technical Systems 1995). Integration of waste management between a port, ships, local offices and industry located near the port will increase the amount of handled waste, giving better economical starting point for environmentally sustainable waste management. It contributes to more efficient use of received waste fractions and recycling.

8.5.6 Reception of oily wastes from ships

Refinery terminals where oil is usually loaded have their own equipment to separate oil from water (Olson 1994). This equipment also enables handling of cargo-related oily wastes, such as contaminated ballast water. It has been thought to be advantageous from an economical point of view to let the oil companies responsible for loading also to be responsible for providing the required reception facilities.

Engine room waste is generally received by port authorities or private companies that are certified to handle oily wastes. This is a good practise in ports serving all kind of ships, not only tankers. Generally, oily waste from engine room (sludge and bilge water) is collected in tank trucks or barges or permanent collection points via quays. The amount of water in oil affects the costs of the treatment, which is why, for example, in the Port of Stockholm the fee for discharging oily wastewater is differentiated according to the water content. An oil terminal of a port can be used to separate excess water from received engine room waste (Olson 1994). Water separated from oil may still contain substances that are not wanted to be discharged to the environment, and it would be recommended to further treat the water before releasing it into the sea.

Dewatered oily residues can be re-refined or incinerated under high temperature. In an urban garbage incinerator they can be blended into the combusted fuel oil. One possibility is to burn them in cement kilns that are able to provide high temperature enough to destroy harmful substances. (Olson 1994).

The receiving and especially the treatment of oily wastes are problematic for ports when detergents from washing of engines are mixed with bilge water (Olson 1994). This leads to a situation where oil separators do not work correctly. This is why it is recommended that ships sign a declaration on the content of their oily water discharge. The same problem exists when using separators onboard of a ship.

8.5.7 General guidelines for harmonizing the waste collection in ports

Harmonizing the collection of waste fractions would simplify and ease the use of reception facilities in ports. To increase the amount of recycling, household waste from ships, in particular, needs standards for sorting. Port communities' waste treatment methods are different concerning the sorted waste, for example, incinerators for garbage are not always available in reasonable distances. This is why many interest groups should be heard when agreeing on the fractions to be sorted.

Colourings used in waste containers vary, and similarities could not be found between ports. This is why it is not possible to recommend the most used colours to be used in all ports. Standardization of colouring of waste containers in stationary collection points at quays would ease the use of waste stations.

Recommended fractions for ship-generated waste that could be received in permanent waste stations (EWC-codes in brackets):

- paper and cardboard (20 01 01)
- glass (coloured and uncoloured) (20 01 02)
- metals (20 01 40)
- plastics (20 01 39)
- biodegradable kitchen and canteen waste (20 01 08)
- combustible waste, when waste is treated in an incineration plant
- non-combustible waste, when waste is landfilled or the characteristics of waste do not allow incineration
- special waste, dangerous due to its foreign origin (outside EU) (18 01 03).

Depending on the need in a particular port

- 20 01 37 wood containing dangerous substances
- 20 01 38 wood other than that mentioned in 20 01 37.

Several hazardous wastes that are generally produced in ships can also be collected in permanent waste stations. The amount of hazardous waste collected in ports is comparatively small. Thus, the costs and needs for permanent collection points vary between ports. The collection points can be, for example, locked containers including smaller boxes, bins, barrels and containers suitable for the collected fraction. The most important is that hazardous waste is collected under supervision of educated personnel, and that the content of received waste is well packed and marked properly using EWC coding when possible.

A permanent reception point for hazardous waste could include, for example, following containers (EWC codes in brackets):

- waste oil such as lubricating oils (13 02 08, 13 02 04, 13 02 05)
- oil contaminated materials such as cleaning clothes and wastes (15 02 02, 15 02 03)
- oil filters (16 01 07)
- paint and solvents (14 06 02, 20 01 13, 08 01 13)
- aerosols (16 05 04)
- batteries (20 01 33)
- electrical waste (20 01 36)
- fluorescent strip lightning (20 01 21)
- other light bulbs (20 01 21)
- medical waste (20 01 32).

9. WP 3: SHIP-GENERATED WASTEWATERS

9.1 Black and grey water

In international regulations, sewage, further referred also as black water, is defined as drainage and other waste from toilets, urinals and WC scuppers and drainage from medical premises via wash basins, wash tubs, and scuppers located in such premises (International Maritime Organization 2004b). Furthermore, sewage is drainage from spaces containing living animals and other wastewaters when mixed with the drainage defined above. The discharge of raw sewage into the Baltic Sea is forbidden by international regulations except when (HELCOM 2004):

- the ship is discharging comminuted and disinfected sewage through an approved system at a distance of more than 3 nautical miles from the nearest land.
- the ship is discharging sewage which is not comminuted or at a distance of more than 12 nautical miles from the nearest land.

It is allowed to discharge wastewaters if a ship has an approved sewage treatment plant in operation. On the basis of this, it could be allowed to discharge treated sewage even while in port, but many ports have forbidden discharging of black water in their port regulations.

Grey water in ships is created in kitchens, laundries, showers, sinks and pools etc. There are no regulations limiting the discharge of grey water into the sea. In many ports it is possible to deliver grey water to be treated at wastewater treatment plant on shore.

The impact of wastewater on aquatic ecosystem depends on the type of contaminants in the wastewater. When discharged in coastal area, it has several serious effects on the coastal ecosystem, but it may also cause aesthetical disturbance. Sewage contains pathogens, which are disease-causing micro-organisms such as viruses, bacteria, and protozoans that affect humans directly by causing illness and possible deaths. Biodegradable organics increase biochemical oxygen demand (BOD) resulting in anaerobic conditions that cause fish kills and bad smell. Toxic compounds accumulate in consumable water organisms (fish, shellfish) and interfere with microbiological process in sewage treatment. The Baltic Sea is almost totally surrounded by land and the residence time of water in the central Baltic is 25 - 30 years. This makes the Baltic Sea very vulnerable and endangered by marine pollution compared to other sea areas (Rheinheimer 1998).

The nutrients in black and grey waters affect marine environment by increasing the growth of phytoplankton, pheriphyton and aquatic plants, thus contributing to the eutrophication process. The eutrophication is considered as the most alarming environmental problem in the Baltic Sea (Bonsdorff et al. 1997). The nutrient load to the Baltic Sea is mainly from diffuse loading, municipal and industrial loading and atmospheric fall-out. However, sewage from shipping may locally act as a significant nutrient source.

When considering passenger vessels with a capacity of more than 3.300 passengers, the amount of grey water may reach 500 m^3 a day (Alstom 2005). An installed vacuum sanitation system needs only 1.2 - 1.5 litres water per flush. Still, the amount of black water can be 45 m^3 a day. During long voyages, the amount of wastewater cannot be stored onboard. It can be expected that one person in one day can produce 25 litres of sewage with a vacuum system and 185 litres of sewage and grey water together.

There are many suppliers of water treatment plants in the market providing equipment to treat both grey and black water. Some ships, especially cruisers, have wastewater treatment plants onboard treating both black and grey waters. Black and grey water can be handled onboard by three basic techniques: biological aerobic treatment, physical and chemical treatments and electrolysis. It has been estimated that 95% of all new ships have a biological sewage treatment plants onboard. Sanitation systems keep black and grey water apart from each other to be handled separately (Reader et al. 1997).

Water injection (also known as Direct Water Injection, DWI) as a technical method to reduce NO_x emissions possesses also a potential to treat wastewaters produced in a ship (Reader et al. 1997). The diesel engine could use wastewater (black and grey) instead of pure water to decrease the combustion temperature to diminish NO_x emissions and at the same time work as a thermal destruction device for sewage. This could make possible to construct vessels without any sewage discharges.

International regulations demand sufficient facilities from the ports to handle wastewaters of any ship calling to the port. Methods to answer to these demands depend on the type of visiting ships and also on the type of discharged wastewater. Portable tanks, tank trucks and fixed reception facilities are generally used systems to receive sewage, black water and grey water, also.

9.2 Port facilities to receive sewage

Sewage installations in ports should be built regarding national and local regulations. A municipal sewage system is often used for reception of black and grey water produced in ships. Wastewater from municipal sewage system is further directed to the local wastewater treatment plant.

Ships with large crew or passengers sailing mostly in the coastal waters have more need than other types of vessels to discharge sewage in the ports' reception facilities because of the large amounts of wastewater produced and restrictions of discharging into the sea. Permanent sewage reception points for such ships are generally used in many ports, because these ships are mostly liners. Also tank trucks are used with suction pumps, if ships own pumps are not able to discharge sewage within a reasonable time.

Ships calling any of the ports studied in this survey can discharge their wastewater ashore. In the ports studied, the common practice is to pipe the received waste black and grey waters directly to a municipal sewer system and further on to the municipal treatment plant. Tanks for storing wastewaters are generally not needed in ports. A temporary storage is installed in the Port of Stockholm where extra capacity is needed when Ro-Ro vessels are discharging wastewater in such a rate that sewage system cannot absorb. The Port of Kolding has storage tanks for received sewage where black water is left to settle and then drained to the sewage system after oil separation filtering.

Those ports that are not able to discharge straight to a municipal sewer system are using the services of tank trucks. The Port of Kolding uses also mobile tanks. When ships are discharging their wastewaters, possible smell problems may be solved by using a technology based on chemicals, removing septicity from wastewater (e.g., the Port of Helsinki uses NUTRIOX® (Yara 2005), a natural biological method for preventing septicity and removing H_2S by a controlled dosage of nitrate).

In the Ports of Mariehamn, Szczecin and Swinoujscie the wastewater is piped or barged directly to treatment plants. The quality of wastewater treatment plants and the municipal wastewater management has considerably improved in the recent decades, making a generally used system a good practice for handling of ship-generated wastewater. A modern sewage treatment plant has been constructed in Szczecin. The mechanical-biological plant with a treatment capacity of 3200 m^3/day can handle sewage from ships calling the Port of Szczecin and sewage from the area of the Szczecin Port. The wastewater plant also includes facilities to treat oily wastewater and wastewater from washing of holds of ships. Wastewaters from ships are barged to the treatment plant. All the processes are highly automated.

The quality of wastewater should be known to guarantee a proper treatment and to prevent causing of harm to the wastewater treatment plant. This is why some ports demand assurance from ships that the wastewater discharged fulfils certain standards. The wastewaters from washing of cargo spaces of ships should be treated before discharged to the sea. Depending on the quality of the washing water, the treatment can vary from removal of oil and/or solid particles to a treatment in an aerobic wastewater treatment plant.

Ports have installed permanent reception points via quays to ease the wastewater reception. Common problems when discharging wastewater can be avoided in permanent reception facilities by appropriate construction design. Pipelines can be bridged to allow traffic at the quay, and adequate suction pumps can be offered. Some ports have plans to increase the amount of permanent facilities at their quays.

The connection between the reception facilities and ships is not a problem. The IMO has described a generally used standard collar. There are some differences between collars used in ships, but technically those can be solved and wastewater discharged in a proper way. Sanctions of the lack of standard collars are also used in some ports, and this probably encourages ships to take the IMO collars in use.

10. CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations are drawn from the Work Packages 1 - 3 of the New Hansa project. The feasibility study includes three main sections according to the Work Packages 1, 2 and 3: atmospheric emissions and noise, ship-generated solid and oily waste and ship-generated wastewaters respectively. The data of the study consist of background data of the participating ports and general information and theory of environmental issues concerning the topics of the Work Packages. The conclusions and recommendations are mainly based on the data collected from the project partners and the topics discussed in the project meetings and visits. The discussion on the project topics is presented in the previous chapters (detailed answers to the questionnaires are to be found in the Appendix 1).

10.1 Introduction of economic incentives

Economic incentives are an effective tool for ports to affect directly to the introduction of an environmental friendly technology, low-sulphur fuels and waste management practices in ships. However, there would be a risk of loosing competitiveness of a port, if it alone should introduce any economic incentives. It requires a national or international agreement to effectively apply this as a system.

Some of the ports of this project have applied economic incentives

- aiming at the reduction of the NOx emissions from ships (e.g., installing abatement technology in ships)
- aiming at the use of low-sulphur fuels in order to reduce the SOx emissions from ships
- aiming at encouraging sorting of waste in ships
- in form of discounts in case a ship shows especially distinguished environmental performance.

The previously mentioned economic incentives have proven to be efficient in encouraging the introduction of an environmental friendly technology in ships. For example, installing of NO_x abatement technology or the use of low-sulphur fuels in ships would decrease the atmospheric emissions of ships when engines are running, i.e., both offshore and at berth. The economic incentives could be applied to promote almost any environmental friendly technology or method, and it is recommended that the various possibilities of using economic incentives would be investigated in the Baltic Sea region.

Because of the direct positive effects in terms of decreasing the amount of waste and emissions from ships, it is recommended that a joint economic incentive system would be developed among the Baltic ports.

10.2 Introduction of shore-to-ship electricity

It is possible to reduce emissions of berthing ships by a shore-to-ship electricity system, a process where shore power is provided to a vessel, allowing it to shut down its auxiliary engines. Thus, all the engines of a vessel could be shut down at berth. This reduces the atmospheric emissions and noise from ships' engines in a port area. There are currently no international requirements that would mandate or facilitate a shore-to-ship connection of marine vessels. The shore-to-ship connection could provide a local solution for air quality problems in port areas.

It is recommended that ports study the cost- and environmental efficiency of constructing a shore-to-ship electricity system. However, there are ports where, due to technical or operational reasons, it is not efficient to implement the system because of, e.g., short berth times of ships or inability to provide the needed amount of power. The efficiency of shore-to-ship electricity to reduce emissions improves when berthing time is rather long, energy usage of a ship is high and the ship has relatively frequent port calls. The standardisation of a shore-to-ship connection in the Baltic Sea region would ensure the same preconditions in all ports that would strive to increase the use and further the efficiency of the system.

10.3 Harmonization of waste collection in ports

It was observed in the New Hansa project that the collection procedures of waste vary between ports. In addition, the sorting procedures vary between ships. Although the ports do not have any significant problems in receiving the waste, a harmonized system of waste collection in ports would make the sorting easier for ships and promote the sorting onboard, thus making the collection of waste more efficient. Therefore, it is recommended that ports would agree about common classification and procedures in waste collection. The harmonized system could be adopted by an individual port to an appropriate extent.

This study presents general guidelines for the classification system that is based on the observations made and data collected during the study (see details from Chapter "General Guidelines for Harmonizing the Waste Collection in Ports"). However, an international agreement is a prerequisite for successful harmonization of waste collection in ports. A challenging task of creating an operational harmonized waste collection system cannot be accomplished within this study period. More discussions about the views of the parties involved, that is, shipping companies, environmental and regional authorities, treatment plants and other Baltic ports, is needed in order to reach the harmonization. For example, one of the most challenging issues in harmonization is the variable waste treatment procedures in different regions.

10.4 Improvement of ship-originated waste management in ports

Ports have a possibility to significantly affect the ship-originated waste management. The project revealed some actions that ports are recommended to consider in order to improve the waste management. Ports should

- establish waste collection stations for ship-generated waste at quays wherever possible (non-hazardous waste).
- establish waste collection stations for hazardous waste at quays with supervised discharging practices.
- respect sorting at source and prevent mixing of sorted waste fractions.
- promote recycling to decrease the amount of waste that is directed to landfills.
- promote the integration of the management of ship-generated waste and waste originated from a port area.

10.5 Encouragement to discharge sewage ashore

Large cruise ships can be compared to small cities concerning the production of wastewater. Thus, passenger ports have to manage more black and grey waters than cargo ports. It is possible to build a treatment system onboard to handle the wastewater of a ship. When validated and maintained properly, this method can be considered as a good practice because of the effluent quality that is comparable to treatment plants ashore.

The problem from an environmental viewpoint is that international regulations allow discharging of black and grey water into the open sea areas without or with only minor treatment. Thus, the possibility of discharging untreated sewage into the sea is commonly used, although there have been attempts to decrease the amount of discharges, for example, by using feeing systems and advanced reception facilities in ports.

However, it is recommended that ports establish permanent reception facilities for wastewater in quays whenever possible. These facilities work very well and can be recommended to be built in quays operating with constant liner traffic. It may encourage ships to leave wastewater ashore for a proper treatment of the wastewater. It is also recommended that ports should claim for certificates from ships to guarantee the quality of wastewater directed to wastewater treatment plants.

10.6 The active promotion of the environmentally sustainable best practices

Ports are important regional actors and authorities possessing various possibilities to promote the environmental friendly behaviour and best practices. A port's active role as an environmental manager is advantageous also when building up the port's own environmental image.

The promotion of the environmental image is an indirect way to affect the improvement of environmental performance of a company. As the public awareness about the environment is constantly growing, the use of environmental performance as a competitive advantage will be increasingly important for both ports and their customers and stakeholders. Among the ports of this project, Stockholm has an "Environmental Buoy", an award granted annually for "work in contributing to a significant environmental improvement in the field of shipping and/or increasing awareness of the shipping sector's environmental work to promote environmentally sustainable best practices".

It is recommended that ports together with their stakeholders should find the incentives to improve the environmental performance of shipping and port operations. The development of active, long-term international co-operation between ports and other interest groups, in order to develop and apply the environmentally sustainable best practices, is recommended. Through co-operation, it is also easier to support and draw public attention to the best practices developed and/or introduced in the Baltic Sea region.

10.7 Gaining the knowledge about ambient environment for harmonization

The knowledge about the state of the environment is a prerequisite for effective environmental management. The national and local authorities are mainly responsible for monitoring of the environment, but ports also need knowledge about the environment, e.g., for environmental permissions and management.

It was observed in the New Hansa project, that the ports have no commonly used models or methods for monitoring, predicting or estimating the state of the surrounding environment. However, the data and factors used in individual models are often from the same source.

In order to develop harmonized environmental practices for the Baltic Sea ports, comparable with each other information about environmental parameters and emissions should be available. Thus, it is recommended that the ports agree on using certain models and calculation methods. This would be a subject of further co-operation.

The models concerning air pollution from shipping and port operations are especially useful for ports. Many of the participating ports within the New Hansa of Sustainable Ports and Cities project have made calculations about the total air pollution amounts originated from ships. This practice can be recommended for all ports. By combining the data with meteorological data and using the distribution models available it is possible to evaluate the impact of shipping on the port environment and surrounding areas.

The ports should consider their needs for supplementary environmental surveys or monitoring. For example, ships' diesel engines or dusting in the port area are one of the potential sources of the fine particles that are particularly harmful for human health. In this case, it is recommended to include PM_{10} and even $PM_{2.5}$ to the studied components of air pollutants.

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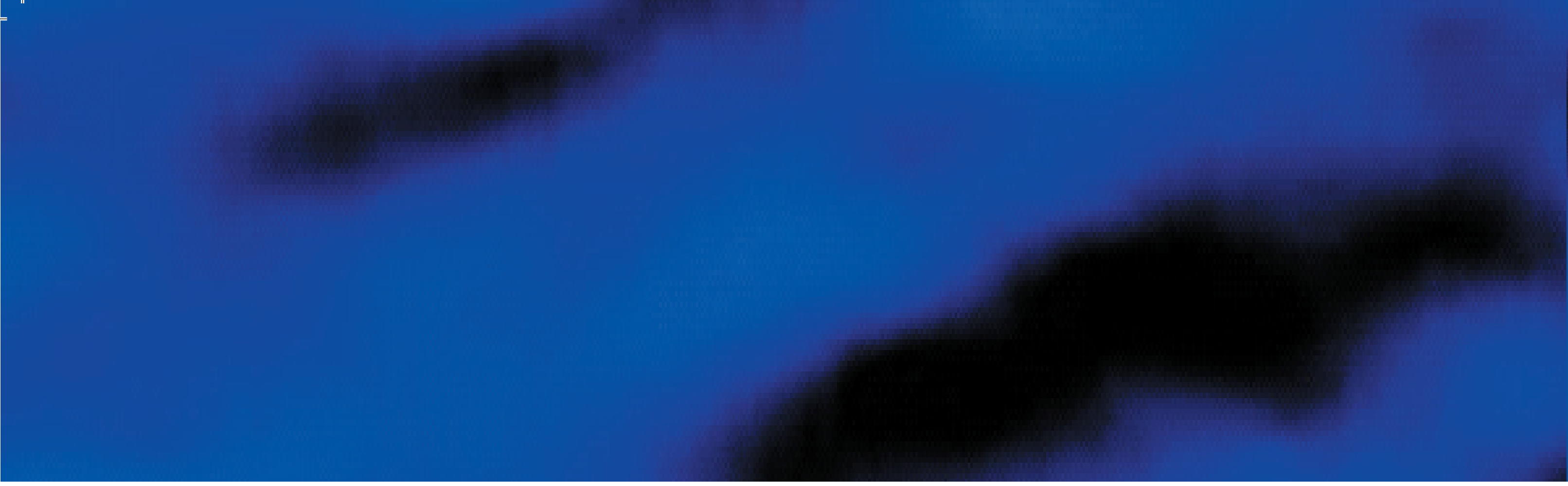

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