COGEA

Consulenti per la Gestione Aziendale

European Commission

Study on differentiated port infrastructure charges to promote environmentally friendly maritime transport activities and sustainable transportation

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List of abbreviations

AIS	Automatic Identification System
ATA	Actual Time of Arrival
BA	Blue Angel
BGTW	British Gibraltar Territorial Waters
BPO	Baltic Ports Organisation
CAAP	Clean Air Action Plan
CARB	California Air Resources Board
CFC	Chlorofluorocarbons
CLECAT	Comité de Liaison Européen des Commissionaires et Auxiliaires de Transport du Marché Commun
CO_2	Carbon Dioxide
CSI	Clean Shipping Index
DTIE	Division of Technology Industry and Economics
DWT	DeadWeight Tonnage
EC	European Commission
ECA	Emission Control Area
ECASBA	European Community Association of Ship Brokers and Agents
ECSA	The European Community Shipowners' Associations
EEA	European Environment Agency
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
EGCS	Exhaust Gas Cleaning Systems
EMAS	Eco-Management and Audit Scheme
EMEC	European Marine Energy Centre
EMS	Environmental Management System
EMSA	European Maritime Safety Agency
END	Environmental Noise Directive
EPA	US Environmental Protection Agency
EPI	Environmental Performance Indicator
ESI	Environmental Ship Index
ESPO	European Sea Ports Organisation
EU	European Union
FEPORT	Federation of European Private Port Operators
GA	Green Award
GHG	GreenHouse Gas

GRT	Gross Register Tonne
GT	Gross Tonne
HCFC	HydroChloroFluoroCarbons
HFO	Heavy Fuel Oil
IAPH	International Association of Ports and Harbors
IMO	International Maritime Organisation
KPI	Key Performance Indicator
LEED	Leadership in Energy and Environmental Design
LNG	Liquified National Gas
MCA	Multi-Criteria Analysis
MDO	Marine Diesel Oil
MEPC	Marine Environment Protection Committee
MRV	Monitoring, Reporting and Verification
MS	Member State
NECA	Nitrogen Emission Control Areas
NMVOC	Non-Methane Volatile Organic Compounds
NO_x	Nitrogen Oxides
NTU	Nephelometric Turbidity Unit
ODS	Ozone-Depleting Substances
OECD	Organisation for Economic Co-operation and Development
OGV	Ocean Going Vessels
OPS	On-shore Power Supply
PERS	Port Environmental Review System
PM	Particulate Matter
PSSA	Particularly Sensitive Sea Area
R&D	Research & Development
SDM	Self-Diagnosis Methodology
SEA	Significant Environmental Aspect
SECA	Sulphur Emission Control Area
SEEP	Ship Energy Efficiency Management Plan
SIFA	Swedish International Freight Association
SO_2	Sulphur Dioxide
SO_x	Sulphur Oxides
SSS	Short-Sea Shipping
ST	Ship Tonnage
TAP	Technology Advancement Program

TEN-T	Trans-European Transport Network
TEU	Twenty-Foot Equivalent Unit
TUP	Tariff for Use of the Port
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
VECS	Vapour Emission Control System
VOC	Volatile Organic Compounds
VSR	Vessel Speed Reduction
WHO	World Health Organisation
WPCI	World Ports Climate Initiative

1 Introduction

1.1 Background

According to the United Nations Conference on Trade and Development (UNCTAD), around 80% of world trade in terms of volume is carried by sea[1], and this share is expected to grow considerably in the near future.

Despite being considered a relatively energy-efficient and climate-friendly mode of transport, maritime transport also has adverse impacts on the environment, human health and climate, which are causes for great concern. Adverse impacts are common to all transport modes and generate external costs that are not fully borne by users, such as pollution, noise, congestion, accidents and spills, etc. Transport providers and users make their decisions without taking into account "externalities", although these inevitably produce side effects on society as a whole. The policy intervention aimed at making side effects part of the decision-making process of transport users is called 'internalisation of external costs'. External costs may be internalised through the use of market-based instruments, which may lead to a more efficient use of infrastructure, reduce negative side effects of transport activities and improve fairness between transport users[2].

Fair and efficient transport pricing is also advocated in a number of policy documents issued by the European Commission, notably the 2011 White Paper on Transport. In 2008, the European Commission released its first handbook with estimates of external costs in the transport sector (then updated in 2014[3]). The handbook, jointly prepared by several transport research institutes, summarises the state-of-the-art best practices as regards the valuation of external costs. The Commission used this handbook to prepare a communication on a strategy to internalise the external costs for all modes of transport that was adopted in July 2008.

There is a range of options that port managing bodies can apply to influence the environmental performance of shipping. Amongst others, one is to offer incentives to the shipping industry in its effort to carry out more environmentally-friendly maritime operations, thus reducing or limiting the negative effects of maritime transport on the environment.

Among the multitude of possible measures to tackle adverse environmental impacts of maritime operations, 'port pricing' or 'environmental charging' has been receiving increasing attention in the last few years, having generated a considerable maritime transport economics literature, as well as a number of concrete, bottom-up initiatives voluntarily implemented by port managing bodies (e.g. the Environmental Ship Index, Clean Baltic Sea Shipping, Green Award, etc.).

Part of this attention originates from the reaction to the EU policy developments of the late '90s, and culminated with the publication of the Green Paper on Sea Ports and Maritime Infrastructure[4]. 15 years later, after a series of legislative advancements and increasing acknowledgment by ports of the role of environmental charging, the 2013 Commission's communication on ports policy (COM(2013) 295) identified the need to raise the environmental profile of European ports as a priority of the EU Transport Policy in the coming years, inter alia by *considering whether to reward operators who anticipate or exceed the application of mandatory environmental standards and promote the use of door-to-door low carbon and energy efficient logistics chains.*

[1] UNCTAD, *Review of Maritime Transport*, 2013.
[2] Ricardo-AEA, Update of the Handbook on External Costs of Transport, Report for the European Commission: DG MOVE, 2014.
[3] Idem.
[4] COM(97)678 final, Green Paper on Sea Ports and Maritime Infrastructure, 10.12.1997

More recently, the Regulation of the European Parliament and of the Council establishing a framework on market access to port services and financial transparency of ports (Regulation (EU) 2017/352) has stated that "The Commission, in cooperation with Member States, should elaborate guidance on common classification criteria for vessels for the purpose of voluntary environmental charging, taking into account internationally agreed standards" (Recital 51), and that "[…] port infrastructure charges may vary in accordance with the port's economic strategy and the port's spatial planning policy, related inter alia to certain categories of users, or in order to promote a more efficient use of the port infrastructure, short sea shipping or a high environmental performance, energy efficiency or carbon efficiency of transport operations (Art. 13.4).

The legal framework in which environmental charging may work is not limited to the EU. Efforts to reduce the environmental footprint of human activity are being carried out worldwide at the international level. In December 2015, in the framework of the 2015 United Nations Climate Change Conference (COP 21 or CMP 11), 195 countries agreed on the Paris Agreement to reduce emissions as part of the method for reducing greenhouse gas[5]. The members agreed to reduce their carbon output "as soon as possible" and to do their best to keep global warming "to well below 2 degrees C". The agreement entered into force on 4 November 2016, but it does not cover air and maritime transport.

Each country that ratifies the agreement will be required to set a target for emission reduction or limitation, called a "nationally determined contribution" (NDC), but the amount will be voluntary. The threshold for entry into force of the Paris Agreement was achieved on 5 October 2016, and the agreement entered into force on 4 November 2016.

More specifically to maritime transport, the International Maritime Organisation (IMO) has assumed responsibility for pollution issues and subsequently has, over many years, adopted a wide range of measures to prevent and control pollution caused by ships and to mitigate the effects of any damage that may occur as a result of maritime operations and accidents. Initially the IMO focussed on prevention of marine pollution by oil, resulting in the adoption of the first ever comprehensive antipollution convention, the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1973. This has changed over the last few decades to include a much wider range of measures to prevent marine pollution, and the original MARPOL Convention was amended many times to also include requirements addressing pollution from chemicals, other harmful substances, garbage, sewage and, under an Annex VI adopted in 1997, air pollution and emissions from ships. Latest developments have led to establishing Sulphur Emissions Control Areas (SECAs) and Nitrogen Oxide Emission Control Areas (NECAs) in several areas of the world, among which are the Baltic and the North Sea (SECA in 2005 and 2006 respectively, and NECA from 2021). Recently the IMO has also approved the entry-into-force of the global low sulphur in fuel cap as from 2020. Furthermore, in view of the Paris agreement, the Marine Environment Protection Committee (MEPC) of the IMO agreed that IMO should determine a possible fair share contribution for the international shipping sector, which if developed, should take into account the circumstances that are relevant to the international shipping sector, including the importance of international trade in supporting the sustainable development of national economies. In October 2016, the MEPC formally adopted a mandatory data collection system for fuel consumption of ships. The MEPC also agreed that an initial but comprehensive IMO strategy on reduction of GHG emissions from ships should be adopted in 2018.

The EU too has a role in this debate. In December 2016, the Environment Committee (ENVI) of the European Parliament adopted a report on the revision of the EU Emissions Trading System (ETS)[6], which puts pressure on the IMO to have a system comparable to ETS operating for global shipping as from 2021. If that is not the case, then shipping should be included in the European ETS as from 2023. Part of the revenues generated from ETS would be channelled through a Maritime Climate Fund to improve energy efficiency and invest in innovative technologies for ports and short sea shipping.

[5] http://unfccc.int/paris_agreement/items/9485.php

[6] ENVI(2016)1215_1. Documents available at http://www.emeeting.europarl.europa.eu/committees/agenda/201612/ENVI/ENVI(2016)1215_1/sitt-3968209

While a system of environmental infrastructure charges may well be a promising method for improving the environmental and social performance of transportation systems, this does not guarantee *per se* that such a solution could be implemented successfully across the whole European sector. From the viewpoint of a port managing body, if inappropriately implemented, environmental charging, could be tantamount to raising prices[7], which in turn may lead to reduced business volumes and negative financial impacts, especially if the implementation of the schemes is on a voluntary basis, i.e. if competing ports are allowed to act as free riders and decide not to implement environmental charging schemes at all. At the same time, however, environmental charging schemes may also serve as potential attractors to generate profits, enhance image and increase the position of a port in the market.

Incidentally, the above-mentioned argument is not limited to the port industry, but is equally valid for all transport modes where a form of differentiated infrastructure charging is applied. Ports are complex entities comprised of different stakeholders, engaged in diverse activities, who need to work together to maximise efficiencies for the entire supply chain. Ports involve facilities for several modes of transport: water, rail, road, or even air. They manage and maintain assets, facilities, utility networks, and utility consumption. They coordinate and optimise transport infrastructure and minimise traffic congestion and environmental impacts. They coordinate leases and tenants and monitor performance.

However, the fact that the EU port sector is so diverse, and also happens to be characterised by fierce competition among players may suggest that a more coordinate approach to environmental charging could ensure a level-playing field, maximise the environmental and image benefits, and reduce 'free-riding behaviour'.

1.2 Objectives, tasks and methodology

In light of the above, and in line with the objectives laid out in COM(2013) 295 'Ports: an engine for growth', the EU Commission's Directorate-General for Mobility and Transport (DG MOVE) decided to conduct a study with the objective of assessing the various options that are currently applied to differentiate port infrastructure charges according to environmental or sustainability criteria with the specific objectives of:

(a) Updating information and data of EU and worldwide existing practices' inventories.

(b) Examining the benefits and costs, including the economic aspect and environmental potential, of certain schemes, and identify good practices.

(c) Develop recommendations and guidelines for the voluntary application of environmental charging principles in European ports.

The study consisted of three tasks, in line with the above-mentioned objectives:

The first task 'Data Collection' aimed to establish the potential qualitative and quantitative costs and benefits for reducing shipping emissions and waste, and to provide an overview of the state of play of environmental charging in the EU.

[7] Bergqvist R, Egels-Zandén N, *Green port dues – The case of hinterland transport*, in "Research in Transportation Business & Management", 2012 (5), pp. 85-91. The authors argue that the introduction of port dues "initially will not produce direct and immediate benefit compensation for the corresponding cost increase related to the fee per load unit, since the transport system is not able to respond quickly to the changes in fee levels. The lag is usually a consequence of transaction cost and system lock-ins, such as contract periods, dedicated transport services, system designs, supplier integration, etc." Hence, ports may benefit from a long-term strategy, which, "if carefully designed and managed, can provide a powerful tool for port management to manage overall efficiency, especially hinterland transport efficiency and the environmental impact of hinterland transport". […] "To increase the feasibility of differentiated port dues, a regulatory framework of a larger area as opposed to a single port authority would minimise distortion of competition and large inter-port shift of volumes".

An analysis of the nature and extent to which port authorities may influence the environmental performance of both the port sector and the shipping industry was carried out, based on desk-research and available literature. The analysis focuses on the increasing awareness by port authorities of the benefits that derive from the monitoring and management of significant environmental aspects.

To compile the inventory of environmental charging schemes in the TEN-T core ports of the EU, a survey was carried out based on a two-step methodology. Firstly, an inventory was compiled after desk-based research on port authorities' websites, so as to produce a number of 'profiles', one for each port surveyed. These profiles were made available online in the form of questionnaires, and port authorities were sent a link and asked to validate them. The purpose of the inventory – which also looked at selected extra-EU examples – was to establish how, and if, environmental charging is implemented across the EU.

As part of the data collection work, an overview of shipping emissions and waste was also compiled (Annex I), analysing the impact and legal limits of several greenhouse gases, air pollutants, and types of waste generated from shipping.

The last output of the first task is a SWOT analysis (Annex III) on environmental charging that prepared the conceptual framework for the analysis carried out in the second task of the study. The SWOT analysis was prepared by the study team, based on their expertise and the knowledge gathered in the first months of the study, and was finalised through a collaborative exercise which involved the study team as well as representatives from port authorities and industry. A first draft of the SWOT was circulated in advance and was then discussed with stakeholders during the meeting. Participants commented on it, thus helping the study team develop a refined version of the SWOT, which also integrated the views of the sector.

The second task 'Assessment' was designed to quantify the costs and benefits of one or more environmental charging schemes for both port authorities and shipping companies. While the first task provided a general framework for potential quantitative and qualitative costs and benefit for reducing emissions, the second task aimed to collect specific data on the actual implementation of environmental charging.

In terms of methodology, since very specific information was needed to carry out such an assessment, 14 case studies[8] were developed with the aim of establishing how an environmental charging scheme affects the environment in the port area, as well as the portfolio of ships calling the port. However, during the study, it soon emerged that, due to a variety of reasons (including technical, financial, organisational and legislative), port authorities do not currently measure the effect of a charging scheme on the environment, and in many instances, they do not monitor the implementation of the scheme from the economic point of view either.

Therefore, to cope with the lack of data, a series of estimations were developed based on 'what-if?' scenarios that assess the environmental and economic impact of environmental charging under certain conditions. The study team corroborated their findings through qualitative information gathered through case studies, as well as through additional questionnaires sent to stakeholders. Furthermore, the findings of this task were also validated by a panel of stakeholders from the port sector during a conference that took place in January 2016.

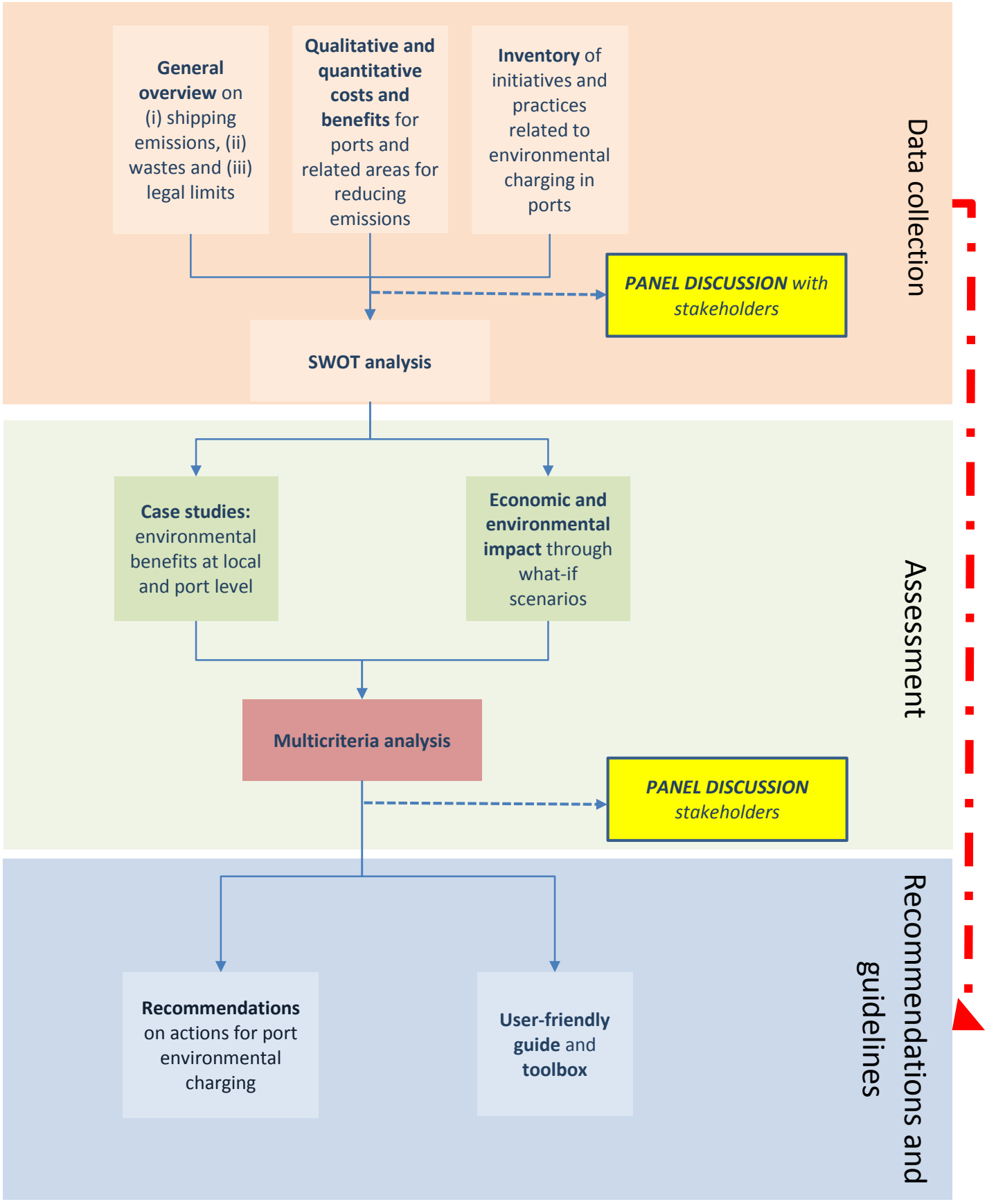
Besides validating the findings of the second task, the conference with stakeholders also represented an invaluable opportunity for sector and industry professionals to voice their opinion on the strengths and weaknesses of environmental charging as it is currently implemented in the EU. The findings of the second task, combined with stakeholders' considerations and needs fed into the third and final task of the study, 'Recommendations and guidelines'. This task aimed to conclude the study by formulating recommendations for port authorities, Member States and the EU with a view to fostering a wider implementation of environmental charging. Another objective of the task was to develop guidelines and an interactive tool designed to assist port authorities in their endeavours to select the most appropriate

[8] The case study ports account for 31% of total throughput in EU ports.

environmental charging schemes according to their specific local circumstances with regard to their environmental objectives.

In order to achieve the objectives of the study, the research pathway adopted integrated the three phases of data collection, assessment and recommendations into an interrogative system that provided the opportunity for validation, stakeholders' feedback and re-assessment throughout the process as indicated in the following diagram:

Figure 1 – Overview of study tasks



Generally speaking, within the text it is possible to find detailed notes as to the methodology used for each step of the study.

1.3 Structure of the report

The report is made up of three sections, one for each task of the study.

The first section 'Data collection' presents the findings of the first task of the Study, i.e.:

- Potential costs and benefits for reducing shipping emissions and waste.
- Summary of the inventory of environmental charging schemes in the EU.

For practical reasons, it was decided to include the full results of the inventory as an Annex. This is because a series of 'profiles' were compiled for each port surveyed with the general characteristics of the scheme implemented.

The second section 'Assessment' includes:

- The main lessons learned from case studies
- The environmental assessment
- The economic assessment

The 14 case studies included information that was deemed confidential by some of the ports interviewed. Therefore, it was decided not to make them publicly available, even though the information in them was used for the study, after aggregating it in such a way as to preserve its confidentiality.

The third section of the report includes the recommendations to port authorities, Member States and the EU.

The report also includes six annexes

Annex I - Overview of shipping emissions and waste, providing a compendium of shipping emissions and waste, their impact on human health, as well as their legal limits.

Annex II - Port profiles: detailed profiles of the ports surveyed and the characteristics of their environmental charging schemes. The profiles were compiled based on information publicly available on the internet, or directly supplied by port authorities themselves.

Annex III - SWOT Analysis outlining streghts, weaknesses, opportunities and threats of the implementation by EU ports of differentiated infrastructure charges based on environemental criteria.

Annex IV - Map of EU ports that differentiate charges based on environmental criteria: a series of maps that show the distribution of environmental charging schemes across the sea basins of the EU.

Annex V - Green shipping: a focus on the main green certification programmes and indexes used by EU ports for their charging schemes.

Annex VI - Environmental charging and the cruise industry: a 'what-if?' scenario that examines the effect of a more consistent application of environmental charging in EU ports from the point of view of cruise lines.

1.4 Sources

Generally speaking, two sources of information were used throughout the Study:

1. Available literature: footnotes with full references are provided in the text, whenever literature was used as a source. A full list of the references used is provided at the end of this report.
2. Port authorities and various stakeholders: port authorities and stakeholders were requested information multiple times throughout the study. All TEN-T core ports were contacted to enquire whether they were implementing an environmental charging scheme, although not all of them actually replied. 14 port authorities were directly interviewed for the case studies. In addition, a series of stakeholders from the port and shipping sector provided information through questionnaires sent by the study team. Among these stakeholders are ESPO, the Green Award Foundation, the British Ports Association, Maersk Line, CLIA Europe. Several other stakeholders contributed to the study by providing their feedback during the two panel discussions hold in Brussels.

1.5 Focus and definition

The focus of this study is on charges to the ship and to the cargo levied by port authorities or other public entities, or entities that levy these charges on behalf of a port authority or another public body. Concessions charges, land leases and charges levied by private operators within the port are excluded from the analysis. Charges levied on the ship are generally referred to as port dues; charges levied on port services, when these services are provided by the port authority or other entities on behalf of the port authority are referred to as (nautical) service charges. Charges levied on passengers or cargo (excluding cargo handling) will be referred to as cargo, berth or wharfage dues. As mentioned above, it should be stressed that the scheme of charges may well be different from port to port, depending on the governance model in force in the port. Customs charges are excluded from the analysis. The scope of the study does not cover either port service charges, or the contractual conditions between port authorities and port service providers which could regulate port service charges.

The involvement of stakeholders throughout the study was pivotal in ensuring that its conclusions are realistic, as evidence-based as possible, and respectful of the role and autonomy of port authorities.

The study team acknowledges with grateful thanks the input, feedback and expertise provided by the wide range of representatives from the port sector and shipping industry who kindly cooperated in the compilation of this study.

Section I - Data Collection

2 Qualitative and quantitative costs and benefits for reducing shipping emissions and waste

2.1 Introduction

The study on differentiated port infrastructure charges provides the opportunity to assess the nature and extent to which port authorities may influence the environmental performance of both the port sector and the shipping industry.

The aims of environmental protection, sustainability and increased efficiency are common to both these elements of marine activities and operations. The sector and the industry respectively must deliver compliance with legislation, and an increasing range of other stakeholders seek transparency and ready-access to science-based evidence of their environmental performance.

The challenge of effective environmental management has evolved from quayside to port area, outward further to embrace the port-city links, and nowadays it may be argued that the most efficient model of transport sustainability will focus on the functional organisation necessary to deliver environmental protection based on the integrated management of the Logistic Chain.

Differentiated charges have the potential to yield benefits to the mutual advantage of all the players involved, and the environment itself. The baseline of performance of the European port sector and subsequent benchmarks over time are important because they are indicative of current competence and capability, and future application of controlling mechanisms such as infrastructure charges.

Whereas the shipping industry is regulated and controlled in terms of environmental liabilities and responsibilities, the approach followed by the port sector is that of compliance through voluntary, self-regulation. It is accepted that this approach is appropriate given that each port is unique in terms of its commercial profile, geographical characteristics, and often by the manner in which it is owned, governed and influenced by local culture and customs.

In the case of the port sector, whilst compliance is, of course, non-negotiable, the manner in which it controls its impacts on the environment is left to the decision-making of the port authority itself. There is scope for ports to influence the extent to which shipping aspects are controlled to mutual advantage of the sector and industry respectively, and to other stakeholders.

The major driver of any credible Environmental Management System (EMS) is to deliver compliance with legislation. Over the last twenty years the definition of environmental management has broadened from conservation and protection to include sustainability and cost- and risk-reduction. It may be argued that with its own established sector-based experience and knowledge, ports are well-positioned to design, evaluate, implement and apply any form of practicable infrastructure charging scheme, if so desired.

The table following demonstrates capability in key provisions of EMS by members of EcoPorts (ESPO):

Table 1 - Benchmark performance of European ports in terms of implementation of the key elements of an Environmental Management System (EMS)

Indicator	1996	2004	2009	2012	2013	% change 2004-2013
Environmental Policy	45	58	72	91	86	+28
Policy available to public	-	59	62	85	82	+23
Policy aimed at compliance	32	49	58	73	68	+19
Publishes Environmental Report	-	31	43	62	64	+33
Designated Environmental personnel	55	67	69	95	94	+27
Recognised EMS	-	21	48	62	64	+43
Environmental monitoring programme	53	65	77	80	79	+14
Performance indicators identified	-	48	60	71	64	+16

Source: EcoPorts, 2014

2.2 The global perspective

While this study focuses on the EU, the research is also taking into account the global response to the environmental imperative. Shipping is recognisably a global activity and it may be argued that the objective of 'a level playing field' in terms of the implementation of environmental legislation is particularly appropriate in this context. Where environmental impacts from a range of aspects are demonstrably trans-boundary in their character, it would appear to make little sense for a vessel to sail from one hemisphere, under a certain set of environmental controls, only to arrive in another with a completely different regime of environmental standards.

The port sector's ability to deliver a harmonised approach is measured to a certain extent in the table above, which, although based on a website survey, is indicative of the range of provisions in place upon which differentiated charges could be effectively operated.

Key elements of port EMS such as policy, monitoring, identification of indicators and reporting of performance are pointers to current capability and future potential for the application of environment-based charging schemes.

There are apparent differences in regional development of EMS and this may also reflect the culture of the sector in terms of awareness and status of environmental issues – see Table 2, following:

Table 2 - Variations in the apparent provisions of significant components of EMS based on publicly available, web-based information

Indicator	Oceania (25)	Asia (25)	Africa (25)	North America (25)	Latin America (25)	ESPO (122)	Baltic* (12)	BPO (48)
1. Website data	56	4	20	16	20	69	75	69
2. EMS	60	20	32	28	20	48	75	38
3. Policy	72	28	36	44	28	72	92	46
4. Policy Public	36	8	12	24	16	62	75	27
5. Report	56	20	20	36	16	43	75	27
6. Monitoring	72	32	40	56	24	77	84	40
7. Indicators	44	16	24	44	8	60	84	31
8. Performance	4	0	8	20	0	36	75	15

Source: EcoPorts, 2014

The work undertaken in the framework of the International Association of Ports and Harbours (IAPH) is of special significance to this study. In April 2008, the IAPH requested its Port Environment Committee, in consultation with regional Port Organisations, to provide a mechanism for assisting the ports to combat climate change.

The C40 World Ports Climate Declaration was adopted in July 2008, as 55 ports from all over the world came together at the C40 World Ports Climate Conference in Rotterdam to commit to jointly reduce the threat of global climate change. The WPCI was formally launched at the symposium which was hosted by the Port of Los Angeles and the IAPH Port Environment Committee on November 24 and 25, 2008, as a follow-up to the Rotterdam conference.

Emerging from the Los Angeles Symposium were these chief goals:

- Deepen the support for WPCI among the world's ports;
- Promote information sharing;
- Establish a framework for CO_2 footprint inventory and management;
- Establish Environmental Ship Indexing and increase support for this measurement;
- Organise global support for WPCI goals among regional and global organisations.

The mission of the World Ports Climate Initiative is to:

- Raise awareness in the port and maritime community of need for action
- Initiate studies, strategies and actions to reduce GHG emissions and improve air quality
- Provide a platform for the maritime port sector for the exchange of information thereon
- Make available information on the effects of climate change on the maritime port environment and measures for its mitigation

The International Maritime Organisation (IMO) has assumed responsibility for pollution issues and subsequently has, over many years, adopted a wide range of measures to prevent and control pollution caused by ships and to mitigate the effects of any damage that may occur as a result of maritime operations and accidents. Initially the IMO focussed on prevention of marine pollution by oil, resulting in

the adoption of the first ever comprehensive antipollution convention, the International Convention for the Prevention of Pollution from Ships (MARPOL) in 1973. This has changed over the last few decades to include a much wider range of measures to prevent marine pollution, and the original MARPOL Convention was amended many times to also include requirements addressing pollution from chemicals, other harmful substances, garbage, sewage and, under an Annex VI adopted in 1997, air pollution and emissions from ships. Latest developments have led to establishing Sulphur Emissions Control Areas (SECAs) and Nitrogen Oxide Emission Control Areas (NECAs) in several areas of the world, among which are the Baltic and the North Sea (SECA in 2005 and 2006 respectively, and NECA from 2021).

In December 2015, 195 countries agreed, by consensus, on the Paris Agreement to reduce emissions as part of the method for reducing greenhouse gas[9]. In the 12-page document, the members agreed to reduce their carbon output "as soon as possible" and to do their best to keep global warming "to well below 2 degrees C".

Each country that ratifies the agreement will be required to set a target for emission reduction or limitation, called a "nationally determined contribution" (NDC), but the amount will be voluntary. There will be neither a mechanism to force a country to set a target by a specific date nor enforcement measures if a set target is not met. There will be only a "name and shame" system. The threshold for entry into force of the Paris Agreement was achieved on 5 October 2016, and the agreement entered into force on 4 November 2016. One of the problems of the Paris Agreement, however, is that it does not include provisions on air and maritime transport.

In view of that, the Marine Environment Protection Committee (MEPC) of the IMO agreed that IMO should determine a possible fair share contribution for the international shipping sector, which if developed, should take into account the circumstances that are relevant to the international shipping sector, including the importance of international trade in supporting the sustainable development of national economies. In October 2016, the MEPC formally adopted a mandatory data collection system for fuel consumption of ships. The MEPC also agreed that an initial but comprehensive IMO strategy on reduction of GHG emissions from ships should be adopted in 2018.At the same time, the MEPC noted that shipping is already, by far, the most energy efficient form of commercial transport. Any increase in shipping activity due to a shift from other less efficient transport modes will in fact contribute to an overall reduction in the world's total CO_2 emissions. On the other hand, an unrealistic contribution to reduce the sector's absolute CO_2 emissions could lead to a shift to less energy-efficient transport modes. This would clearly be counterproductive with respect to reducing the world's total CO_2 inventory[10].

MEPC's decision to adopt a strategy on reduction of GHG emissions from shipping only in 2018 was the result of discussion and compromise. The EU enter the debate and in December 2016, the Environment Committee (ENVI) of the European Parliament adopted a report on the revision of the EU Emissions Trading System (ETS)[11], which puts pressure on the IMO to have a system comparable to ETS operating for global shipping as from 2021. If that is not the case, then shipping will be included in the European ETS as from 2023. Part of the revenues generated from ETS will be channelled through a Maritime Climate Fund to improve energy efficiency and invest in innovative technologies for ports and short sea shipping.

2.3 European initiatives

The European Sea Ports Organisation (ESPO) has an established record of effective environmental management programmes since 1994, including the development by its members of the EcoPorts network (www.ecoports.com). The Organisation introduced its own EMS standard, the Port Environmental Review

[9] http://unfccc.int/paris_agreement/items/9485.php

[10] http://www.worldshipping.org/public-statements/regulatory-comments/MEPC_70-7-8_-_Development_of_a_road_map_to_determine_IMO_contribution_Aug_2016.pdf

[11] ENVI(2016)1215_1. Documents available at http://www.emeeting.europarl.europa.eu/committees/agenda/201612/ENVI/ENVI(2016)1215_1/sitt-3968209

System (PERS) that is available to its members on a voluntary basis and is independently audited by Lloyd's Register. The standard is recognised by the American Association of Port Authorities (AAPA) under an MOU with ESPO, and ports in Colombia and Taiwan have achieved Private Entity Reporting Standards (PERS) to date (www.ecoslc.eu).

It is significant to note that both EcoPorts' SDM and PERS are currently listed in a source of Good International Industry Practices (GIIP) in the World Bank Group Environmental, Health and Safety Guidelines for Ports, Harbors and Terminals (available at www.ifc.org/ehsguidelines). The EHS Guidelines are used by all World Bank Group entities (International Finance Corporation, World Bank, MIGA) and their clients (Governments, private sector, industry and financial intermediaries) but also by 80 Equator Principles Financial Institutions, 34 OECD Export Credit Agencies, and 15 European Development Financial Institutions.

As of May 2016, the International Finance Corporation (IFC), a member of the World Bank Group, is currently updating the World Bank Group Environmental, Health and Safety Guidelines for Ports, Harbours and Terminals and is actively evaluating up-date information on SDM and PERS as continued sources of GIIP. ESPO has provided all relevant documentation to support the review. Such recognition confirms the credentials of the European port sector to develop and maintain a trustworthy environmental programme.

Within Europe, Baltic ports have been particularly pro-active in a number of significant environmental initiatives. This is relevant to the current research pathway because of the case-study examples already available, and it indicates potential examples of applied good practice and input data (Table 3, following).

Components of an effective EMS such as the inventory of aspects, monitoring programme, reporting formats and certificated standards are directly relevant to the research in terms of identifying current practices, detail available, potential for application of a charging scheme, and the knowledge-base upon which the charging models may be formulated. Again, the performance of Baltic ports indicates active awareness and knowledge-based implementation of effective environmental programmes.

Table 3 - Performance of ESPO (as represented by EcoPorts) and BPO ports in implementing the main elements of a credible EMS

Indicator	Baltic %	Europe %
1. Environmental Policy?	91.67	89.87
2. Does the Environmental policy refer to ESPO's guideline documents?	25.00	37.97
3. Inventory of relevant environmental legislation and regulations?	100.00	89.87
4. Inventory of Environmental Aspects?	100.00	83.54
5. Objectives and targets defined?	91.67	83.54
6. Environmental training program?	50.00	65.82
7. Environmental monitoring program?	83.33	78.48
8. Responsibilities documented?	83.33	70.89
9. Publish an environmental report?	75.00	62.03
10. Certificated standard?	75.00	54.43

Source: EcoPorts, 2014

A Port Authority is expected to identify its Significant Environmental Aspects (SEAs) that is, those activities, products and services that may impact on the environment directly, or indirectly. The impacts may be beneficial or adverse. The tests of significance are i) aspects for which the Port Authority has strict liability or responsibility in law, ii) those over which (as a landlord) it may reasonably be expected to be able to bring influence to bear (e.g. over tenants/operators), and iii) aspects that are deemed to be of local, regional or national importance. Point ii) above is important in the context of this research. The Authority may not have direct liability, but if they are in the position of a 'landlord' and charging tenants and operators for use of land/sea space, they may be deemed in a court of law as being in a position to bring influence to bear on the environmental behaviour of their tenants and thus share some of the liabilities.

This is an important point in identifying the benefits and value-added component of applying differentiated charges. If a port has a liability for certain aspects that are common or closely linked with the shipping industry, then there is potential mutual advantage in a collaborative approach and in fact, wider advantages to a range of stakeholders. Table 4, following, illustrates the detail available in terms of the functional organisation required to develop and implement differentiated charges at least from the perspective of the port sector.

Table 4 – Availability of functional organisation required to develop and implement differentiated charges

SDM Ref	Question/Indicator	Baltic %	Europe %	% diff.
A.1	**Does port have Environmental Policy?**	91.70	85.90	+ 5.8
A.3	**Communicated to stakeholders?**	91.70	81.10	+10.6
A.5	**Policy available on website?**	75.00	72.10	+ 2.9
A.10	**Prevention of pollution?**	91.70	89.20	+ 2.5
A.13	**Reduction of resource consumption?**	75.10	74.30	+ 0.8
A.15	**Aspects including tenants & operators?**	75.00	78.40	- 3.4
A.16	**Reference to ESPO documents?**	25.00	40.80	- 15.8
A.17	**Reference to sustainable development?**	91.70	77.90	+ 13.8
A.19	**Inventory of Legislation & Regulations?**	100.00	87.70	+ 12.3
A.21	**Inventory of Aspects**	100.00	76.60	+ 23.4
A.83	**Objectives and targets identified?**	91.70	78.20	+ 13.8
B.1	**Staff for Environmental management?**	100.00	93.60	+ 6.4
B.9	**Responsibilities documented key staff?**	83.30	69.20	+14.1
C.5	**Environmental Training Programme?**	50.00	61.50	- 11.5
D.1	**Public Environmental report?**	75.00	63.20	+11.8

Source: CLEANSHIP, 2013

Using EMS components as performance indicators, the strengths of the both Baltic and EcoPorts (amalgamated) Organisations can be demonstrated.

Within Europe it is interesting to note that there is a range of environmental programmes that reflect regional initiatives and current levels of awareness and good practice with regard to EMS. It may be suggested that without the above management processes or provisions in place, it is unlikely that a port authority would have the data or organisation to develop and implement an efficient fee charging scheme.

Even amongst the EU ports that currently apply differentiated fees (see Section I - § 3), their current monitoring policies and practices tend to reflect interest in their perceived priority issues or Significant Environmental Aspects (see Table 6), rather than the impact of applying differentiated fees *per se.* Nevertheless, there is knowledge and experience at both sectoral and port-specific levels that provides insight into both the potential benefits and the practical challenges of implementing a fee-charging scheme including actual measurement of its impact.

2.4 Environmental monitoring in EU ports

The fact that the ideas, values and practices of environmental monitoring are now established throughout the European port ector is extremely significant and encouraging for the promulgation and uptake of fee charging schemes. Monitoring describes the processes and activities that need to take place to characterise and illustrate the quality of the environment, and is a fundamental requirement of any, credible EMS. All monitoring strategies and programmes have reasons and justifications which are usually designed to establish the current status of the port area (and increasingly, its environs) and to establish trends in environmental parameters. Even in the late 1990s the practice was not widespread, but now, the benefits of being able to demonstrate compliance and illustrate positive trends of environmental quality means that many more ports are now likely to be receptive to the notion that fee charging may well lead to discernible improvements.

Analysis of the declared provisions of Baltic and ESPO port members demonstrates that monitoring and reporting environmental performance is well-established at least among the pro-active port authorities. If the purpose of the application of differentiated charges is to improve environmental quality, sustainability of port and shipping operations, and improve overall efficiency, then the basis of the environmental charging scheme must be based on science-based knowledge, and the subsequent tracking of performance and attainment of targets requires effective monitoring and reporting.

The table below demonstrates that monitoring and reporting of relevant performance criteria within the sector that is of direct relevance to the Project's objectives. As noted above, the ability and practice of identifying, and possibly quantifying the absolute environmental benefits of a particular charging scheme may not currently be pursued *per se,* but the scope and potential for such procedures is evolving within the sector and its associated network of other, responsible authorities. The fundamental components over which EMS aims control are, of course, air, water, soil and sediment. As shipping aspects contribute directly to the actual and potential impacts on these media, the scope for an integrated approach through a differentiated charging scheming is a practicable option, given the degree of background knowledge, experience and reported benchmark performance to date. Charging schemes can only be assessed in terms of their efficacy if the benchmark performance of appropriate indicators can be tracked. The management process itself is a fundamental component of the perceived costs and benefits.

The development and gradual implementation of monitoring protocols has arisen from a variety of drivers and motivational experiences. As environmental considerations moved on from the purely conservation perspective to take on overall environmental quality, so the motives have broadened from basic compliance to sustainability and recognition of the port authorities' roles in the Logistic Chain.

Port managers are now well-aware of the scrutiny under which they operate coming from a wide range of stakeholders. The fundamental task of attempting to control impacts on the basic media has been superseded by the recognition that effective EMS must be implemented and operated to organise a multiplicity of issues over a range of scales both in terms of time and space.

The ongoing experience of the sector is highly significant to the study of port infrastructure charges, because elements of overall policy, calculated costs, perceived benefits and technical competence are all mirrored in the authority's philosophy and potential toolbox of options.

The development and expansion of the monitoring programmes reflects the recognition of the widening arc of interest and the expectations of stakeholders. This experience is reflected in the attitude to

compliance and the status of environmental quality, the investment in R &D, and monitoring activities, and ultimately in the data available for decision-making on potential fee models.

Table 5 - Issues with major monitoring programmes reported as active within Baltic and all EcoPorts authorities

SDM Ref	Question/Indicator	Baltic %	Europe %	% diff.
E.1	**Action Plans for objectives**	91.70	62.80	+ 28.9
G.2	**Environmental monitoring programme**	83.30	78.10	+ 5.2
G.3	**Air quality**	58.30	52.90	+ 5.4
G.4	**Water quality**	50.00	57.44	- 7.4
G.5	**Soil quality**	16.70	39.70	- 23.0
G.6	**Sediment quality**	58.30	51.50	+ 6.8
G.7	**Terrestrial habitats**	33.33	35.30	- 1.97
G.8	**Marine ecosystems**	33.33	33.33	0.0
G.9	**Noise**	50.00	54.40	- 4.4
G.10	**Waste**	50.00	64.70	- 14.7
G.11	**Carbon Footprint**	25.00	47.10	- 22.1
G.12	**Energy consumption**	66.70	66.20	+ 0.5
G.13	**Water consumption**	58.30	60.30	- 2.0
	Average	67.56	65.48	
	% Balance difference Baltic: Europe			+58.75

Source: CLEANSHIP, 2013

At the same time, it should be noted that the precise identification and quantification of the perceived benefits of the application of charging schemes themselves are not currently performed to any degree of detail (see Section 2 - §5), because of considerations of cost, technicalities, equipment, liabilities, natural dynamics and systems (trans-boundary flows of air, water, sediment, noise *etc.*) and the multi-disciplinary nature of the source-impact models involved. In the second section of the Study (see Chapter 5 "Environmental Assessment), it is explained why the lack of precise data on the benefits of charging schemes makes it inherently difficult to determine the environmental effects of differentiated charging.

2.5 The Top-10 Environmental Issues

The analysis of the EcoPorts Network of ESPO demonstrates the priority ascribed to key environmental issues. The table below is derived from the Self-Diagnosis Methodology (SDM) database of EcoPorts and represents the opinion of 76 port environmental managers as to the perceived priority issues requiring action.

7 out of the Top-10 issues are directly related to the factors involved in determining the extent to which port authorities may influence the environmental performance of shipping related to specific aspects. The priority allocated to the issue is indicative of its status and significance to the port authority. This in turn suggests that it will already be incorporated into the environmental programme, and it is therefore likely that there will be in-house knowledge and experience upon which the authority may draw to incorporate the issue into a model of infrastructure charging.

The list indicates that significance is attached to key components that may be factored in to a charging scheme, and that the port authority may already have liabilities and responsibilities for these issues. As reported above, authorities may also be in a position 'to bring influence to bear' in terms of differentiated charging because of shared responsibilities. These factors may be over and above the benefits to be obtained from enhancements to improved performance of shipping environmental management.

Table 6 - Correlation of interests between the priority issues as recognised by port authorities and the potential components of infrastructure charging schemes

RANK	ISSUE	SIGNIFICANT to Project? – YES/NO
1	Air quality	YES Major aspect. Transboundary. Directly related to Project objectives.
2	Garbage/waste	YES Associated with (5) below. Implications for infrastructure.
3	Energy consumption	NO – not directly - may be factored-in to OPS decision and management.
4	Noise	YES Direct significance. Perceived as a challenge to monitor.
5	Ship waste	YES Major consideration and directly significant for charging model
6	Local community	YES Significant qualitative component for costs and benefits
7	Dredging operations	NO.
8	Dust	YES Related to 1 and 6, above
9	Water quality	YES Directly related to selected indicators.
10	Port development (land)	NO.

Source: EcoPorts and own elaboration

The priority issues above were identified by port environmental managers in 2013. Interestingly one may note that, in contrast to Table 5, carbon footprint was not reported as a priority issue requiring action. This is in marked contrast with the consensus as to the urgency to take all necessary measures to reduce global warning. However, further considerations should suggest that the reason why carbon footprint is not in the list of ports' top-priority issues is to be ascribed that, if acting in isolation, ports may only have a marginal impact. Tackling global warming by reducing carbon footprint requires concerted effort from the whole industry to produce appreciable effects. Another consideration to be factored in is that environmental aspects such as air quality, waste, energy consumption or noise have a direct and visible impact on communities living in port areas. For this reason, some ports may have an incentive to take action on issues that produce an immediate effect on the public opinion.

Naturally, this should not lead us to conclude that environmental charging cannot play a role in reducing CO_2 emissions from shipping. On the contrary, it reinforces the argument that any signification action can only be taken in the wider framework of a common and concerted effort that has to be agreed at EU and / or global level. If ports are left alone, they may channel their resources towards other priorities at a smaller and local scale.

Last but not least it should be noted that the list above aggregates priorities as perceived by 76 port environmental managers, but the EU port sector is widely heterogeneous and there may be substantial

differences from one port to another. Recent examples suggest that some ports, especially the busiest ones, are indeed concerned about their carbon footprint, and are taking action to reduce CO_2 emissions[12].

2.6 The role of Port Authorities

The extent to which any individual port authority may influence discharges and emissions from shipping depends on a variety of factors including various legal liabilities and responsibilities, economic circumstances, governance, commercial profile and geography.

As a consequence of the diversity of the EU port sector, environmental control is often beyond the control of their port authority's activities. These thus incorporate monitoring tools into their environmental control systems that enable them to determine the extent to which the companies that operate in the ports are behaving appropriately from an environmental point of view. This sometimes leads to the monitoring of certain environmental variables by the company which generates them, by the port authority that manages the port area, and sometimes by the public administration with competence in the matter, and it may even be the case that they are all doing so independently without coordination. As noted recently[13], this lack of coordination seems to be far more limited in the northern European countries, where generally speaking, the authorities competent in environmental issues are responsible for the measurement and control of environmental parameters, thereby integrating environmental information from the ports into the rest of the territorial environmental information.

The port sector and its constituent port authority members have well-established links with a wide range of relevant stakeholders at local, regional, national and international levels. The extent to which a port authority can actually influence shipping or any other major marine industry is treated with great caution as expressed by port representatives who have expressed opinions for this study. The ability to actually exert power over, for example, the shipping industry is seen as non-existent but the opportunity to encourage, persuade and motivate is seen as a realistic ambition carried out routinely through time-honoured communication and information-exchange pathways.

The port sector cannot operate in isolation from its local, city or municipality institutions, and neither can it conduct its business without integrating its efforts with responsible agencies, government institutions and industrial organisations. As emerged from the interviews, the significance of programmed communication and meetings with a wide range of stakeholders particularly on such aspects as land planning and development, coastal zone management, and transport systems. The analysis of the case studies on various environmental projects confirms that ports collaborate effectively with a wide range of partners to mutual advantage in both research and implementation methodologies related to EU Directives and other, international legislation. Recent years have shown a closer amalgamation of port and shipping interests within the same research project (e.g. Clean Baltic Sea Shipping) and this is viewed as a positive model for the identification, development and selection of practicable options that may lead to green shipping and cleaner port areas.

In terms of using financial incentives to reduce the environmental impact of shipping, the port's position may also be swayed by its own philosophy toward reward or penalty, local culture and customs, and attitude toward the nature of motivation that may be offered. The Port Authority itself may be spurred by a range of considerations including the safeguard of being seen to be taking all reasonable steps to deliver sustainability and environmental protection.

Table 7 summarises the major, headline components over which a port authority could exert influence or work in collaboration with shipping to deliver enhanced environmental management. The port authority may not have strict liability or be required to actually control impacts arising from its tenants and operators (including ship management companies). The option of differentiated fees is a multidisciplinary

[12] See, for instance, http://www.zeroco2.no/projects/rotterdam-climate-initiative

[13] Project Mermaid, WP2.2 - Environmental Monitoring Systems in European Ports, Final Report, 2015.

consideration where many of the components are not discrete entities in form or function. The port-shipping interface is a complex comprised of a range of factors where considerations of economics, competition, governance and trade patters all interact to shape the functional incentives that may be applied through a particular differentiated fee scheme.

Where a port authority has direct liability and responsibility for a specific aspect the decision to manage will be clear-cut and the options available by which due care and attention may be exercised will probably be established and controlled by a recognised process. The costs associated are likely to be known and performance indicators will have been identified as part of the 'value-for-money' review, or accepted as part of the non-negotiable stance on compliance.

Where the activity, product or service that makes up the aspect may be attributable to both the sector and the industry, or where there is a common link (landlord-tenant-operator), then there is scope for an integrated approach, voluntary collaborative initiative, or regulatory agreement. Permeating the whole debate will be the basic question – 'who pays?' (The polluter, port authority, ship-owner, tax payer, customer?).

Table 7 - Aspects over which Port Authorities may have direct or indirect influence over shipping emissions and discharges

On-shore power supply
Green Ship Promotion a. Environmental Ship Index (ESI) b. Clean Shipping Index (CSI) c. Energy Efficiency Design (EEDI) d. Differentiation of port fees
Waste reception facilities
Bunkering options
Vessel speed reduction a. voluntary b. virtual arrival
Port infrastructure
Automated mooring
Vessel Traffic Services

Source: CLEANSHIP, 2013

The aspects listed in the table above are key components of any reputable EMS and an auditor would expect to see these represented in the port's environmental management programme. In the CLEANSHIP project they are viewed as effective indicators within the overall Index of the port's own competence, and of its ability to influence and facilitate other initiatives in collaboration with shipping interests.

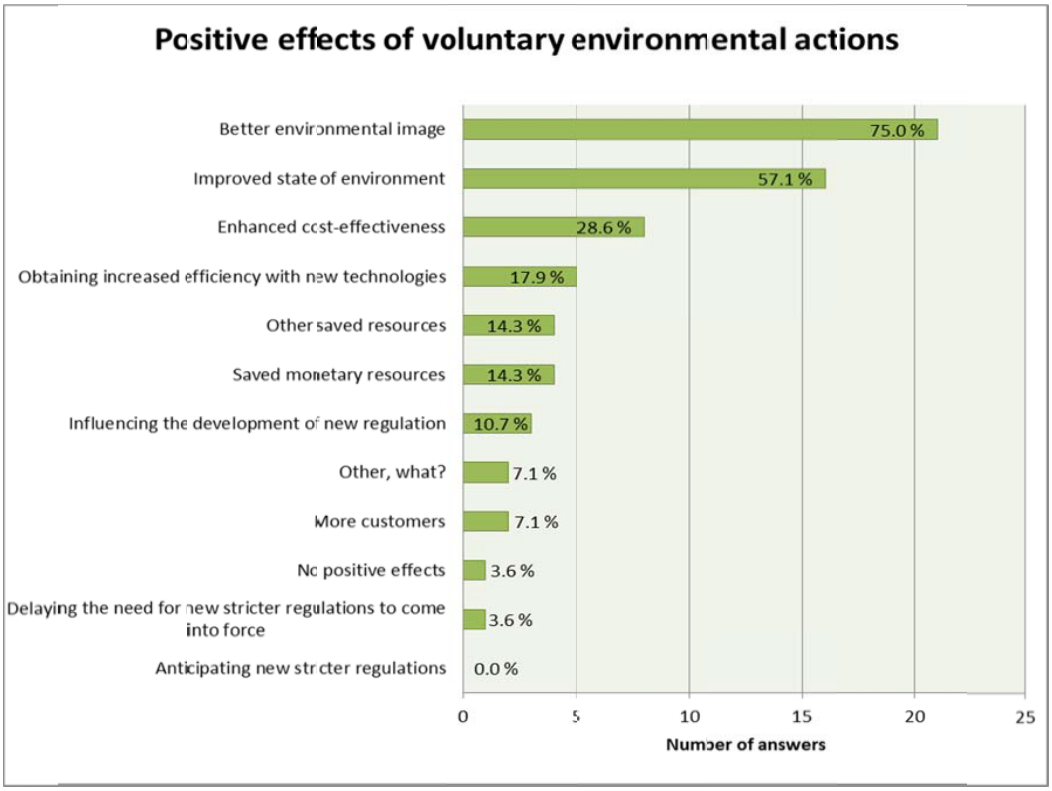
2.6.1 Responsibilities for monitoring

Many ports consider that some obligatory measurements are pointless, since the results of the measurements do not change, if nothing has changed in the port operations, that is, monitoring for the sake of monitoring brings no benefits yet involves costs and the commitment of resources. In addition, sometimes ports are required to measure emissions that they do not even produce, as often ports act only as landlords, and the private companies that operate in the port area produce the majority of the port emissions. Some Statutory Authorities are also criticised by ports, since they apparently do not always seem to understand the whole operation of port activities. The fact is, of course, that there are many instances where local, regional and even national authorities have responsibilities to monitor e.g. air quality

and other related emissions in order to develop appropriate strategies for the management of conditions where they have direct liability or responsibility as a result of relevant legislation. These circumstances flag the mutual benefits of a collaborative approach between ports and other, responsible bodies to combine their efforts and resources in their endeavours to manage the trans-boundary, areal impact of several key impact factors.

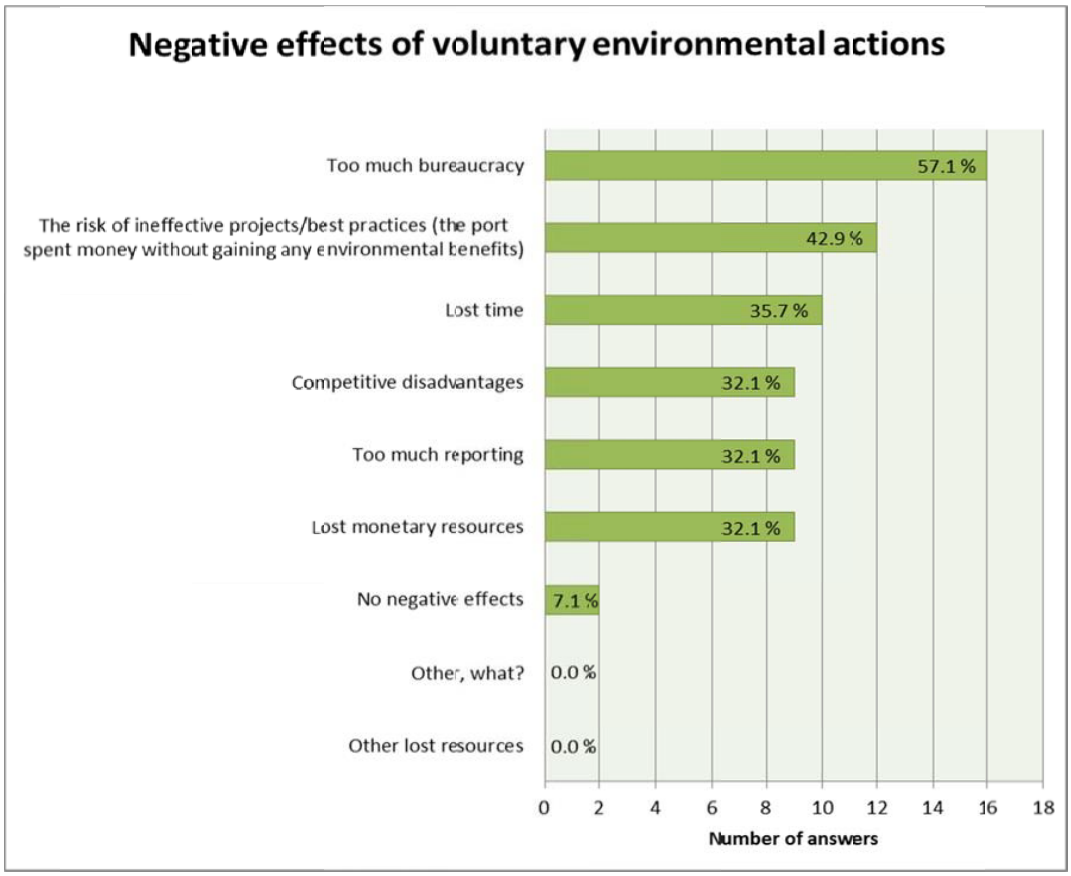
According to the interviews carried out by Kunnaala-Hyrkki *et al* (2015), some voluntary actions have demonstrably improved the state of the surrounding sea or land areas, but usually the improvements are focused on increasing the efficiency of port operations or loading/unloading processes. All of the interviewed ports saw that even if there was no environmental legislation or environmental permits, they would still operate at the same environmental level as nowadays.. In addition, the payback time has usually been relatively short in environmental investments. According to the questionnaire, the voluntary actions performed by the ports include, for example, real-time air emission control and measurements of air quality, measures to reduce noise emissions, participation in different projects, actions in the field of waste management, and sorting of waste.

Figure 2 - The positive effects that the voluntary actions of ports can have. The respondents were able to choose 1-3 most important alternatives



Source: Kunnaala-Hyrkki *et al* (2015)

Figure 3 - The negative effects that the voluntary actions of ports can have. The respondents were able to choose 1- 3 most important alternatives.



Source: Kunnaala-Hyrkki *et al* (2015)Source:

In the above Report, entitled 'Management of ports' environmental effects – a comparative review', the EU legislation was also discussed during the interviews and in the questionnaire. The ports considered that the EU legislation may distort competition between ports if not applied consistently across the Union, by making transport of goods to and from Northern Europe more expensive. This can also mean that more and more of the cargo transportation might be transferred to roads or rails. The interviewed ports pointed out that even though the Sulphur Directive has a beneficial impact on the environment, legislation and directives should nevertheless treat everyone equally.

Factors that affect the competitiveness of the port are rather the port location and the port infrastructure, such as the depth of the waterways, road and railway connections to the port, shipping routes and connecting ocean lines, and available port facilities. These issues affect the port competitiveness more than the ports' environmental image.

As many different stakeholders with local, regional or international interests are involved in the decision-making processes, the implementation of legal standards or technical solutions for better air quality often takes too long. Currently, only few ports make the most of their opportunities to significantly reduce air pollution. Many different reasons contribute to this lack of action: ports consist of various stakeholders and responsible authorities, so it may be difficult to get everyone to agree on a concept. For national and regional governments, it is difficult to create and implement legislation in such an international arena. But

more regulation on an international level (such as from the IMO) has the advantage of creating a level playing field and ensuring fair competition among all the interest groups involved.

On the other hand, the downside is that compromises call for lengthy negotiations and might not go far enough in terms of results. Stricter regional environmental requirements are feared because they could be a competitive disadvantage. Industries and authorities often hardly see a rate of return for ecological investments. The question as to who should pay for air quality (and other environmental) measures is the subject of much debate. The financial crisis of 2007 in particular brought investments to a halt: politicians try to avoid more financial burdens for the industry and are therefore reluctant to introduce stricter regulation ('Clean Air', 2015).

2.7 Potential benefits

As differentiated fee models may incorporate *malus or bonus,* so the perceived benefits to the environment may include both positive enhancements and the avoidance of situations or conditions becoming worse. Hence, the reduction of deleterious effects on climate change, the avoidance of eutrophication and acidification, and the decrease of harm to the health of the community may be balanced by positive enhancements and improvements to environmental quality, biodiversity and overall living conditions of local residents.

Table 8 - Main qualitative benefits that may be achieved through the application of differentiated fees where emissions to air and discharges to water are factored-in to the proffered functional incentives

Physical, chemical and biological improvements to environmental quality	Increased market share or maintenance of profile through user options
Protection and improvement of habitats	Reduction of insurance premiums
Protection of ecosystems	Improved health of local residents
Reduction of risk	Sector/Industry 'license to operate'
Increased efficiencies	Development and planning regimes
Better public relations	Operational costs related to clean-up/incidents

It should be noted that the concept of differentiated port infrastructure charges is just one option from an array of positive actions that a port authority may take to operate a credible EMS. Indeed, it is unlikely that charges alone would deliver the desired results – it may reasonably be argued that incentives need to be set and applied in the wider context of a comprehensive and coherent EMS. The significance of this point to the study is that it highlights the challenge of identifying discrete costs and benefits when the reality of port and shipping operations is that it is an amalgam of interrelated factors across a wide range of natural scientific and socio-economic considerations.

2.8 Conclusions

Benefits:

1. The precise identification and quantification of the perceived benefits of the application of charging schemes themselves are not currently performed to any degree of detail because of considerations of cost, technicalities, equipment, liabilities, natural dynamics and systems (trans-boundary flows

of air, water, sediment, noise *etc.*) and the multi-disciplinary nature of the source-impact models involved.

2. Priority issues recognised by the ports including air quality, carbon footprint, port and ship waste, dust, water quality and local community have direct relevance for this study, and the awareness by port authorities of such key aspects (activities, products and services that may impact on the environment) is a positive component of their EMS.
3. Current programmes of monitoring include those focussed on waste, water quality and air quality, and as such, mean that the port authorities are reasonably placed to consider the practicalities of monitoring the performance of green-charging actions.
4. The sector recognises that monitoring results assist the ports directly in terms of confirming compliance with legislation and regulation and in the attainment, and retention of EMS standards.
5. Monitoring provides tangible evidence not only for compliance, but also for the assessment of trends from a baseline, confirmation of continuous improvement, and is often directly beneficial for the management of safety and health.
6. There is growing awareness that the results of a structured and systematic monitoring programme may assist the port in its endeavours to reduce costs and risks, enhance its public relations image, and support the objective of sustainable development.
7. Effective monitoring by the port authorities of their own programmes may serve as an early warning system for accidents or incidents that may impact on the environment.
8. The monitoring of EPIs that directly relate to the efficacy of differentiated charging schemes may assist the port to identify benefits and improvements in the quality of the environment that may be attributed to such schemes – though there is general acceptance of the complexity of confirming such linkages, and broad agreement that the trends of environmental performance may be more significant than absolute, spot values.

Cautions:

1. Both perceived and experienced costs of designing, implementing, operating and maintaining a comprehensive monitoring programme.
2. Identifying the port authority's own liability and responsibility when a multiplicity of agencies from international through to national, regional and local may well be involved directly or indirectly.
3. The overall priority given to the status of the environment in spite of the apparent environmental imperative especially when ranked against commercial/economic, safety, health and security issues.
4. Changes in legislation.
5. Lack of guidelines and interpretation of legislation.
6. The lack of in-house knowledge, skills and support mechanisms.
7. The requirement for purchase and maintenance of equipment and technology, scientific analytical services and training.
8. The issues of shipping emissions and air quality in general are multi-component, trans-boundary, and multi-media phenomena that do not lend themselves to discrete monitoring, mapping or sampling activities. Experience shows that a systems approach over a long time-span is generally required to yield meaningful results upon which strategic decisions can be based with confidence.

9. In many ways, the monitoring of waste lends itself to quantification in terms of volumes, weights and classification of types – but the operational management systems do vary between one port and another which often makes direct comparisons difficult.
10. In many instances, well-founded and systematic research-based monitoring programmes finish or collapse at the end of the funding stream.

Conclusions:

1. An absolute correlation between charging schemes and improved quality of environment is most likely to be achieved only on the basis of trends over considerable time periods. The transboundary nature of many of the parameters, the variations in the commercial and industrial activity profiles of the port area, and the dynamics of meteorology, hydrology and hydrography make for a chaotic complex of interaction and impact.
2. From the perspective of a port authority, considerations of cost (of monitoring) and actual liabilities and responsibilities remain major decision-making factors.
3. The significance of the aspects (activities, products and services) that may impact or influence the port area from the city, hinterland, shipping, tenants and operators, and Logistic Chain Operations may well need to be configured into any meaningful assessment of the overall quality of the port's environment.
4. Collaborative programmes between port authorities and other, responsible agencies tend to yield the most cost-effective and comprehensive results, as well as spreading or recognising the joint responsibilities between stakeholders.

3 Inventory of practices of environmental charging in EU ports

3.1 Methodology

An inventory of existing environmental schemes was compiled in the first phase the Study. The inventory surveyed all EU TEN-T core ports, plus the ports of Civitavecchia and Gibraltar. In addition, selected non-EU ports such as Bergen (Norway), Long Beach (United States), Los Angeles (United States), Vancouver (Canada), Singapore were also analysed, on account of the relevance of their environmental charging schemes.

The survey was carried out based on a two-step methodology. Firstly, an inventory was compiled after desk-based research on port authorities' websites, so as to produce a certain number of 'profiles', one per each port surveyed. These profiles were made available online in the form of questionnaires, and port authorities were sent a link and asked to validate them.

However, the reply rate was very low, and only few port authorities actually validated the findings of the research team. This means that the results of the inventory are largely based on desk research of publicly available information. While in principle it is possible that some environmental charging schemes were overlooked, the research team is confident that, albeit almost entirely desk-based, the inventory offers a rather complete overview of environmental charging in the EU.

3.2 Results

Overall, 30 ports applying at least one environmental charging scheme were detected in the EU. 11 of them are located in the Hamburg-Le Havre port range, between the Netherlands and Belgium (with the exception of Le Havre in France). Seven of them are in the Baltic Sea, while only one was detected in the North Sea.

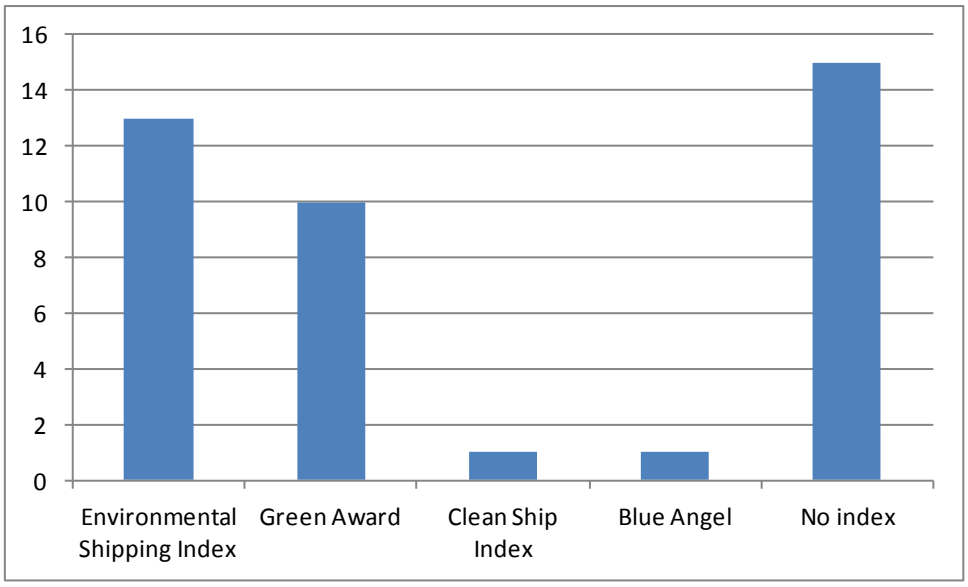
6 ports were identified in the Mediterranean, and 5 in the South-Atlantic Ocean. No ports were detected in the North Atlantic Ocean and in the Black Sea.

Size of port *per se* does not seem to be an obvious driving factor in the decision of implementing a scheme, although it can be assumed that larger ports tend to have more financial capacity and manpower to put in place and monitor an environmental charging scheme.

In 25 cases, schemes offer rebates on port dues that range from 0,5% to 20% to vessels that are certified under the Environmental Ship Index (13), Green Award (10), the Clean Shipping Index (1), and Blue Angel (1)[14]. Applying rebates to ships adhering to indexes or certificated by environmental initiatives seems to be the preferred method to differentiate port charges based on environmental criteria. It may reasonably be assumed – and the case-study ports interviewed in the second phase of the Study confirm this idea – that the success of this practice is to be found in the fact that these initiatives are very popular in the shipping industry, and assign 'user-friendly' scores to ships that comply with certain environmental standards. It is thus much easier for port authorities to structure differentiated charging based on well-established criteria certified by a third party. At the same time, it would also seem more convenient for ship owners to benefit from rebates based on well-known certifications.

[14] For more details on the schemese identified, please see Annex IV to this Report.

Figure 4 – Number of environmental charging schemes identified by index / certification



Source: own elaboration

This practice, inter alia, inevitably reduces the resource gap between larger and smaller ports when it comes to managing an environmental charging scheme. When the verification of compliance with increased environmental standards is delegated to third-party certification bodies, the effort related to the implementation and management of the scheme is reduced accordingly, as the port authority simply verifies whether the certification exhibited by the vessel owner is valid.

In 15 instances, we detected schemes that are not based on any existing index and / or certification. Some ports offer combinations for discounts based on different options and indexes / certifications. It should be noted that 7 of these ports are Spanish. In Spain, ports do not have autonomy for deciding their port dues, which in fact are decided through a state law (Royal Legislative Decree 2011/2) and under the umbrella of a state agency, Puertos del Estado. The discount is applied when a vessel demonstrates compliance with certain conditions of respect for the environment, thus going beyond what is required by international standards and conventions, and when the shipping company or the ship owner has signed an agreement with Puertos del Estado on 'good environmental practices'.

This agreement shall provide for a set of technical and operational instructions, based on the "Guidelines of good environmental practices" approved by Puertos del Estado, whose operational compliance can be verified through an environmental management system. Ships' compliance with these rules and international conventions must be certified by accredited certification bodies belonging to the International Accreditation Forum. The compliance with the agreement signed will be verified by the Port Authority

This is to say that the seven Spanish ports should be considered as seven different applications of the same scheme decided at central level[15].

On the overall, the typologies of schemes identified do not vary to a great extent. Apart from the Spanish case – which stands out since to our knowledge it is the only existing initiative that harmonises environmental charging at national level – as mentioned above most schemes are based on environmental indexes and / or certifications. Generally speaking, they all tend to apply discounts on the tonnage tax for

[15] According to the Spanish legislation, it is compulsory for all ports to apply the rebates (bonificaciones in Spanish), provided that a customer requests them. Port authorities are entitled to decide the content of the environmental agreement, although they must follow the guidelines of Puertos del Estado. In our survey of TEN-T core ports, we only detected 7 Spanish ports that explicitly mention rebates related to good environmental practices. However, in principle all ports in Spain are obliged to apply them, should a customer request them.

certified ships. The discount consists of a reduction of the ship's gross tonnage[16] that is used to calculate the tax. So, even though the certification that enables a ship owner to benefit from a discount may change from port to port, the underlying principle remains very similar throughout European ports.

When it comes to the type of ships that can benefit from discounts, it is easy to note that in most instances environmental charging schemes do not discriminate against a particular ship type, as long as the ship has the certification required (ESI, Green Award, CSI, or even the agreement with Puertos del Estado in Spain). In some other instances, however, discounts are addressed to specific ship categories: it is the case for instance of LNG-fuelled (or other environmentally-friendly marine fuel) vessels, but also of vessels that use on-shore power supply. By looking at the inventory, it is sufficiently clear that there seems to be a preference at port level to reward these two types of technology, although this should not automatically suggest that they are particularly effective to achieving certain environmental goals.

Furthermore, at least 8 of the ports surveyed price short-sea shipping traffic lower that the other traffic. Although not strictly an environmental charging scheme, it is important to look at short-sea shipping on account of the fact that it is generally associated with lower pollutants emissions, especially if compared with road transport.

One of the main problems encountered when surveying schemes that address waste management is that, in line with Art. 8(c) of Directive 2000/59/EC of the European Parliament and of the Council on port reception facilities[17], a considerable number of ports states that *fees may be reduced if the ship's environmental management, design, equipment and operation are such that the master of the ship can demonstrate that it produces reduced quantities of ship-generated waste*. However, an exact specification of the necessary criteria and the extent of the reduction is rarely made available online. Since, as explained above, several ports did not look at the results of our desk-based survey to validate them, it was impossible to enquire further.

3.3 Waste

In at least 7 instances, we could survey schemes that apply rebates on, or related to, waste management: Civitavecchia, Huelva, Klaipeda, Kotka, Las Palmas, Tallinn, and Ventspils. This certainly is a 'hot topic' in the framework of Directive 2000/59/EC. It is also particularly relevant for the cruise industry (as stated during the first panel discussion with stakeholders, which took place in April 2015) that, comprehensibly, tends to generate larger amounts of waste on board. However, while some ports undoubtedly reward virtuous waste management (see for example Tallinn and/or Klaipeda), it is interesting to note that some others envisage discounts on waste collection tax, although the incentive is on how green the ship is on the overall (e.g. if it achieves a certain ESI score), and not necessarily to what is being done to reduce ship-generated quantities of waste or to manage it in a more environmentally-friendly way (see, for instance, Civitavecchia).

More generally, there is a lack of specific details as to how schemes addressing waste management are actually implemented and what objectives they seek to achieve. In the case of Kotka, for instance, it is simply stated that the port 'may give a reduction to the waste management charge for vessels which use equipment, methods or fuel grades which have significantly decreasing impacts on the amount of waste'[18], without further specifying the details.

[16] N.B.: in France port dues are based on the volume of the ship rather than on tonnage, but the underlying principle remains the same.

[17] Directive 2000/59/EC of the European Parliament and of the Council of 27 November 2000 on port reception facilities for ship-generated waste and cargo residues, available online at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:32000L0059

[18] See http://www.haminakotka.fi/sites/default/files/public/hinnasto/HKS_Pricelist_2015_ENG.pdf.

Different solutions are adopted by the port of Tallinn (9,38% rebate for cruise ships that collect garbage separately) and Ventspils (50% rebate for vessels equipped with an incinerator).

3.3.1 The Spanish case

As with emissions, Spain once again stands out, as a 20% rebate on the waste collection fee is obtainable in all national ports, upon presentation of a certificate released by the maritime administration, proving that, due to its design and management characteristics, the ship produces reduced quantities of waste. Quite similarly, but only at port level, Klaipeda grants a 20% rebate on the 'sanitary fee' to ships certified with Green Award and / or other modern systems intended for minimisation of waste formation.

Spain has regulated ship-generated waste reception services through the Law on State-owned Ports and the Merchant Navy (Legislative Royal Decree 2/2011), which, among others, covers the activities required to collect ship-generated waste, transfer it to a waste management facility authorised by the competent authority, and, where appropriate, its storage, sorting and pre-treatment in an area authorised by the competent authorities.

Under this law, ship-generated waste is intended as all waste produced by vessels, including cargo-associated waste, which falls under the scope of Annexes I, IV, V and VI of the 1973 International Convention for the Prevention of Pollution from Ships, amended by its 1978 Protocol, in its current version (MARPOL 73/78), and by its 1997 Protocol which amended the aforementioned Convention and added Annex VI to it.

Waste reception services can only be provided in Spain by companies that have obtained the corresponding port authority licence and have been authorised by the competent environmental body to carry out the waste management activities referred to this type of service, and in addition, have provided documentary evidence of a commitment made by the target waste reception facility to accept the treatment and elimination of this waste.

In order to reduce the discharge of ship-generated waste into the sea, according to the Spanish legislation, port authorities shall apply a fixed charge to vessels berthing in their ports on each call, whether or not they make use of a waste reception service. The fixed charge, based on ship's gross tonnage, entitles vessels to make use of land collection methods in 'Zone 1' of the port to discharge all the waste included in Annexes I and V of the MARPOL 73/78 Convention, during the first seven days of their stay in port, without any extra charge. If the collection is carried out at sea or takes place in 'Zone II' of the port, a 25% surcharge will be added to the charge established for collection in Zone I. Any charges for waste discharge included in Annexes IV and VI, as well as any discharges made after the 7th day of the port call will be paid directly to the service provider according to the volume of the waste collected. Service providers may, on their own account, reach agreements with users to offer discounts on the charge, based on types and annual volumes of waste delivered.

The fixed charge to be applied to a ship on each port call is as follows:

Waste reception tariff	
Tariff = basic charge (R) * following coefficients	
Ship G.T.	**Coefficient**
Between 0 and 2.500	1,5
Between 2.501 and 25.000	GT * 0,0006
Between 25.001 and 100.000	GT * 0,00012 + 12
Over 100.000	24

The basic charge is currently set at € 80,00 and may be reviewed in the Spanish General State Budget Law.

The volume of waste actually discharged under Annexes I and V of MARPOL 73/78 will be paid by the port authority to the service providers, in line with the tariffs established in the specific requirements of the service. Should the amount collected by the fixed charge exceed the amount paid, the port authority is entitled to distribute a percentage of the remaining amount among the service licence holders to contribute to the viability of the service in case of insufficient demand. The distribution criteria will be included in the specific requirements of the service and will be objective, transparent, proportional, fair and non-discriminatory.

As mentioned above, when a vessel has a certificate issued by the maritime administration proving that, due to its environmental management, design, equipment and operation, it produces reduced quantities of waste, is entitled to a 20% rebate on the fixed charge for the reception of ship-generated waste.

Furthermore, the amounts collected through the fixed charge shall contribute to funding the cost of providing the service and to promoting best environmental practices, thus discouraging the discharge of waste into the sea. To this purpose, and based on a minimum volume of discharged waste, the port authority may establish rebates on the fixed charge per cubic metre of waste discharged and certified, based on a binding report from the State-owned Ports Body, and as long as these rebates are added to the cost structure of each port authority, in a framework of fair competition between ports.

3.4 Conclusions

The group of ports surveyed is arguably no more and no less representative than any other such small sample, so some initial observations may be pertinent to the study's objectives. Several authorities are certificated under an Environmental Management System (mostly ISO 140001), which supports the submission previously made that port authorities that are environmentally aware, pro-active and capable of demonstrating competence in environmental protection are more likely to recognise and incorporate environmental aspects into their business plans and associated fee structures.

The range of qualifying criteria and standards recognised, and the variations in benefits applied confirm the view that the voluntary initiatives are far from harmonised, and vary significantly from port-to-port. This statement may seem in contradiction to what suggested above about a certain uniformity in the typologies of schemes identified. However, while it is true that most schemes tend to revolve around the same principles, researching the port websites more widely confirmed that even the terminologies applied lack consistency. For example, fee reductions may be applied to: 'Harbour dues', 'Port dues', 'Port fees', 'Marine Service Charges', and 'Tariff of Port Use' (TUP). In addition, qualifying criteria may apply to waste reception, vessel type, Short-sea shipping, or use of OPS.

Similarly, the format, style and content of information sources relating to port rates and fees vary substantially from port to port in terms of the details and nomenclature used to specify and explain the summary of rates available. Straightforward percentages or coefficients by discount may be quoted or used in tandem, and certain qualification criteria may depend on utilisation rates and nationality of home port.

Nevertheless, it is interesting to note that the widely-recognised key factors or issues that could be addressed by collaboration between port authorities and the shipping industry are indeed represented even within this small sample, namely:

- Green Ship certification
- Beneficial rates for LNG-fuelled vessels
- Use of Onshore Power Supply (OPS)
- Short Sea Shipping (SSS)
- Condition of waste

Below is a summary table with an overview of environmental charging schemes characteristics by port:

Table 9 – Summary table of schemes identified in ports

Port	Index	Information on the environmental charging scheme		Incentives related to short-sea shipping	Incentives related to waste management
Bremen	ESI	Discount	5% or 10% on port dues		
		Type of ship	All ships with an ESI score between 30 and 40 (5%). Higher scores will get a higher discount (10%)		
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Cartagena	ESI	Discount			
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	50% on port dues		
		Type of ship	LNG-driven ships on high seas or use of liquid natural gas / electricity at berth		
Civitavecchia	ESI	Discount	From 6% to 15% on waste collection fee, depending on the ESI score		Discount on the waste collection fee connected to the ESI score.
		Type of ship	All ships		
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Ghent	ESI	Discount	5% on 'environmental dues' (part of port dues)	Discount of 5% on port dues if a bulk vessel has a valid shortsea Green Award certificate	
		Type of ship	All ships with an ESI score of at least 20		
	GA	Discount	15% on port dues		
		Type of ship	Bulk vessels		
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	50% on 'environmental dues' (part of port dues)		
		Type of ship	All ships that use an environmentally friendly fuel (marine diesel, gas oil, LNG, other)		

Port	Index	Information on the environmental charging scheme		Incentives related to short-sea shipping	Incentives related to waste management
Gibraltar	ESI	Discount			
		Type of ship			
	GA	Discount	5% on port dues		
		Type of ship	All ships		
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Gothenburg	ESI	Discount	10% on port dues		
		Type of ship	All ships with an ESI score of at least 30		
	GA	Discount			
		Type of ship			
	CSI	Discount	10% on port dues		
		Type of ship	All ships that achieve green standard according to the CSI		
	BA	Discount			
		Type of ship			
	No index	Discount	20% on port dues		
		Type of ship	All ships that switch to LNG as a fuel		
Hamburg	ESI	Discount	From 0,5 to 15% on port dues, depending on the ESI score	'Short distance traffic' is priced lower that the other traffic in terms of price in € per tonne Handled, price in € / loaded TEU, and price in € / GT	
		Type of ship	All ships. Ships that are exclusively powered by LNG get a 15% discount		
	GA	Discount	3% on port dues		
		Type of ship	Crude oil/Product Tankers, Chemical Tankers, LNG carriers		
	CSI	Discount			
		Type of ship			
	BA	Discount	2% on port dues		
		Type of ship	All ships that hold a valid RAL-UZ 110 (Blue Angel) certificate		
	No index	Discount	15% on port dues		
		Type of ship	All ships that use OPS while berthing in the port. The overall discount cannot exceed € 2 000		
Huelva	ESI	Discount		Short-sea shipping vessels have a cheaper basic rate than other vessels	The 20% discount is related to a certificate issued by the Maritime Administration stating that reduced amounts of waste are generated due to the ship's environmental management
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	20% on port dues		
		Type of ship	All ships with a certificate issued by the Maritime Administration		

Port	Index	Information on the environmental charging scheme		Incentives related to short-sea shipping	Incentives related to waste management
Klaipeda	ESI	Discount			Discount of 20% on sanitary dues applied to ships equipped with waste treatment system complying with Green Award and other modern waste treatment systems intended for minimization of waste formation and waste re-sing and separation
		Type of ship			
	GA	Discount	20% on sanitary dues		
		Type of ship	All ships equipped with waste treatment system complying with Green Award		
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Kotka	ESI	Discount			The port may give a reduction (amount not specified) to the waste management charge for vessels which use equipment, methods or fuel grades which have significantly decreasing impacts on the amount of waste.
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Las Palmas	ESI	Discount		Short-sea shipping vessels have a cheaper basic rate than other vessels	Discount of 20% on the waste management charge applied to ships are certified with an Environmental Management System
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	5% on port dues		
		Type of ship	All ships that have an agreement on good environmental practices with Puertos del Estado		
Le Havre	ESI	Discount	10% on port dues		
		Type of ship	10 cleanest container or Ro-Ro ships ships with an ESI score of 31 or more		
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			

Port	Index	Information on the environmental charging scheme		Incentives related to short-sea shipping	Incentives related to waste management
Lisbon	ESI	Discount			
		Type of ship			
	GA	Discount	5% on port dues		
		Type of ship	Crude Oil/Product Tankers		
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Marseille Fos	ESI	Discount			
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	20% on port dues		
		Type of ship	Ships that use maritime fuel with zero sulphur content to produce electrical energy at berth		
Moerdijk	ESI	Discount		Vessels with a CCR4 certificate will be granted a discount of 30% on the port dues	
		Type of ship			
	GA	Discount	6% on port dues		
		Type of ship	Crude oil/Product Tankers		
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Riga	ESI	Discount		Short-sea ships are exempted from port dues.	
		Type of ship			
	GA	Discount	10% discount on port dues		
		Type of ship	Oil tankers		
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			

Port	Index	Information on the environmental charging scheme		Incentives related to short-sea shipping	Incentives related to waste management
Rostock	ESI	Discount	From 1% to 3%, depending on ESI score		
		Type of ship	All ships with an ESI score ≥ 10		
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Rotterdam	ESI	Discount	10% on port dues		
		Type of ship	Ships with an ESI score ≥ 31		
	GA	Discount	6% on port dues		
		Type of ship	Crude oil/Product Tankers and LNG carriers		
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Stockholm	ESI	Discount			
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	Cash contributions		
		Type of ship	Ships that convert to get connecte to electricity at the quayside, LNG vessels, reduced emissions of NOx		
Tallinn	ESI	Discount			A discount of 9,38% on the waste fee is applied to cruise ships that collect garbage separately by types, in case at least one type of recyclable garbage (excluding mixed domestic waste) listed in MARPOL Annex V (garbage) is discharged
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	9,38% on the waste fee		
		Type of ship	Cruise ships that collect garbage separately		

Port	Index	Information on the environmental charging scheme		Incentives related to short-sea shipping	Incentives related to waste management
Tenerife	ESI	Discount		Short-sea shipping vessels have a cheaper basic rate than other vessels	
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	5% on port dues		
		Type of ship	All ships that have an agreement on good environmental practices with Puertos del Estado		
Valencia	ESI	Discount		Short-sea shipping vessels have a cheaper basic rate than other vessels	
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	5% on port dues		
		Type of ship	All ships that have an agreement on good environmental practices with Puertos del Estado		
		Discount	50% on port dues		
		Type of ship	liquid natural gas-driven ships on high seas or use of liquid natural gas / electricity at berth		
Ventspils	ESI	Discount		Coasters shall pay charges in the amount of 50% of the basic rate	Discount of 50% on the sanitary fee applied to vessels is equipped with a certified incinerator.
		Type of ship			
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount	50% on the sanitary fee		
		Type of ship	Ships equipped with an incinerator		
Wilhelmhaven	ESI	Discount	From 2,5% to 10% on port dues, depending on the ESI score		
		Type of ship	All ships with an ESI score ≥ 20. A maximum of 10 ships' calls per owner/operator can be accepted		
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			

Port	Index	Information on the environmental charging scheme		Incentives related to short-sea shipping	Incentives related to waste management
Zeebrugge	ESI	Discount	10% on port dues		
		Type of ship	All ships with an ESI score ≥ 30. The discount cannot exceed EUR 750 per call		
	GA	Discount			
		Type of ship			
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			
Zeeland	ESI	Discount	Discount on port dues based on the ESI score obtained		
		Type of ship	All ships with an ESI score ≥ 25		
	GA	Discount	6% on port dues		
		Type of ship	Crude oil/Product Tankers and LNG carriers		
	CSI	Discount			
		Type of ship			
	BA	Discount			
		Type of ship			
	No index	Discount			
		Type of ship			

Source: own elaboration based on publicly available information

Section II - Assessment of the implementation of environmental charging schemes

4 Case studies

The case study methodology has been employed successfully in port studies for several decades thanks to its flexible data requirements; case studies enable to collect diverse types of data, such as interviews, questionnaires, published and unpublished materials, and direct observation.

Another benefit of case studies is the contextual sensitivity inherent to this method, which allows uncovering how local economic, technological, political and environmental contexts influence the successful adoption of the charging system. Such an approach allows, next to the more descriptive and broader (statistical) analysis within fact finding studies, to uncover more in-depth insights. Furthermore, some elements crucial to the assessment of the schemes are not likely to be available in public and need close interaction with port management bodies (e.g. impacts on the commercial and financial level, evolution of the ship portfolio calling the port, etc.).

Further to the data collection phase of the study, it was observed that most schemes tend to revolve around a common set of core principles. This should not come as a surprise, as many ports are involved e.g. in the ESI working group, and in general the industry has a tendency to be subject to a large degree of the so-called 'mimetic and normative isomorphism', i.e. a natural way to commonly adopt certain processes and structures, given the frequent and multiple interactions within – for instance – trade associations or other industry-led initiatives (ECOPORTS e.g.).

In light of the above, a series of case studies were developed to collect more specific quantitative and qualitative data on environmental charging in the EU. The original idea in the Tendering Specifications for this study was to develop at least 5 case studies, each reflecting a 'promising' environmental charging scheme. However, in order to give a more adequate representation of the inherent diversity of EU ports, it was decided to develop 14 case studies. The choice was based on factors such as position, size, specialisation and governance model of ports. The final list of case studies includes:

1. Amsterdam
2. Antwerp
3. Bremen
4. Civitavecchia
5. Gothenburg
6. Hamburg
7. Le Havre
8. Riga
9. Rotterdam
10. Setúbal
11. Stockholm
12. Tallinn
13. Valencia
14. Zeebrugge

Overall, the 14 ports selected account for 29% of cargo throughput of EU ports in 2015 (source: Eurostat).

The vast majority of ports analysed are in the Hamburg-Le Havre port range. This is most likely because, with the exception of Sweden, environmental charging in the EU started as a bottom-up initiative of the ports in that area, and the uptake consequently remains high.

In an effort to examine the international, non-EU, experience, the port of Vancouver was also approached as a potential case study, however without success.

In-depth interviews were carried out with representatives from each port to obtain information on:

- A short description of the economic, social, political and environmental context, with particular attention to the volume and typology of traffics, number, type, flag and origin of ships, the relations with the local communities and the competitive position of the port.
- The structure of any charging schemes at the port and in particular any differentiated infrastructure charging schemes aimed at reducing external environmental costs with specific focus on ship dues, berthing dues and any other charges that can be associated with the use of a specific piece of infrastructure or with the limitation of negative external impacts. Green incentive schemes such as reduction on port dues based on existing indexes/certifications or other metrics developed by port authorities, generally as a percentage reduction on port dues will also be included.
- The analysis of the rationale for which a charging scheme has been set up, mostly through interviews with port authority officials and selected port users, the collection of local and international expert opinions, and available data.
- Specific details on the financial dimension of the scheme.
- A quantitative assessment of the effectiveness in terms of reduction of environmental impacts of the charging scheme under current market conditions when information is available (e.g. air quality, water quality, congestion, noise, etc.).
- The perceived impacts of the charging scheme at least for port users, local communities and other stakeholders in term of, for example, image, relations with the local community or perceived environmental performance of the port. This section of the case study was built on the basis of structured interviews with key stakeholders where a number of semi quantitative indicators were collected per port.

4.1 Main lessons learned

Motivation for implementation: virtually all ports mentioned their environmental strategy as the main driver for implementing an environmental charging scheme. More specifically, the significant environmental aspects that are taken into account are mainly air quality, noise and waste. NO_x and SO_x – and their concentration and impact on the areas surrounding the port – seem to be frequent causes for concern, especially in larger ports. However, other driving factors were also mentioned, notably port-city links, encouraging ship owners to reduce impacts, pressure (of course not directly) from Ecoports and the Worlds Port Climate Initiative.

Size and specialisation play a somewhat lesser role than expected: our sample of ports include a wide range of diverse ports in terms of size, specialisation and also geographic location. None of these factors, however, seem to produce a tangible effect on the decision on whether to implement an environmental charging scheme. There is a higher concentration of ports with environmental charging schemes in the Hamburg-Le Havre port range, but this can be attributed to the fact that the World Port Climate Initiative and the ESI originated from an initiative of some ports in that area. Many other ports from the same area followed the example.

Autonomy in tariff setting: while size does not seem to be a driving factor, autonomy to set tariffs clearly is. All the ports considered in our case studies do have autonomy to set their tariffs, except for Civitavecchia, Stockholm and Valencia. Where there is no autonomy in tariff setting, the decision-making role of the port is very limited. It is the case of Italy, where ports are not allowed to set tariffs and dues, but only fees for a limited number of services (e.g. waste collection). Civitavecchia's scheme, for instance, envisages a rebate on the waste collection fee for ESI-certified vessels with a certain score. What may seemingly be illogical – ESI deals with emissions, and consequently there is no incentive to reduce or improve the management of waste – is the result of the impossibility for the port authority to modify port dues. Similarly, in Spain, port dues are decided at national level. Valencia's scheme can be used as an example for the purposes of the Study, but in fact, by virtue of

a national law, the same environmental charging scheme applied there can be applied in all Spanish ports with only minor differences.

Environmental indexes / certifications: as emerged in the first phase of the study, most schemes are based on environmental indexes / certifications, namely the Environmental Ship Index and Green Award. The reasons for that are discussed above and mostly to be found in the fact that it is easier for ports to rely on an existing index / certification that assesses and certifies how 'greener' a ship is, rather than developing a new metrics from scratch. Furthermore, these indexes / certifications are perceived as reliable, and the uptake in the industry is high.

Start date: based on case studies, environmental charging is a relatively recent practice in the EU. With the notable exception of Stockholm, which started rewarding green vessels in 1991 (the scheme was then revised in 1993 and 1996), environmental charging has been implemented regularly only since 2011, with Antwerp, Rotterdam and Hamburg rewarding ESI-certified vessels. In the following years, many ports have been following that example. In Spain too, where a national environmental charging scheme exists, the law that lays down the requirements for its application was approved in 2011. Several schemes were approved as late as 2015. This should suggest that the 'momentum' is still high, and it is quite likely that many other ports will decide to implement an environmental charging scheme in the near future.

Decision-making process: in virtually all ports the decision-making process sits at least with the environmental department of the port authority. In the Hamburg-Le Havre port range, however, where the EU busiest ports are, and where the ESI initiative originated, the commercial department is often reported to be the main decision-maker.

Budget: with the exception of Civitavecchia, all case-study ports allocate a variable budget for the payment of rebates connected to their environmental charging schemes. A variable budget means that adjustments can be made during the year. The budget allocated is generally the result of a learn-by-doing process, whereby ports estimate the necessary amount of money to manage the scheme, based on the number of calls and rebates of the previous year. Most port authorities preferred not to disclose exact figures, as budget allocation is considered confidential data. However, some ports agreed to give exact figures, namely Antwerp, Civitavecchia (both around EUR 500 000 a year), and Amsterdam (EUR 135 000). It would also be interesting to know the percentage of the budget allocated for the scheme on total port dues. While many ports refused to disclose this data, it is known that in Rotterdam it is <1%, in Antwerp it is between 0,5 and 1% and in Civitavecchia it is 2,2%. The budget allocated is generally redistributed through rebates for eligible ships.

Monitoring: the vast majority of ports interviewed does not carry out any specific environmental and economic monitoring of the impact of the charging scheme applied. What emerges from the case studies is that port authorities do not specifically monitor the impact of the environmental charging scheme they implement. Despite environmental monitoring being increasingly acknowledged as a fundamental practice, it has not yet evolved to including the impact of differentiated charging.

The lack of data from specific monitoring of environmental charging schemes makes it particularly difficult to analyse the phenomenon from a quantitative perspective. While there are certain inherent difficulties in gauging the environmental effects of a charging scheme (discussed in the next section), when it comes to economic monitoring, it is mainly the lack of resources (especially in smaller ports) that prevents ports from evaluating the impact of a scheme from the quantitative point of view. As an exception to this 'rule', interesting data is available from the port of Rotterdam:

Table 10 – Number of ESI calls in the port of Rotterdam

Year	Number of calls of ships with an ESI score	Number of calls under ESI (≥ 31 points)	Total number of calls (seagoing ships)
2011	83	/	29 076
2012	1 057	/	27 434
2013	4 825	1 846	25 321
2014	5 359	1 712	25 393

Source: Port of Rotterdam Authority (2015)

As can be noted, in 2013 and 2014 the number of ships with an ESI certificate (regardless of the exact score) was about 19% and 21% of total calls, while ships eligible for a discount (i.e. with a score equal to or higher than 31) were around 7% of total calls.

The port of Rotterdam can offer interesting insights on the impact of environmental charging, because it is the busiest port in Europe, and because it monitors the portfolio of ships visiting the port, thus detecting potential changes in the amount of ships possessing an ESI certificate. Although not causally linked to the implementation of the scheme (many parameters are influencing), interesting insights can be deducted. There are analytical exercises on potential impacts (results are not public), but these show that in the short run schemes do not lead to altered behaviour when it comes to change in the existing fleet of ships. The incentive is only effective when it comes to the development of new ships (rewarding early compliance, i.e. shipping lines take into account technologies beyond compliance) and the choice of fuel (more environmentally friendly). As a result, the real impact of the scheme is to be considered in a long-term perspective. In the short run, if a liner ship obtains rebates in multiple ports (e.g. 4 ports), the rebates could provide the stimulus to pay the extra price for cleaner fuels.

The effectiveness of the scheme is measured by the number of calls (the more, the better) falling under the scheme (in absolute terms), as well as the increased number of ports and ships participating in the scheme. The scheme is set up as a short-term, temporary impulse to stimulate altered behaviour (investment decisions, fuel use). The idea is not to provide a kind of fixed income for the customer. This message is also consistently conveyed to users. Although there is no absolute upper limit for the total amount of rebates given, financial monitoring is present, meaning that adjustments can be made when necessary.

Resources required to manage the scheme: the study attempted to quantify the Full-Time Equivalent (FTE), i.e. the workload of an employed person necessary to manage an environmental charging scheme. Not all ports were able to provide such a figure, however, on average, the FTE varies from 0,5 and 3 a year. It can be argued that managing a scheme is not particularly burdensome in terms of effort and human resources. This should not come as a surprise, since, as mentioned above, the vast majority of schemes is based on environmental indexes / certifications for the very reason that this solution makes it easier for ports to implement and manage a scheme, thus reducing their workload to a great extent.

Malus scheme: since all schemes identified work as bonus schemes, ports were also asked to express their opinion about introducing malus schemes. There was unanimous agreement that malus is not a priority of the moment. It is perceived as more complex to manage, with additional administrative costs. Above all, ports feel that it should not be their duty to sanction polluting vessels, because existing legislation already lays down requirements with which vessels must comply. Nevertheless, it should be noted that, if the principle of revenue-neutrality is to be respected, then an implicit transfer of value from more polluting to less polluting ships must take place in any case, through recalibrations in the tariff structure.

A set of tables below summarises the main findings from the case studies.

Table 11 – Case studies summary table – Hamburg - Le Havre port range

	Hamburg – Le Havre port range	PORT OF						
		ANTWERP	ZEEBRUGGE	ROTTERDAM	AMSTERDAM	LE HAVRE	HAMBURG	BREMEN/BREMERHAVEN
CHARACTERISTICS	Location/range	H-LH	H-LH	H-LH	H-LH	H-LH	H-LH	H-LH
	River/coastal port	River	Coastal	Coastal/river	River	Coastal/river	Seaport	Seaport
	Located in or near large urban area	YES	NO	YES	YES	Limited interference	YES	YES
	Located in SECA area	YES	YES	YES	YES	YES	YES	YES
	Ownership / governance model	Municipality/ Autonomous company	Municipality/ Autonomous company	Municipality & state/ Autonomous company	Municipality/ Autonomous company with a separate department for the harbour master	State-owned establishments	Municipality (City-state of Hamburg)	Municipality (City- of Bremen)
	Total revenue (€)	338 406 000	69 436 143	660 000 000	142 400 000	173 210 000	176 202 531	-
	Total cargo (Tonnes - 2014)	199 012 082	45 000 000	444 700 000	79 800 000	67 592 820	145 700 000	78,2
	Dominant cargo	– Containers – Liquid bulk – Conventional goods	– LNG – Short-sea RoRo – LoLo containers	– Containers – Dry bulk – Liquid bulk	– Liquid bulk – Dry bulk – Cruise	– Liquid bulk – Containers	Universal	Bulk, container and general cargo, cars
	Presence of industry	+++	0	+++	++	++	+++	+++
	Dominant industry	Petrochemical	/	Petrochemical + Biobased	Energy (coal & petrol)	Energy	Container	Container / automobile/bulk/ breakbulk
ENVIRONMENTAL STRATEGY	Relevant environmental aspects	– Air quality – Waste	– Air quality – Waste – Noise – Land use & nature conservation	– Air quality + odours – Noise – Nature – Waste	– Air quality + odours – Waste – Efficient energy-use	– Land use & nature conservation – water quality – Air quality – waste – Noise	– Air quality – Noise – Nature – Waste	– Air quality – Noise – Nature – Waste - Sediments - CO^2 saving
	Focus strategy	Air quality	Waste	– Air quality – Noise	Air quality	Land use & nature conservation		Greenports strategy

	Hamburg – Le Havre port range	PORT OF						
		ANTWERP	ZEEBRUGGE	ROTTERDAM	AMSTERDAM	LE HAVRE	HAMBURG	BREMEN
DIFFERENTIATED CHARGING	Autonomous tariff-setting	YES	YES	YES	YES	YES (Budget is fixed, but system behind division of it is autonomous decided)	Responsibility lies with the Supervisory Board	YES
	ESI	YES (10%, if score ≥ 31 points)	YES (10%, if score ≥ 30 points)	YES (10%, if ≥ 31 points -20%, if LNG fuel/large catalysts)	YES (Variable % depending on gross tonnage -> 1st reduction if score ≥ 20 points, 2nd reduction if score ≥ 31 points)	YES, but only applied to the top-10 shipping lines with a maximum rebate of 10% (score ≥ 31 points)	YES (differentiated discounts based on ESI scores)	YES. A discount of 15% on port dues is applied to ships with an ESI score 40 or higher. The rebates are applied per call and only 25 ships with the best ESI score will receive the discount.
	Green Award	NO	NO	YES	YES	NO	YES (3% discount on port dues for product and chemical tankers, crude oil, LNG carriers)	NO
	Additional environmental schemes	YES (Incentive scheme on fine particles)	NO	NO	NO	YES − Rebate on concession fees regarding container traffic, if modal shift objective is realised − Rebate related to transhipment of containers via SSS	YES (Blue Angel award 2% rebate/ port power discount scheme 15% discount on the GT portion of port fees/LNG fuel scheme 15% rebate on port fees- Blue Angel Award and LNG Scheme)	Incentives for LNG Ships (1. year 50 %, 2. year 25 %, 3. year 15 %, Ships with dual fuel half of the rebate. A Study on "Quality Shipping and Fair Pricing" will be finished in spring 2016 and used for further discussions but not to implement a new Bonus system for the two Ports
	Start date of use	ESI: 2011 Other: 2015	2012	ESI: 2011 Green award: 2013	ESI: 2011 Green Award seagoing ships: 2003 Green Award inland vessels: 2015	2012	ESI: 2011 Green award: 2014 Other: 2015	ESI: 2012 LNG: 2016

	Hamburg – Le Havre port range	PORT OF						
		ANTWERP	**ZEEBRUGGE**	**ROTTERDAM**	**AMSTERDAM**	**LE HAVRE**	**HAMBURG**	**BREMEN**
FTE &MONITORING	Total FTE resources per year	Ca. 0,5 FTE	Ca. 0,5 FTE	Ca. 1 FTE	0,2 – 0,3 FTE	Ca. 0,5 FTE	Not available	
	Main dimension of monitoring	Financial, incl. # ships & total amount of rebates	Financial, incl. # ships & total amount of rebates	Financial + Environmental	No monitoring, but reflecting upon future measures and KPI's. And within the ESI working group, experts of Amsterdam are contributing to an environmental impact assessment module	No monitoring, but within the ESI working group, experts of Le Havre are contributing to an environmental impact assessment module	Not available	
	Structural evaluation	Quarterly reporting to Executive Committee + monitoring	Yearly ad-hoc adaptations	Including monitoring changes in the ship portfolio	No reporting to Executive Committee	Yearly reporting to the management board	Not available	
MALUS SCHEME	In favour of malus	NO, but…*	NO	NO, but…*	NO, but…*	NO	NO	NO
	Explanation	−Complexity on admini-strative level − audit costs (proof of evidence reversed) *Only possible if 80%-90% of the users compliant; currently used for single hull ships	− more coordination between ports necessary − inefficient market shifts − higher administrative costs − complexity ↑ − audit costs	− audit costs (proof of evidence reversed) − complexity↑ *Malus applied to polluting inland waterway vessels	− Practical issues (diversity of cargo & environmental risks) − more coordination between ports necessary *Only possible if 50% of the users compliant + should be developed by central governments	− ESI not suited to apply within malus scheme − Traffic shifts to countries without the scheme − regulatory, non-discriminating characteristic	Legal constraints and indexes have been developed only to be used as incentives.	

	Hamburg – Le Havre port range	PORT OF						
		ANTWERP	ZEEBRUGGE	ROTTERDAM	AMSTERDAM	LE HAVRE	HAMBURG	BREMEN
DIFFERENTIATED CHARGING	Part of the ESI-working group	YES	YES	YES	YES	YES	YES	YES
	Focus on certain market segment	NO	YES (Focus on short-sea shipping)	NO	NO	YES (Focus on car carriers & containers)	NO	
	Motivation implementation	– EU level: WPCC 2008 – National level: action plan on fine particles and NO_2 in the port and the city of Antwerp - 2008 – Pressure stakeholders – Promotion of port – Neighbouring ports were applying	– Pressure of governments – Need of collaboration of ports to make an impact – Image to stakeholders	– European level: Worlds Port Climate Conference 2008 – Green image – Neighbouring ports make use of it	– European level: Worlds Port Climate Conference 2008 – Green image to stakeholders	– European level: Worlds Port Climate Conference 2008 – Independence of participating ports in the application – simplicity and dynamic initiative		ESI : Enhancing the environmental performing of ships LNG: Support for a faster implementation of LNG,
	Proof of environmental certificate responsibility	Port	Port	Port	Shipping line / Shipping agent	Shipping line & port (environmental charter)	Port	Shipping line
DECISION-MAKING PROCESS	Departments involved	Environmental + Financial	Environmental + commercial + financial	Environmental + commercial + port user association	CSR + commercial + harbour master	Environmental + commercial + financial	Financial, legal, environmental	
	Main decision-maker	Board of directors + Executive Committee	Financial	Commercial	Commercial	Management board based on proposal from commercial and environmental divisions	Management	Senator for Economic Affairs, Labour and Ports
FINANCIAL ASPECTS of ESI	Fixed/variable budget	Variable	Variable within range	Variable	Variable	Fixed	Variable (up to a certain limit)	
	Total amount of rebates	± € 500 000	Confidential	Confidential	€ 135 000	€ 100 000	Not available	
	% of total port dues	0,5% - 1%	Not disclosed (confidential)	< 1%	± 0,5%	0,2% - 0,5% of the ship dues (= ship related charges, ≠ volume related charges)	Not available	
	Number of calls under ESI / number of calls of seagoing vessels (2014)	501 / 14 009	/ 7 720	1 712 / 25 393	633 / 4 927			445/2045

	Hamburg – Le Havre port range	PORT OF						
		ANTWERP	ZEEBRUGGE	ROTTERDAM	AMSTERDAM	LE HAVRE	HAMBURG	BREMEN
WASTE MANAGEMENT	Special rebate	YES (vessels powered by environmental friendly fuel)	NO	YES, free of charge (under certain environmental friendly conditions)	YES (vessels powered by environmental friendly fuel)	YES (fixed part of the fee is reimbursed if the waste is deposited in the port)	NO	Waste fee management is divided in two categories; disposal of domestic waste (ship-generated) and disposal of ship-generated residues and oily waste. There is no special rebate. But unreasonable amounts of waste are not included in the "No special fee"-system.
SSS	Dedicated tariff structure and/or rebate within general tariffs	Dedicated tariff structure	Dedicated tariff structure and rebate	Dedicated tariff structure	Dedicated tariff structure and extra waste rebate	Dedicated tariff structure, but rebate related to transhipment of containers via SSS	Dedicated tariff structure	Dedicated tariff structure

Table 12 – Case studies summary table – Baltic Sea

	BALTIC	PORT OF			
		STOCKHOLM	GOTHENBURG	TALLINN	RIGA
CHARACTERISTICS	Location/range	Baltic	H-LH	Baltic	Baltic
	River/coastal port	Coastal	Coastal	Coastal	Costal
	Located in or near large urban area	YES	YES	YES	YES
	Located in SECA area	YES	YES	YES	YES
	Ownership / governance model	Autonomous & Municipality	Municipality	State	State/ Municipality
	Total revenue (€)	75 710 000	n.a.	111 000 000	52 145 388
	Total cargo (Tonnes -2014)	8 000 000 metric	37 100 000	28 300 000	
	Dominant cargo	– Containers – Dry bulk – Liquid bulk - Passengers	– Short-sea RoRo -LoLo containers -Liquid bulk	– R0-Ro – Dry bulk – Liquid bulk - Passengers	– Containers – Dry bulk – Liquid bulk
	Presence of industry	Restricted	+++	Restricted	+++
	Dominant industry	High Technology	Container / passenger/liquid bulk	Transit & distribution services	Bulk
ENVIRONMENTAL STRATEGY	Relevant environmental aspects	– Air quality – Noise – Waste - Energy efficiency	– Air quality – Noise – Nature – Waste	– Air quality – Noise –Ship's Waste – Local Community	– Air quality – Noise – Nature – Waste
	Focus strategy	- OPS - Waste		- EMS Certification	

	BALTIC	PORT OF			
		STOCKHOLM	GOTHENBURG	TALLINN	RIGA
DIFFERENTIATED CHARGING	Autonomous tariff-setting	NO	YES	YES Port Authority	YES
	ESI	NO – Swedish Environmental Research Institute study found no Index that fully met all fee considerations e.g. passenger vessels	YES (10%, if score >/= 30 points)	*To be confirmed*	No
	Green Award	NO	NO	*To be confirmed*	YES crude oil tankers holding a Green Award Certificate are granted a 10% reduction on all port charges and dues
	Additional environmental schemes	YES – for NOx, SOx, LNG, OPS	Yes (CSI:10%rebate on port dues /LNG fuel scheme: 20%rebate)	YES – (-10% waste fee) Cruise Ships	NO
	Start date of use	1991 (Voluntary), revised 1993 and 1996	ESI: 2015 CSI: 2015	2014	April 2014
	Part of the ESI-working group	*To be confirmed*	YES	*To be confirmed*	NO
	Focus on certain market segment	NO	YES (Focus on short-sea shipping)	YES Cruise ships	NO
	Motivation implementation	- Port-city links. - Strategic value of environment. - Collaboration between port, city and Swedish Maritime Administratn	Integral part of port strategy	- Encourage ship owners to reduce impacts	Improve the image of the port, improve quality of ships in the port
	Proof of environmental certificate responsibility	Swedish Maritime Administration & Port	Port		Ship owners. Green Award produces a list of the certificate holders.
DECISION-MAKING PROCESS	Departments involved	*To be confirmed*	Environmental + commercial + financial	'Commission of Port Dues' within Port Authority	Environmental + marketing + legal + financial
	Main decision-maker	Swedish Maritime Administration	Financial /port authority		Board

	BALTIC	PORT OF			
		STOCKHOLM	GOTHENBURG	TALLINN	RIGA
FINANCIAL ASPECTS of ESI	Fixed/variable budget	N/A	Variable	*To be confirmed*	Variable (depending on the amount of certificate holders)
	Total amount of rebates	N/A	Not disclosed (confidential)	*To be confirmed*	Very low
	% of total port dues	N/A	Not disclosed (confidential)	*To be confirmed*	Less than 0.5%
	Number of calls under ESI / number of calls of seagoing vessels (2014)	N/A	/ 7 720	*To be confirmed*	Not monitored
FTE & MONITORING	Total FTE resources per year	*To be confirmed*	Ca. 0,1 FTE	*To be confirmed*	Less than 0.05
	Main dimension of monitoring	*To be confirmed*	Financial, incl. # ships	*To be confirmed*	No specific monitoring action is undertaken
	Structural evaluation	*To be confirmed*	Yearly ad-hoc adaptations	*To be confirmed*	No specific evaluation action is undertaken
MALUS SCHEME	In favour of malus	NO	NO	NO, but…	YES
	Explanation	Incentive schemes should encourage compliance-plus. Malus would punish vessels and thus not viewed as constructive	– a malus scheme placed risk on the shipoweners	In order to avoid 'waste tourism' there should be harmonised implementation requirements related to scrubber residues and PRF in all MS	Very hard to implement due to commercial constraints
WASTE MANAGEMENT	Special rebate	N/A	Free of Charge	YES (-10% for cruise ships separating by type (MARPOL Annex V)	Special rebates are applied for ships with a sanitary waste treatment system on board (almost all) and for vessels with liner status that call at the port multiple times.
SSS	Dedicated tariff structure and/or rebate within general tariffs	*To be confirmed*	Dedicated tariff structure	- Discount for Ro-Ro (-15%) – (-40%) - Container (Regular) -15% to -45%	Only vessels with liner status that call in the port regularly enjoy the rebate. Almost all vessels in Riga are SSS vessels.

Table 13 – Case studies summary table – Mediterranean Sea and Atlantic Ocean

	MEDITERRANEAN/ATLANTIC	PORT OF		
		VALENCIA	CIVITAVECCHIA	SETÚBAL
CHARACTERISTICS	Location/range	MED	MED	ATL
	River/coastal port	Coastal	Coastal	Coastal
	Located in or near large urban area	YES	NO	YES
	Located in SECA area	NO	NO	NO
	Ownership / governance model	State	State	Municipality/ Autonomous company
	Total revenue (€)			22411090
	Total cargo (Tonnes -2014)			8058000
	Dominant cargo	– Containers – Conventional goods	– Dry Bulk – Liquid Bulk	– Other liquid Cargo – Solid Bulk - Containers - Fertilisers
	Presence of industry		+++	+++
	Dominant industry		Thermoelectric + metallurgical	Paper
ENVIRONMENTAL STRATEGY	Relevant environmental aspects	– Air quality – Soil & water quality – Waste – Nature – Noise	– Air quality – Efficient energy-use – Waste	– Air quality – Efficient energy-use of natural resources – Waste -Nature
	Focus strategy	– Air quality – Noise	– Air quality – Noise	– Waste – Efficient energy-use of natural resources

	MEDITERRANEAN/ATLANTIC	PORT OF		
		VALENCIA	CIVITAVECCHIA	SETÚBAL
DIFFERENTIATED CHARGING	Autonomous tariff-setting	NO	Limited	
	ESI	NO (Own incentive scheme: Environmental Best Practices Agreement)	YES but rebate given on the waste collection fee	Yes(3% if score >/=30 points)
	Green Award	NO	NO	Yes, 3% premium on Tariff of port use (TUP) for Crude oil/Product Tankers
	Additional environmental schemes	YES (Incentive scheme for port operators)	NO	YES (Incentive scheme for port operations)
	Start date of use	2011	2013	2013
	Part of the ESI-working group	NO		YES
	Focus on certain market segment			
	Motivation implementation	− Pressure of regulation − Ecoport II Project	− Measure to improve the quality of life in the areas surrounding the port − Easier to manage − Reliability	GREEN AWARD PROJECT
	Proof of environmental certificate responsibility	Shipping lines / Port operators	Port	
DECISION-MAKING PROCESS	Departments involved	Environmental	Environmental	Environmental
	Main decision-maker	Environmental	Environmental	Environmental
FINANCIAL ASPECTS of ESI	Fixed/variable budget	Variable	Fixed (annually determined)	
	Total amount of rebates		500 000	
	% of total port dues		2,2%	
	Number of calls under ESI / number of calls of seagoing vessels (2014)			/1523

	MEDITERRANEAN/ATLANTIC	PORT OF		
		VALENCIA	CIVITAVECCHIA	SETÚBAL
FTE & MONITORING	Total FTE resources per year	1,5 person	3 persons	Ca. 1 FTE
	Main dimension of monitoring	Financial + Environmental	Environmental + Financial	Environmental
	Structural evaluation			
MALUS SCHEME	In favour of malus		NO	
	Explanation	Not a priority	Ports are not in a position to sanction ships	Malus applied to Pollution paying principle
WASTE MANAGEMENT	Special rebate			
SSS	Dedicated tariff structure and/or rebate within general tariffs	Tariff structure and rebate		Liners service vessels have a port reduced scheme according to their frequency. Other reductions offered according to the services required or the conditions presented.

Sources of the tables: own elaboration based on interviews with port authorities

5 Environmental assessment

5.1 The significance of monitoring environmental charging schemes

Even though Section I demonstrates that environmental monitoring is a well-established practice in the EU port sector, the case studies revealed that many of the questions asked and the issues raised are only now emerging as points of consideration for port authorities themselves. Even where some schemes have been implemented for several years and the fees are well established, it does not necessarily follow that the environmental impacts or benefits of the scheme are actually known or even actively monitored.

As widely recognised, the motives for implementing such charges focus on air quality, waste management and on-shore power supply (OPS), and these aspects reflect the wider scale and scope of port environmental management, as port authorities acknowledge that the remit of environmental concerns extends from shipping lanes to inner city, and from port area to port-city environs.

The research pathway of this study included detailed briefings, discussions and interactive sessions with a range of stakeholders and it is interesting to note the cautions, problems and gaps in data reported by different, individual authorities. It may emerge that the range of fee models used is relatively narrow and that the overall, sector-wide approach is in itself moderately harmonised. However, it seems that motives, approach, knowledge of costs and information on actual environmental benefits is far from consistent and that many gaps still remain.

The policies and practices adopted obviously have a profound effect on the extent to which the quality of the environment itself is protected or improved, and the degree to which the impacts of the scheme may be rigorously assessed through monitoring and reporting. For the latter to be achieved to any level of confidence, the functional organisation of the environmental programme requires the identification and selection of appropriate performance indicators specifically targeted at the impact of the charging scheme itself.

The relevance to this study of differentiated fees is that for all standards, and the initial EcoPorts Self-Diagnosis Methodology (SDM, checklist of the components of any credible EMS), ports must indicate the extent to which they have developed a monitoring system. The system must be based on appropriate performance indicators and apply to both their EMS and the quality of the environment itself. 79% of all EcoPorts members (75) indicate that the port authority has an Environmental Monitoring Programme, and 64% respond that Environmental Performance Indicators (EPIs) have been identified and selected. The following table from the EcoPorts database shows the ranking of Monitoring Programmes:

Table 14 – Ranking of environmental monitoring programmes in EU ports

Rank	Monitoring Programme	%
1	Energy consumption	67
2	Waste	65
3	Water consumption	61
4	Water quality	58
5	Noise	55
6	Air quality	53
7	Sediment quality	52
8	Carbon footprint	48
9	Soil quality	40
10	Terrestrial habitats	36
11	Marine Ecosystems	34

Source: EcoPorts

The issues of waste (2nd), water quality (4th), noise (5th) and air quality (6th) are emerging as key considerations of the components factored in to the main differentiated fee schemes. The connections with shipping are clearly obvious, and so are the links to OPS, Green Shipping Certification and waste management programmes**.** What emerges from the study is the point that, although the port sector has demonstrable competence and commitment to environmental monitoring and reporting (64% produce publically available environmental report), there are very few instances where the environmental benefits of the application of differentiated charging schemes can be identified on the basis of systematic, scheme-specific, scientific monitoring.

This lack of evidence should not lead to concluding that differentiated charging is not effective *per se.* On the other hand, the obvious corollary to burning cleaner fuel, producing less waste, operating a 'greener' vessel and using OPS is an improvement, or at least enhanced protection of the environment in terms of quality and the standard of living of local communities. However, there is a range of problems reported by ports in setting in place systems apt to gauge the extent to which differentiated charging schemes deliver environmental benefits.

At sectoral level, the adoption and application of differentiated port infrastructure charges is arguably still in the development stage, and efforts to evaluate impact and validate models are only now being pursued. The current status of such schemes is derived from the mix of concept, motives, qualifying criteria, fees and cost structures, commercial imperative and perceived environmental benefits. The extent to which a port authority or its decision-making body can influence the environmental behaviour of shipping is limited by considerations of costs, liabilities, competition, responsibilities, technology, natural systems and, to a certain extent, policy and operational practice. The costs and benefits are not based on absolute parameters or predicated against uniform criteria or common factors.

Feedback from port sector stakeholders suggests that it may be difficult to monitor and quantify the environmental benefits of such schemes because of the difficulties of distinguishing the impact of specific emissions or discharges related to differentiated charging schemes from the sum total of aspects impinging on environmental quality in its entirety.

The problem of monitoring air quality is central to the whole debate concerning the efficacy of differentiated charging schemes. Air quality is in itself a dynamic, transboundary phenomenon representing an amalgam of constituents. Its characteristics can pervade every niche of the port-city complex, and they may have profound influences on health, general living conditions and the natural environment in its entirety. The port sector has recognised air quality as a priority issue for the last

ten years and has endeavoured to manage air quality through individual port initiatives and through its representative organisations. The following table illustrates the priority ascribed to air quality by European ports over the last ten years.

Table 15 – Priorities ascribed to environmental issues by EU ports of the last ten years

	1996	2004	2009	2013
1	Port Development (water)	Garbage / Port waste	Noise	Air quality
2	Water quality	Dredging: operations	Air quality	Garbage / Port waste
3	Dredging disposal	Dredging disposal	Garbage / Port waste	Energy Consumption
4	Dredging: operation	Dust	Dredging: operations	Noise
5	Dust	Noise	Dredging disposal	Ship waste
6	Port Development (land)	Air quality	Relationship with local community	Relationship with local community
7	Contaminated land	Hazardous cargo	Energy consumption	Dredging: operations
8	Habitat loss / degradation	Bunkering	Dust	Dust
9	Traffic volume	Port Development (land)	Port Development (water)	Port Development (land)
10	Industrial effluent	Ship discharge (bilge)	Port Development (land)	Water quality

Source: European Sea Ports Organisation: ESPO Port Performance Dashboard – May 2013

The difficulties of monitoring source-specific impacts reported by port authorities probably reflect the complex of legislative and technological considerations set within the dynamics of naturally occurring systems (for example, meteorological, climatological and hydraulic) that are themselves often chaotic in performance. Port's activities produce emissions, the control of which may come under international, national, municipal or any other agency jurisdiction. Local community representation may be a factor and the whole issue may focus concern on health and environmental quality prompting mitigation responses. Port authorities may be in the situation where, in law, they do not have direct liability or responsibility, but as landlords, they may be deemed to be in a position to bring influence to bear on their tenants and operators. Add to this the Principles such as 'Precautionary', 'Taking all Reasonable Steps', 'Due diligence' and 'Duty of Care'; it is not surprising that these are some of the drivers encouraging research into practicable response options.

However, albeit technically challenging, it should be possible to at least try to develop modelling techniques that make use of precise emission inventories and time series that include monthly means of dispersion factors, in such a way as to allow estimating the overall impact of a specific charging scheme on certain significant environmental aspects. The models developed would then have to be tested against a set of observational data to verify their reliability. Even though not specifically focusing on environmental charging, dedicated projects have sought to identify quantitative input components in order to ascertain the extent to which shipping impacts on port area environmental quality. For example, the Port of Oslo, Norway (in SECA) has recently presented a study on the management of air quality[19] that identified source-specific impacts on air quality.

With the close juxtaposition of commercial port area, city structures including dwellings, and natural landscape, the Port of Oslo makes an appropriate case study. The activity profile consists of:

[19] Managing air quality at Port of Oslo: Bridging Port and City - Heidi Neilson, Head of Environment, Port of Oslo, and The Thanh Nguyen, CEO, PortsEYE AS) at the GreenPort Congress (Copenhagen, October, 2015)

- 50-60 calls/week, 3.000+ annually
- 6 million passengers per year
- 212.000 container (TEU)
- 8 million tonnes goods
- 2 million tonnes wet bulk
- 1,3 million tonnes dry bulk
- 57.000 new car imports annually

The Norwegian Institute of Public Health, Norwegian Public Roads Administration and University of Oslo - Faculty of Medicine quotes around 50.000 deaths caused by air pollution in Oslo through a period of 10 years.

The accompanying table shows the Inventory of Emissions for the Port of Oslo (2013), and clearly demonstrates the range of vessels and activities that need to be considered if a comprehensive register of releases is to be attempted.

Table 16 – Inventory of emissions for the Port of Oslo

Vessels / Sector	NO_x	PM_{10}	SO_2	CO_2
Bulk Carrier	10,10	0,15	2,71	461,58
RO-RO	19,93	0,31	5,43	946,83
Container	59,13	0,99	16,17	2.806,72
Cruise	164,41	3,49	58,69	10.741,32
Ferry (foreign)	264,89	6,36	91,19	17.223,79
General Cargo	28,60	0,43	7,90	1.371,41
Oil / Chemical Tankers	42,27	0,65	12,35	2.115,54
Commercial Fishing	0,30	0,01	0,20	30,42
Ferry - Excursion	79,41	3,41	48,86	10.241,14
Recreational	4,55	0,20	2,84	461,65
Supply Vessels	1,82	0,08	1,07	184,40
Tug - Push boat	6,38	0,28	3,75	646,89
Work boats	5,74	0,25	3,38	582,26
Other vessels	8,80	0,39	5,50	893,29
Traffic	22,15	0,58	0,01	2.043,99
Cargo Handling Equipment	40,89	0,45	0,00	5.538,06
TOTAL	**759,37**	**18,03**	**260,04**	**56.288,88**

Source: Port of Oslo - Air Quality Assessment 2014

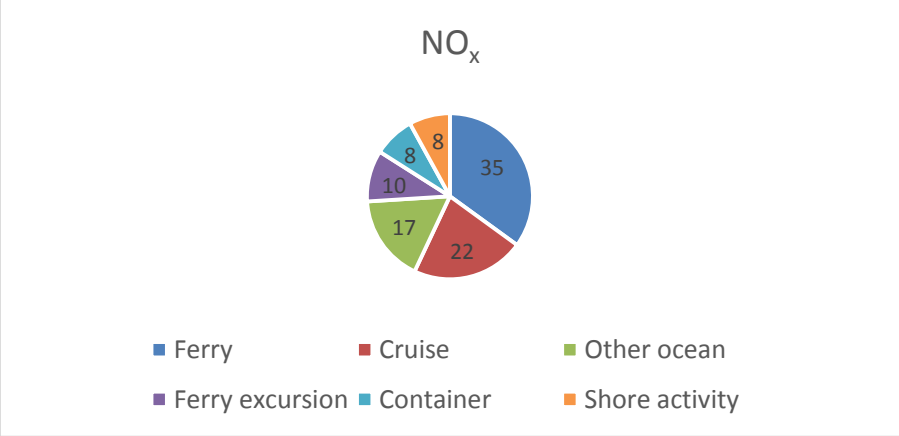
At the data-gathering stage, the quality, availability and degree of representation of information will be paramount along with decisions on cut-off boundaries or zones when port-city-hinterland models are taken into consideration.

The extent to which any particular period of data may be considered genuinely representative will vary depending on traffic profiles, meteorological conditions and overall port area activity.

Inherent in this form of monitoring are also the elements of cost and considerations relating to cross-organisational collaboration. The old adage that results are only as good as the data on which they are based is particularly applicable in this context, due to the ramifications related to Safety, Health and Environmental that may arise from the values, trends and benchmarks that may be identified.

The percentage of NO_x emission sources for the 2013 survey in the Port of Oslo attributed 82% to road traffic, 9% to the Port of Oslo, and 9% to 'other sources'. The contributing percentages for the Port itself are shown in the following chart:

Figure 5 – Emission sources (%) Port of Oslo



Source: Port of Oslo - Air Quality Assessment 2014

The Port of Oslo has provided OPS since 2011 and promotes ESI as a voluntary incentive programme for oceangoing vessels. Recognising the spatial dimension of air quality management, the Port also recognises the necessity for collaboration because the objective of clean air will include targets outside immediate port control, such as:

- Reduce 20% of road traffic volume in Oslo;
- Reduce 5% of emissions from Port of Oslo;
- Speed reduction for highways and ring roads;
- Increase 20% of electric and 5% of hybrid road vehicles;
- Full operation of existing ventilation towers in tunnels during the day is assumed.

The fact that 9% NO_x emission sources are attributed to the Port of Oslo in the city-wide survey provides a marker for context and perspective. The identification of source-specific data can be an expensive and technically challenging specialist exercise. At the same time, the example of the Port of Oslo shows that it is indeed possible to try to estimate source-specific data. With the necessary changes, a similar exercise could be conducted as an attempt at quantifying the environmental impact of a differentiated charging scheme.

At meetings with port authority representatives (including Sustainable Development Technical Committee, ESPO; European Sustainable Shipping Forum; and individual port managers at the GreenPort Congress, Copenhagen, 2015) a range of opinions were expressed related to environmental assessment and the concerns and considerations that apply to differentiated charging schemes. Specific comments, topics and issues included:

i. The extent to which a higher degree of coordination could, or should be achieved is a frequent theme with a growing consensus that the current schemes applied are not in fact as disparate as originally thought. The sector's established policy of a level playing-field is often cited as a justification for seeking a more synchronised approach. In the case of fees

related to waste, it was often stated that any apparent lack of coordination would lead to the 'shopping effect' on waste disposal.

ii. In terms of both setting fees and assessing impacts, it is often pointed out that it is not always the port authority that makes decisions on fees and exemptions. Such control may be practised by State Departments or other Agencies. The effects of schemes could be unbalanced depending on type of traffic and changing commercial activities.

iii. Where specific schemes are in place, for example on the management of waste, it is often difficult to measure the impact because of variations in ship types, visits and waste delivered. Comments also relate to different interpretations of legislation and regulation, and some port representatives expressed the view that this was not fair practice between ports.

iv. The difficulties of actually assessing impacts and presumed benefits were repeated themes. The motives for initiating such charging schemes were often qualitative and aspirational in nature aimed at generally encouraging better environmental behaviour. It was interesting to note that several ports declared that "cost is not everything" – "a good quality, efficient and user-friendly service is just as, if not more, important". The refrain often expressed the view that the charging scheme should be 'fair' – though this was never clarified in terms of beneficiary: port authority, sector, shipping industry, city or State?

v. The problems of calculating costs were seen to go hand-in-hand with the difficulties of assessing environmental benefits so that generalisations such as "differentiated fees produce better environmental behaviour" were the norm rather than quantified statements based on rigorous performance indicators. The view from the sector seems to be that there are few, if any, quantified measures of environmental benefits, and that even the calculation of costs "come with a health warning".

vi. There seems to be a dichotomy of views relating to the availability and accessibility of data and information, even where such detail exists. For some, the apparent lack of transparency of the calculation of costs and recovery mechanisms is detrimental to the objective of a level playing-field. Others hold the view that free competition and the market-drivers necessarily imply a certain degree of confidentiality and negotiation.

vii. In terms of strategic policy options, the view was expressed that there is no reason to have only one, generic charging scheme but that certain options should be avoided. Specific details were not immediately available but there seem to be, as expected, differences between the views of the port sector and the shipping industry. Some views were expressed that some alignment of charging model was desirable and that the level of incentives should be clearly defined. The suggestion was made that charging schemes should be linked with the objectives of relevant Directives. Upon further reflection, this consideration may make the case for introducing an alternative approach that lies in between complete auto-regulation of differentiated charging – as it is of today – and rigid legislation that may result from centralised EU intervention. It may be possible to define basic common requirements at EU level that would create a "level playing field", without prejudice to the diversity of EU ports in terms of ownership, governance, tariff systems, etc. The need for a more coordinated approach to differentiated charging was also expressed at the panel discussion with stakeholders that took place in January 2016 for this study.

viii. Some representatives believed that inherent differences between certain types of vessels and the nature of waste produced inevitably leads to disparity in the fees levied. The confirmation of any environmental benefits may take several years to identify which makes the whole cost-benefit calculation so fraught with uncertainties. The opinion was also voiced that benefits should be assessed in a systems approach, not port by port. There was also the view that ship operators would opt for clean fuel and greener profiles as a matter of their own efficiency and profile regardless of the influence of incentives.

ix. There was a call for a set of Guidelines (a deliverable of this study), and cautions expressed about the multiple agencies and bureaucracy involved in the implementation and operation of incentive charging schemes. The point was put forward that "there is no fee to use the ocean" and that costs should be spread across the whole maritime infrastructure in order to pay for technology capable of assessing total environmental impact. As with many operational procedures, different stakeholders may well seek distinct benefits.

The above considerations point to the fact that there are apparently no definitive or substantive statements on the sum total benefits that may accrue to the environment from the recognition, by any means, of so-called 'green shipping' certification *per* se, although – and herein lies the contradiction – there are many reports on the regulations and limits to control emissions of NO_x, SO_x and GHGs. Statistics abound on the number and sizes of vessels at sea, the number of calls made, the number of vessels certificated *etc.* Similarly, there are a range of values quoted for the impact of shipping in selected port or coastal areas where such studies have been applied, for example, the Port of Oslo, Norway (in SECA) where the percentage of NO_x emission sources for the 2013 survey in the Port of Oslo attributed 82% to road traffic, 9% to the Port of Oslo, and 9% to 'other sources'.

It is relevant to note that even where a dedicated study on several key aspects of environmental charging schemes has been carried out with specific reference to air quality (e.g. Port of Civitavecchia), the conclusion is that "the environmental monitoring system in place is not measuring the impact of the charging scheme on air and water quality. There is no data at all that could be used to gauge how and if the charging scheme has actually had any tangible effect on the environment. However, the port authority believes that – albeit useful – the charging scheme alone can have a limited effect on improving air quality, and thus it would be extremely difficult to gauge its impact".

Similarly, analysis of the ports represented in the case studies of this report confirm that even some of the arguably most pro-active port authorities do not monitor the environmental impact of the application of differentiated charging schemes as discrete initiatives.

In the case of the Port of Rotterdam, the portfolio of ships visiting the port, detecting potential changes in the amount of ships possessing an ESI certificate is monitored. Although not causally linked to the implementation of the scheme (many parameters have influence), it is claimed only that "interesting insights can be deducted". Analytical exercises on potential impacts are conducted (results are not public), but these show that in the short run the schemes do not lead to altered behaviour when it comes to change in the existing fleet of ships. The incentive is only effective when it comes to the development of new ships (rewarding early compliance, i.e. shipping lines take into account technologies beyond compliance) and the choice of fuel (more environmentally friendly). As a result, the real impact of the scheme is to be considered in a long-term perspective.

The success of effectiveness of the scheme is measured by the number of calls (the more, the better) falling under the scheme (in absolute terms), as well as the increased number of ports and ships participating in the scheme. The scheme is set up as a short-term, temporary impulse to stimulate altered behaviour (investment decisions, fuel use). The idea is not to provide a kind of fixed income for the customer and it is reported that this message is also consistently conveyed to users.

The statements of most ports with regard to environmental assessment are clear and unambiguous, for example, in the case of Amsterdam "the port does not monitor the environmental impact of the scheme, i.e. there is no formal reporting". Their annual report mentions the amount spent on the ESI related incentive scheme with details of % of ships with an ESI score / Green Award visiting the port, the number of calls, and the perception of users (agents, shipping lines) with regard to the scheme. Likewise, the Port of Le Havre states that "there is currently no specific monitoring on the level of emissions to air or changes in the ship portfolio in terms of altered behaviour or patterns".

It is apparent that for the reasons stated (complexity and cost), economic assessments are currently carried out rather than environmental assessments. For example, the Port of Zeebrugge states that

"the charging scheme is re-evaluated on an annual basis with great attention to the financial aspect: the budget has to stay within a certain range. As a result, from time to time the parameters to calculate the rebate are adapted". It goes on to affirm that "in general, both to measure the economic and environmental impact, the port authority considers it too costly and too uncertain to come to conclusions given the multiple interfering parameters and evolutions in other sectors, lack of very detailed data and history of the adoption of the scheme".

By the same token, the Port of Antwerp's response is that "there is no formal monitoring of the economic and environmental impact of the scheme, as the port authority is not capable in terms of efficient use of managerial resources to verify the exact source of the decrease" (i.e. establishing causal links). Antwerp Port Authority sees little short-term causal relations between the scheme and uptake of technologies/investment on ships (reducing impacts in the short run) and/or changes in ship deployment to the port. The same is valid for traffic diversions. Besides this, the port does not believe that the scheme alters behaviour of the shipping lines in the short run (e.g. in terms of speeding up investments in new, more environmentally friendly technology on the vessels). Short-term impact on the environmental level is influenced by legislative changes directly impacting the shipping lines (such as the SECA regulation), but not through financial incentive schemes at the side of the port authority. The change in the number of calls by vessels with an ESI certificate and the corresponding total amount of rebates are the only two 'impacts' that could be directly linked to the ESI.

The number of estimates of the contribution that shipping makes to emissions to air have grown steadily in recent years. An IMO study estimated that shipping emitted 1.046 million tonnes of CO_2 in 2007, which corresponded to 3.3% of the global emissions for that year. Most of these emissions (870 million tonnes or 2.7% of the global emissions) of CO_2 in 2007 were attributed to international shipping (Second IMO GHG Study 2009, International Maritime Organisation).

The sector's environmental impact is significant as emissions such as carbon dioxide (CO_2), nitrogen oxides (NO_x), sulphur dioxide (SO_2) and particulate matter ($PM_{2.5}$) from shipping occurring in European waters can contribute up to 10–20% of overall worldwide shipping emissions. When considering all ship traffic from national and international shipping arriving or departing from EU-27 ports, the contribution can be up to 30 % for CO_2 (The impact of international shipping on European air quality and climate forcing, Report by EEA, Technical report No 4/2013). It also stated that NO_X emissions could be equal to land-based emissions sources from 2020 onwards and that SO_2 emissions in European waters will continue to decrease further from 2020 onwards due to legislation on the sulphur content in fuel. It is expected that this will also lead to a decrease in emissions of $PM_{2.5}$.

As commented upon in many studies, the EEA report also includes the statement that "a review of available observation data shows that there are relatively few measurement data available to attribute the contribution of ship emissions to local air pollution", but adds that available data shows that the contribution of particulate matter from shipping to local concentrations can be up to 20–30%, especially for fine particulate matter.

Back in 2009, the OSPAR Commission wrote in its report entitled 'Assessment of the impacts of shipping on the marine environment' that much progress had been made to develop measures to address the various threats from shipping to the marine environment, primarily within the framework of the International Maritime Organisation. It noted that many of the measures had then only recently entered into force or were pending entry into force. As a result, there was very limited data to allow assessing the effectiveness of such measures at that point in time. It recommended that OSPAR countries should consider the development of the means to collect and collate accurate and uniform data that can be used in future assessments of the impact of shipping on the marine environment.

Similarly, in its Final report, the Clean North Sea Shipping project (March, 2014) recommended that harbours estimate emissions from ships in port, including manoeuvring and at berth using the proposed freely available CNSS model. This would help to improve reliability and comparability

between different harbours, and test the effectiveness of different incentive schemes. In terms of assessing the impact of shipping on air quality in cities, the project recommended that authorities use models of an appropriate level of sophistication such as computational fluid dynamics (CFD) models. Significantly, it pointed out that application of such models requires skilled personnel and highly sophisticated input data on emissions and meteorological conditions.

The significance of these observations for this study is the fact that there is published data on the impact of shipping in terms of global, some coastal area, and selected port-city scales, but arguably no discrete data on the differences between the actual environmental impacts of certificated 'green' ships compared with their non-certificated equivalents. Unambiguous information is readily available for clean shipping technology and options that indicates potential environmental benefits from systems *per se.* The following table was compiled from the Clean North Sea Shipping Report (March, 2014) and demonstrates the factual data available for selected technical options. The environmental effects are potentially obviously beneficial, but there is apparently no systematic appraisal to date of the sum-total impact that the combined 'Green Certificate' options actually deliver.

Table 17 – Environmental effects, disadvantages and costs of air pollution technologies

MEASURE	ENVIRONMENTAL EFFECT	DISADVANTAGES/ CAUTIONS	COSTS/ NOTES
Direct Water Injection: Freshwater is injected under high pressure in the combustion chamber just before the fuel is injected. This reduces the cylinder temperature, because the water vaporises and absorbs heat. The lower temperature reduces the formation of NOx during combustion.	Water to fuel ratios of 40-70% can achieve NO_x-reductions of 50-60%. Higher ratios can even result in 70% NO_x reduction, but will result in lower engine efficiency. 30-40% water/fuel ratios can be used without compromising fuel consumption, leading to roughly 30% reduction in emissions.	Cannot be used if the load is lower than 30-40% of full load in order to avoid the formation of white smoke and the increase of black smoke.	Capital costs vary between 130.000 US dollars for a tanker and 620 US dollars for a cruise ship. Operational costs are around 2 US dollars per MWh. An example of operational costs is the costs for distilled water. Costs for retrofitting are 25% higher compared to new engines. Maintenance costs are reduced by up to 25% due to minimised thermal stresses on the engine components and prevention of carbon build-up.
Exhaust Gas Recirculation (EGR): A fraction of the exhaust gas is filtered and re-circulated back into the combustion chamber after cooling. The formation of NO_x is reduced since the specific heat capacities of the principal exhaust components are higher than air; a lower oxygen supply also prevents the formation of NO_x.	A recent MAN Diesel experiment showed that EGR can reach 80% reduction. An EGR test on a MAN 4T50ME-X engine has verified IMO Tier III compliance by measuring an 85% reduction of NO_x at the beginning of 2011.	Literature also mentions reductions of PM, SO_2 and VOC, but these are caused by the switch from RO to MD and not by the technology itself.	Estimations of capital costs are highly uncertain.
HAM – Humid Air Motors: For humid air motors (MAN), NO_x emissions are reduced by adding water vapour to the combustion air. The air is humidified by guiding the turbo-charged and heated combustion air through a special cell	There is a wide range of percentages named by literature varying from 20% to 80%. MAN Diesel for example, mentions 40% and 65% NO_x reduction can be achieved when additional air is u s e d .	Disadvantages are the fact that the humidifier requires a large surface and volume. The HAM should be integrated in the engine itself and a humidification tower, heat exchanger and water tank should be installed.	Investment costs are relatively high due to the installations needed. There are only a few humid air motors in use, therefore cost estimations are uncertain.
CASS – Combustion Air Saturation System: water is already injected under high pressure into the inlet air right after the turbocharger. The water enters the cylinders as steam and evaporates causing the combustion temperature to reduce leading to the reduction of NO_x formation.	A 3 g/kWh NO_x level can be reached using CASS. The potential reduction of CASS is 30-60% NO_x	There are no commercial CASS applications yet.	No estimations of costs are available

MEASURE	ENVIRONMENTAL EFFECT	DISADVANTAGES/ CAUTIONS	COSTS/ NOTES
LNG – Liquefied Natural Gas: Use of Liquefied Natural Gas (LNG) instead of conventional diesel based fuels can significantly reduce emissions of all pollutants to air from ships.	Recognised potential to reduce emissions of practically all air pollutants if LNG is used in contrast to using SCR or scrubbers which reduce the emissions of only single substances while increasing the fuel consumption at the same time. For example, compared to SCR the use of LNG avoids PM, HC and SO_2 emissions.	LNG must be kept cold at ca.-160℃, therefore the handling, maintenance and distribution is more complicated and poses higher risk than traditional fuels. This places new demands on the distribution and handling infrastructure, as well as on ship design, knowledge, training	Traditionally LNG has not been traded in small quantities based on short-term contracts. This means a new set of business models and commercial arrangements will be required before the LNG marine fuel market can compete with the existing marine fuel oil market.
OPS – Onshore Power Supply: Use of OPS can reduce the amount of local emissions from ships at berth but we acknowledge that electricity generation may produce emissions of pollutants elsewhere.	OPS is particularly suitable for liner traffic spending considerable time in port. The more power that is generated onshore by renewable sources compared to on-board ships by means of auxiliary engines, the more an OPS investment makes commercial and environmental sense.	Unlikely that ship owners will take the initiative for a sector wide implementation of OPS. Society, in the form of national, regional and local government, has several instruments at its disposal for promoting deployment of OPS and other clean shipping technologies, such as differentiated port dues, tax reductions for shore based power, and grants.	OPS is a complex issue involving a large number of diverse stakeholders at various levels in society and the shipping supply chain. Although not technically complicated, the question of whether to invest in OPS or not depends on a large number of interrelated issues that ports and ship owners must evaluate, i.e. commercial viability of the investment, environmental impact, rate of utilisation as well as impacts of future emission reduction regulations on the trade.
Scrubber: Exhaust gas scrubbers can remove the majority of SO_x emissions from the exhaust stream, as well as a significant proportion of the particulate matter.	Use sea water, fresh water or chemicals to wash out or neutralise the SO_x	Various systems developed for marine use.	The discharge quality of exhaust gas after cleaning are regulated in the IMO Resolution MEPC 184(59). All scrubbers need to attain the certificate complying with the standard.
Selective Catalytic Reduction (SCR): Urea is added to the exhaust stream and the mixture passed over a catalyst.	Up to 95% reduction can be achieved. NO_x reductions are high and the use of SCR allows the engine to be tuned for minimum fuel consumption.	A number of SCR systems are in operation on ships.	The installation and maintenance costs are substantial.
Low Sulphur Fuels: The most straightforward method of reducing SO_x emissions is to reduce fuel sulphur content.	IMO MARPOL Annex VI will allow global fuel sulphur content of 3.5% until 2020, a further decade from now. By comparison, the diesel fuel used for road transport (ULSD) contains only 0.0010% sulphur by mass.	Lighter fuels, e.g. Marine Diesel Oil, Marine Gas Oil and ULSD used in some ships in auxiliary engines. MDO and MGO have lower sulphur content, down to around 0.1%.	Higher quality marine diesel fuels are available, but at a greater cost.

Source: Clean North Sea Shipping Report (March, 2014)

In its summary of the differences between the Environmental Ship Index (ESI) and the Clean Shipping Index (CSI), the CNSS Report (2014) noted that ESI and CSI are heavily influenced by the impact of exhaust gases – driven by a requirement to meet current legislation. ESI considers NO_x to be the most important factor, which is highlighted by a heavy weighting for NO_x in the index (up to 64.5%). CSI treats NO_x, SO_x and CO_2 equally. However, the three exhaust gases combined account for 60% of the total number of points available.

Observations in the same report also included the fact that economic differences also exist between the two schemes. Good ESI scores can result in actual financial rewards, as selected ports have offered discounted dues for ships with good ESI scores. The economic rewards of CSI are less obvious, with no tangible incentives offered at present; however, it is recommended that the index be used as a bargaining tool in procurement situations as it is thought that a higher CSI score will provide a greater likelihood of procuring business.

In order to calculate and assess accurately the actual environmental benefits that may accrue from the recognition of any, one, green shipping index, a far more coherent, comprehensive and science-based monitoring and reporting mechanism would be required with all the attendant costs, technologies, and skills that such methodologies imply. The variations in the criteria upon which such indices are based, the variables involved, and the diversity and multiplicity of ship types involved means that best estimate of trends is a more likely outcome of any attempted modelling and monitoring rather than absolute impacts. Such a mechanism does not exist currently in any of the ports surveyed for this study. This, however, does not mean that it cannot or should not be established. The following paragraph reports examples of source-specific monitoring that, albeit not specifically dealing with differentiated charging, could be adapted to the purpose of teasing out the impact of a relatively small variable such as a charging scheme over a complex phenomenon, such as, for instance, air quality in port area.

This in turn raises the question of the concept and approach to monitoring strategies (and several port authorities, associations and organisations have strong views on these) in terms of applying differentiated fee schemes based on such policies. Motives, charging models, liabilities and responsibilities, and port-city alliances also come into consideration. It may also be suggested that the scientific imperative of accurate, representative and meaningful data is also a highly significant. It is of course understandable that the original point of concern was the impact of shipping in the port-city area, and this remains a priority focus. As with other environmental aspects (those activities, products and services that impact on the environment), there is growing recognition of the impact and need to manage coastal areas and seas, and indeed the global perspective itself.

Whereas models can be produced to show annual NOx emissions of cargo ships in the North Sea in 2011 for the size of class 5000-10000 GT, for example, (CNSS, 2014), there are currently no equivalent measures of what the plot would represent if a percentage of the vessels were ESI- or CSI-certificated.

The transboundary nature of the overtly global impact of ship emissions challenges many of the precepts in terms of the extent to which port authorities alone can influence the sum-total impact.

5.2 Current monitoring practices and potential

The systematic checking, recording, tracking and control of situations and processes related to charging schemes is a fundamental component in the assessment of a scheme's potential and the verification of the results it may produce. Monitoring is an inherent factor in the appraisal of both economic and environmental strategies, and this section reviews current practice and potential when applied to charging schemes from the environmental perspective.

It is well-established that the major driver for the port sector's response to the environmental imperative is that of compliance with legislation and regulation. Successive EC Directives have required substantive evidence of environmental quality or condition to be ascertained for purposes of protection, planning and

consent. The port sector and shipping industry may be influenced directly and indirectly by the associated provisions. The need for reliable, science-based information and data has grown markedly during the last twenty-five years with the established adage that 'results are only as good as the data on which they are based' being confirmed time and again as decisions based on sound monitoring deliver the desired objectives confirmed by specific targets, whilst judgements founded on indefinite, inadequate or spurious data have led to disappointment in the least, or disaster in the worst scenario.

Many of the declared objectives and targets of such Directives are predicated on the identification of effective Environmental Performance Indicators (EPIs) monitored and reported by systematic programmes of investigation and analysis. The identification and selection of EPIs has grown in significance for port authorities as they are increasingly challenged to show evidence of compliance, demonstrate trends of improvement, and to provide science-based testimony in a court of law (in the event of prosecution) or in a planning application. By the same token, the extent to which EU (environmental) Directives are actively being implemented and achieving objectives can only meaningfully be assessed by reference to EPIs. Their significance to the port sector was confirmed in the EC-funded research project PPRISM (www.pprism.eu) where it was established that ports currently employ 125 EPIs (including physical, chemical, biological and socio-economic) in order to track trends of performance. Successive EC Directives and their concomitant research highlight the responsibilities, scope and options associated with port operations. A useful overview of significant Directives relevant to this study is provided by Kunnaala-Hyrkki et al (2015)[20] in which the following provisions are identified:

5.2.1 Legislative background

The Birds Directive (Directive 79/409/EEC of the Council on the conservation of wild birds) and the Habitats Directive (Directive 92/43/EEC of the Council on the conservation of natural habitats and of wild fauna and flora) and the Natura 2000 network that is based on them, can affect the ports directly. The ports can be affected by the directives for example during port development and port expansion plans.

The Port Reception Facilities Directive (Directive 2000/59/EC of the European Parliament and of the Council on port reception facilities for ship-generated waste and cargo residues) affects ports directly. The aim of the directive is to prevent and reduce the discharges of ship-generated waste and cargo residues into the sea. The main focus is in diminishing illegal discharges from ships using ports in the Community area, by improving the availability and use of port reception facilities for ship- generated waste and cargo residues, and thereby enhancing the protection of the marine environment (IMO, 2013). The cost recovery systems for using port reception facilities shall provide no incentive for ships to discharge their waste into the sea (Directive 2000/59/EC).

The aim of the Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy) is to establish a framework for the protection of inland surface waters, transnational waters, coastal waters and groundwater. The purpose is to prevent further deterioration, and protect and enhance the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems. What is relevant is the sustainable use and long-term protection of water sources. The aquatic environment is protected and improved through specific measures for the progressive reduction of discharges, emissions and losses of priority substances; and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances (Directive 2000/60/EC). The Water Framework Directive contains a large number of tasks in a variety of areas, including scientific/technical, information management, economic and administrative, which must be addressed by each member state. The directive was adopted in 2000, but there have been many amendments. (Marine Institute, 2013).

[20] Kunnaala-Hyrkki et al., V. & Brunila, O-P. 2015. Baltic Rim Economies, Corporate Social Responsibility trends in maritime logistics, Baltic Rim Economies, Special issue on corporate social responsibility, issue 2/2015, pp. 29-30.

The aim of the EU's Marine Strategy Framework Directive (Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy) is to protect the marine environment more effectively across Europe. The goal of the Marine Strategy Framework Directive is in line with the objectives of the 2000 Water Framework Directive, which concerns surface freshwater and ground water. The Marine Strategy Framework Directive constitutes the vital environmental components of the European Union's future maritime policy, designed to achieve the full economic potential of oceans and seas in harmony with the marine environment (Directive 2008/56/EC).

The marine strategies to be developed by each member state must contain a detailed assessment of the state of the environment, a definition of 'good environmental status', at regional level and the establishment of clear environmental targets and monitoring programmes. The development of strategies for the marine environment takes place in different phases. By 2015, a series of measures should be developed so as to be applicable in 2016. By 2020, the measures should result in a good state for the marine environment (Directive 2008/56/EC; ESPO 2012).

The 'Sulphur' Directive (Directive 2012/33/EU of the European Parliament and of the Council amending Directive 1999/32/EC as regards the sulphur content of marine fuels) is an example of a directive that can affect the ports indirectly. The directive from the year 1999 (Directive 1999/32/EC of the Council relating to a reduction in the sulphur content of certain liquid fuels), and the amending directives from the year 2005 (Directive 2005/33/EC of the European Parliament and of the Council as regards the sulphur content of marine fuels), and 2012 (Directive 2012/33/EU) concern the sulphur content of marine fuels. Because of the Sulphur Directive, the ports have to consider whether their port Management of Ports' Environmental Effects 13 reception facilities can be used to treat scrubber-generated waste. In addition, due to the directive, the ports have to consider whether they can facilitate the use of alternative fuels.

At the EU level, there are also provisions concerning environmental assessment; that is, a procedure that ensures that the environmental implications of decisions are taken into account before the decisions are made. Environmental assessment can be undertaken for individual projects, such as a dam, motorway, airport or factory, on the basis of the Environmental Impact Assessment, that is, the EIA Directive (Directive 2011/92/EU of the European Parliament and of the Council on the assessment of the effects of certain public and private projects on the environment); or for public plans or programs, on the basis of the Strategic Environmental Assessment, that is, the SEA Directive (Directive 2001/42/EC of the European Parliament and of the Council, on the assessment of the effects of certain plans and programs on the environment).

The newly amended Environmental Impact Assessment (EIA) Directive (Directive 2014/52/EU of the European Parliament and of the Council amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment) entered into force on 15 May 2014 to simplify the rules for assessing the potential effects of projects on the environment. It is in line with the drive for smarter regulation, so it reduces the administrative burden. It also improves the level of environmental protection, with a view to making business decisions on public and private investments more sound, more predictable and sustainable in the longer term. The new approach pays greater attention to threats and challenges that have emerged since the original rules came into force some 25 years ago. This means more attention to areas like resource efficiency, climate change and disaster prevention, which are now better reflected in the assessment process.

5.2.2 Applied examples of port responses – reasons to monitor

On the international level, environmental noise is regulated by the European Union Environmental Noise Directive, END, which was issued in 2002 (Directive 2002/49/EC of the European Parliament and of the Council relating to the assessment and management of environmental noise). The Directive is in the first place a tool for policy makers to acknowledge the environmental noise problem and to take appropriate steps to control the impacts. Noise monitoring is now carried out as a matter of course by several port authorities often in collaboration with municipalities or city organisations. Noise is consistently identified as a key issue with regard to both a licence to operate and is often a major consideration in port development planning. Instances of good practice and results of noise mapping were summarised in the NoMEPorts Project (see following). It makes noise maps and action plans against noise obligatory in bigger cities. However, it does not give guideline values for noise. Another EU directive which has relevance to the ports is the equipment noise directive (Directive 2000/14/EC of the European Parliament and of the Council on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors), which regulates the noise emissions from for instance certain types of cargo handling equipment. World Health Organisation, WHO (1999), has issued guidelines for community noise, and specific night noise guidelines for Europe (WHO 2009). The WHO (1999, 55-65) guidelines are based on thorough epidemiological studies and define values for community noise in special environments, such as dwellings, schools, hospitals and outdoors in parkland. Due to this, they are quite complicated to apply when limit values are to be set in the environmental permits. As END does not either define guideline values, the practical application of WHO guidelines takes place in each member state (Project Pentathlon, 2007-2013).

Figure 7 - Port of Hamburg – Road traffic noise (Lden). An example of noise mapping based on site-specific noise monitoring. Note that the map is for road traffic noise only

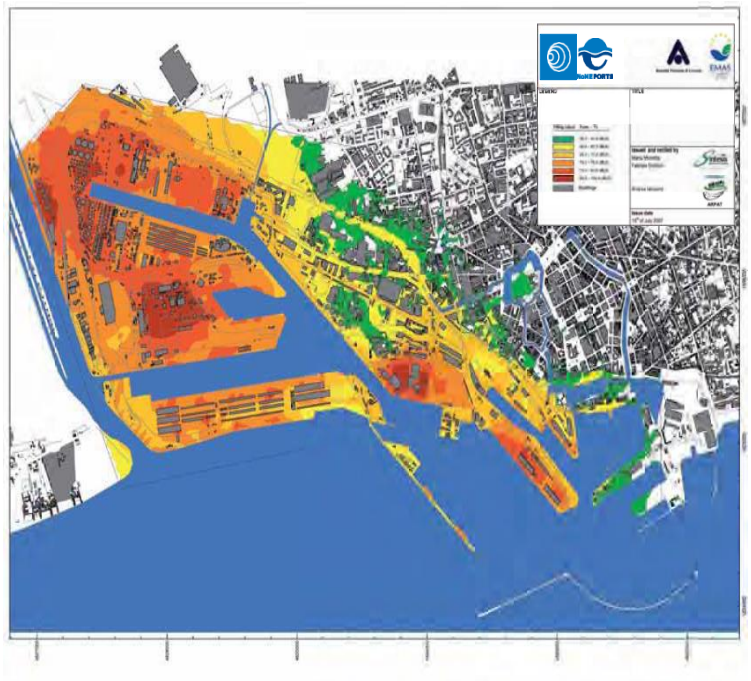
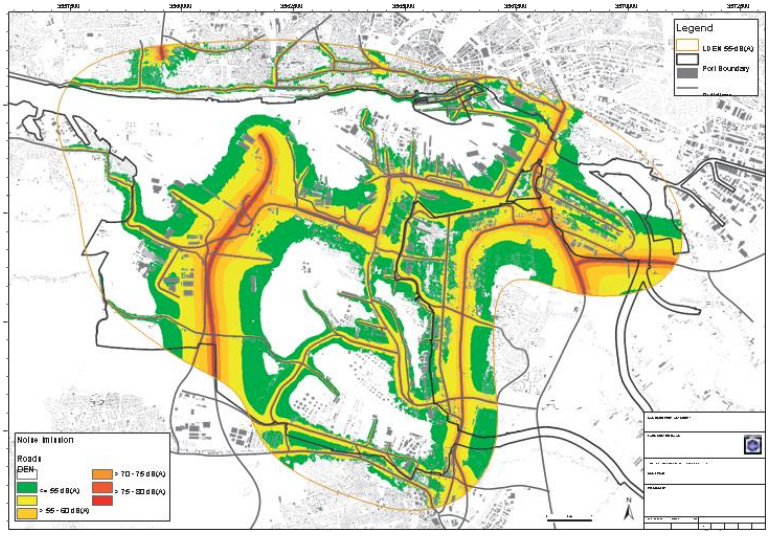


Figure 6 - Port of Livorno - All sources (Lden)



The Environmental Noise Directive 2002/49/EC (END) has several implications for those agencies and institutions responsible for the health and environmental management of port areas particularly where are part of agglomerations (part of a territory having a population exceeding more than 100.000 persons and a typical population density for urbanised area). Noise mapping for agglomerations has to consider traffic on roads, railways, and airports as well as industrial activities including noise from port areas. However, it may be advisable that ports in smaller cities or in isolated areas outside

agglomerations should be mapped to help these ports to get a reliable basis for discussions with urban planners trying to plan residential areas in the direct vicinity of the port area, or to assist planning applications for port development (NoMEPorts, 2008).

This Project also identified additional considerations that may be taken into account, for instance, a monitoring system which measures the noise on the terminal as well as the residential area, and alerts the operator when the reference value is exceeded. The results of the measurements can be documented and evaluated regularly, and used to monitor and respond to complaints. The maps give some indication of the complexity of noise mapping in terms of identifying and measuring propagation from a variety of sources that may include residential, industrial, port activities, road and rail traffic, and shipping. The maps also demonstrate that collaborative research programmes involving port authorities, research institutes and professional consultancies can deliver meaningful and well-founded results on the basis of systematic monitoring. In many instances, world-wide, the challenge is to sustain or up-date the monitoring programmes once the research project is completed and budgets spent.

As described in the Project Pentathlon (2007-2013) there are efficient noise abatement techniques available for most noise sources, but their feasibility is always a financial question. In environmental justice, the 'polluter pays' principle is widely accepted, and it is also embodied in the European Union Liability Directive (Directive 2004/35/CE of the European Parliament and of the Council on environmental liability with regard to the prevention and remedying of environmental damage). To be a noise polluter means a responsibility to pay for the needed noise abatement measures. In the environmental permits of the ports, the port authority or the port company is considered to be the 'polluter', regardless if the authority has the control of the polluting activities or not. In some cases, the definition of the polluter is not too clear. This is especially the case when it comes to noise from vessels. All the ports in the Pentathlon Project are using external stevedoring companies for cargo handling operations. Therefore, the port authority is obliged to monitor the environmental performance of the port operators and other port-related businesses within the port premises, and also to take measures to secure that the conditions of the environmental permit are followed.

The Polluter Pays principle is widely accepted. The question is the definition of the polluter, and there are no self-evident answers to it. The starting point of environmental permits is that ports are responsible, but drawing the limits of liability is no easy task for permit authorities. The main problems are noise from vessels, from the road and street traffic, from stevedoring activities and noise-isolation of the nearby buildings.

The Clean Air Programme for Europe[21] focuses on measures to ensure that existing targets are met in the short term, and new air quality objectives for the period up to 2030 were announced in 2013. The package also includes support measures to help cut air pollution, with a focus on improving air quality in cities, supporting research and innovation, and promoting international cooperation.

The clean air policy package updates existing legislation and further reduces harmful emissions from industry, traffic, energy plants and agriculture, with a view to reducing their impact on human health and the environment. Air pollution also causes lost working days, and high healthcare costs, with vulnerable groups such as children, asthmatics and the elderly affected the most. It also damages ecosystems through excess nitrogen, pollution (eutrophication) and acid rain. The direct costs to society from air pollution, including damage to crops and buildings, amount to about € 23 billion per year. The benefits to people's health from implementing the package are around € 40 billion a year, over 12 times the costs of pollution abatement, which are estimated to reach € 3,4 billion per year in 2030.

The monitoring of air quality is consistently a priority issue for port authorities according to the EcoPorts Network (www.ecoports.com). The monitoring of air quality epitomises the challenges of measuring dynamic, trans-boundary parameters and the benefits of a collaborative approach. Ports try to estimate how much air pollution they cause and in which proportions in order to set up a plan to reduce air

[21] http://ec.europa.eu/environment/air/clean_air_policy.htm

pollution. With an 'emission inventory' as a first step, specifically determined emissions of a port such as NO_x, SO_2, VOC, PM_{10} and $PM_{2.5}$ are calculated and attributed to different sources such as ocean-going vessels, harbour vessels, cargo handling equipment, locomotives and vehicles. An inventory provides a baseline from which mitigation strategies can be created, developed and implemented, and on the basis of which the performance and success of the port in reducing its emissions can be tracked over time (Clean Air, 2015).

Emission inventories have been issued for several American ports such as Corpus Christi, Beaumont/ Port Arthur, Houston/Galveston, Los Angeles, Long Beach, Oakland, New York/New Jersey and Portland by consulting companies such as Starcrest, Environ, ACES and Bridgewater that also consult other major ports worldwide. It is reported that the Polish ARMAAG Foundation runs air pollution measurement stations in the area of the 'tricity' Gdansk, Sopot and Gdynia. They state that the ports in Gdynia and Gdansk contribute 9,7% and 7,3% respectively to air pollution in the region of the three cities.

The Antwerp Port Authority (APA) has conducted an emission modelling project for ocean-going vessels as part of the INTERREG-subsidised project Clean North Sea Shipping (CNSS, 2014) in order to get a more accurate view of ship emissions. In order to calculate detailed ship emissions even for single ships and their spatial distribution within the port area at different times a sophisticated model system (called EMPORTANT) has been developed under the leadership of Antwerp Port Authority. The model was originally configured to fit to the terrain of the port of Antwerp. It is implemented as a web application that is freely available and well documented, so that it can be adapted to any other port. Further requirements to use this model are Automatic Identification System (AIS) data for the specified region and time episode as well as ship characteristics of the vessels visiting or operating in the port of interest. One of the major advantages of this sophisticated model approach is that emission scenarios can be calculated taking any technological and legislative developments into account.

The EMPORTANT model makes use of AIS data to derive ships' activities within the port (sailing, in lock, mooring and at berth). In combination with a database of ship characteristics using a set of specific emission factors, the model estimates ship emissions over a certain time or a certain area. The ship characteristics data, such as length, width, draught and engine power, originate from Lloyd's Register (IHS Fairplay). In the case of the Port of Antwerp these activity data are supplemented with their own registrations in Antwerp Port Authority's (APA) database APICS. Provided that AIS data are available in high resolution, the model can readily calculate emissions for 250m x 250m geographic grids that are typically used for advanced urban air quality models (See pages 26-29 inclusive of CNSS Final report, 2014, for figures of detail.

In CNSS, model systems with different complexities have been applied and tested for their suitability to quantify the effect of shipping on the concentrations of pollutants in the atmosphere at city scale. To illustrate the impact of shipping in port areas, it is important to use models that can tackle higher resolutions than can be achieved by regional models. Therefore, the Operational Priority Substances 1 model, which is routinely used in the Netherlands and Belgium, was applied to the region of Rotterdam.

The Operational Priority Substances model, though lacking atmospheric chemistry routines, is capable of modelling yearly averaged concentration levels at a resolution down to 0.5x0.5 km². NO_x and PM concentrations can be modelled. In the specific case of Bergen, the Operational Priority Substances model is less appropriate due to the complex topography of the city's surroundings. Therefore, the Aermod2 model, that can handle complex terrain, was applied.

High resolution modelling also requires highly detailed emissions from the sources to be considered. This turns out to be one of the major constraints to the applicability of the models and the validity of the model results. In the case of the Port of Rotterdam area, sufficient data is available for the use of the Operational Priority Substances model. The emissions from different sectors (industry, road traffic, consumers, shipping etc.) are available at a sufficiently high level of detail. Industrial emissions can usually be given as point sources and more diffuse emission sources, such as road traffic and households can be supplied to the model as area sources, usually ranging from 1x1 km^2 (i.e. traffic) to 5x5km^2 (i.e. surrounding agricultural emissions).

The purpose of referencing the results of the above, specific projects is to illustrate the fact that modelling and monitoring (the two techniques are necessarily linked in terms of data acquisition, validation of results and forecasting) at this level of detail are inherently specialist in application, analysis and interpretation, and expensive in technology and support skills.

Another example of collaborative monitoring in the context of an industrialised port area is provided by Port Talbot (UK). It is recognised that elevated PM_{10} concentrations are linked to the industrial activities in the Port Talbot area, which are dominated by a major steelworks. There are numerous industrial operations taking place across the industrial area including the individual processes involved in the steel-making, as well as related operations using the by-products, and it is still unclear which of these are the principal contributors to the elevated PM_{10} levels. The attribution of sources remains unclear even after numerous measurement and analysis programmes extending back over a decade.

Figure 8 - Port of Talbot - Locations of PM_{10} monitoring sites

Red dots indicate current sites. Green dot indicates former site. 1) Docks (NPTCBC), 2) Talbot Road (NPTCBC), 3) Theodore Road (NPTCBC), 4) Margam (AURN - fire station), 5) Prince Street (EAW), 6) Groeswen (AURN – hospital), 7) Twll–yn-y-Wal Park (NPTCBC), 8) Dyffryn School (NPTCBC), 9) Coastal Site (Tata). NPTCBC = Neath Port Talbot County Borough Council, EAW = Environment Agency Wales. (Contains Ordnance Survey data © Crown copyright and database rights 2011).

This example is relevant to the study because it demonstrates the task of identifying sources and impacts when a port is in close juxtaposition with an urban complex. Considerations of safety, health and environment inter-play in a complex where sampling site selection, appropriate technology, meteorological conditions, and temporal and spatial variations in industrial activity produce multifaceted scenarios.

The Group recommended that a priority for further work should be to model the impact of all the sources within industrial complex on PM_{10} concentrations observed in Port Talbot. The modelling should have an hourly resolution covering the whole year, with the results verified by comparison with the monitoring data. There would be a need for close linkage between the modelling and the emission inventory, with feedback from the modelling used to highlight areas for improvement within the inventory. The modelling should allow for terrain effects on wind flow and dispersion, which would require a model domain extending beyond the immediate vicinity of the site to include the hills to the east. The modelling should also consider buildings, in so far as they will affect initial dispersion (not wind flow); both these effects can

be accounted for in readily available dispersion models. It also recommended that an initial dispersion modelling exercise should be carried out using readily available information on emissions from all sources, which can be supplemented over time with a more detailed time-resolved emission inventory. It recognised that some components of the inventory would be difficult to quantify with a high degree of accuracy, but this should not constrain the development of an initial best possible inventory using available information.

Even though not promoted by port authorities in the first place, another interesting example of collaborative monitoring can be found in the APICE project (2010-2013)[22]. The general objective of APICE was to pinpoint concrete actions to lower emissions and mitigate air pollution in harbour cities, while preserving economic potential of coastal areas. Five habour cities were involved in the project: Barcelona, Marseille, Genoa, Venice and Thessaloniki. Two specific objectives of APICE are germane to the discussion on the importance of monitoring and its effect on environmental charging:

1. Pinpointing, through monitoring campaigns and models, the relative contribution of several pollution sources to the air quality in the project harbour areas, understanding the differences and similarities among the selected areas, and designing future environmental, economic and urbanisation policy-scenarios.
2. Facilitate and promote voluntary agreements among local administrations, port authorities, ship owners and cargo handlers (like differentiated dues, kilometres charges, blue flag & tradable emission permits) that can concretely contribute – in the medium term – to curbing emissions and improve the environmental balance of the coastal communities without affecting the economic growth potential of harbours districts.

In other words, APICE wanted to demonstrate that, albeit costly and technically challenging, it is in principle possible to set up a monitoring scheme that can apportion air pollutant emissions to several sources, based on inter-comparison between different datasets. This task was carried out by a scientific group following two different techniques of Source Apportionment analysis, based respectively on receptor models and Chemical Transport Models (CTMs). In each studied area, a long air pollution monitoring campaign, with aerosol measurements and chemical speciation, was carried out. A common feature was the choice to monitor two or more sites in each urban area, having different exposures to emission sources. In every city, at least one site was more exposed to maritime emissions (from harbour terminals or at least from ship traffic), one site was urban background and possibly one place more exposed to surrounding industrial area. The long monitoring campaigns in each study area produced a quite detailed picture of PM composition and sources. Unfortunately, despite being mentioned as one of the objectives of the study, no conclusions on the effectiveness of 'differentiated dues' were put forward in the final report[23].

Even though no results are available at the time of writing, it may be worth looking at the Clean Inland Shipping project (CLINSH). In the framework of this project, which however focuses on inland shipping, Dutch, Belgian, German and English public and private organisations will work together to improve air quality in urban areas by accelerating emissions reduction in Inland Waterway Transport, this being a major source of air pollution.

Funded by the European LIFE Programme, the project started in September 2016 and will run until August 2020. The performance of various emission reduction techniques, alternative fuels and onshore power supply will be tested on 30 ships. Before and after these adjustments, the ships emissions (NO_x and PM) will be monitored in real-life conditions.

Measurement results will be collected in a database that will provide local, regional, national and European governments with a tool for (new) policies on the greening of waterways. In addition, according to the

[22] Funded by the European Programme for Territorial Cooperation MED 2007/2013. Official website: www.apice-project.eu

[23] http://www.apice-project.eu/img_web/pagine/files/Publication/Final%20Publication.pdf

CLINSH consortium, their data will provide skippers with more insights into the most cost effective environmental measures for their ship.

Again, the multiple-agency involvement, the challenges of scientific precision, and the implicit costs are major factors for consideration in developing and operating any, comprehensive monitoring programme. These cautions need not necessarily prohibit effective monitoring, but they do suggest that a pragmatic approach based on best available scientific technology set within a realistic business plan is essential. In essence, a collaborative approach involving all stakeholders is most likely to produce a practicable monitoring programme.

5.3 Environmental assessment of the impact of waste as a factor in charging schemes.

The issue of waste is consistently identified as a priority topic throughout the European port sector, and its perceived significance in terms of compliance with legislation and cost implications are reflected in the number of ports that declare that selected aspects of waste are routinely monitored and reported. The importance of waste from the points of view of potential direct impact to air, water, soil and sediment; the issue of sustainability, use of resources, recycling, and as an option for models of differentiated charging is widely recognised.

Systematic and on-going research and investigative programmes by individual port authorities, port organisations and groups such as the European Sustainable Shipping Forum through its Sub-group on Port Reception Facilities has produced a wealth of information on current and other possible models of charging whereby selected components of waste management may be recognised as qualifying criteria for reduction in fees.

Directive 2000/59/EC on port reception facilities and the studies on cost recovery systems in EU ports have been the catalyst for focusing sector experience and perspectives on the models of charging schemes that are, or could be applied to achieve improvements in environmental quality throughout the port area and its environs. Papers, reports and meeting presentations demonstrate the range and scope of the technical, economic, organisational and administrative complex that constitutes the operational regime of port reception facilities (PRF).

A sector-wide review indicates that there is widespread consensus on many of the major issues in terms of approach, objectives and cautions. Considerations include the polluter pays principle, the provision of an incentive not to discharge waste at sea, the payment of a significant contribution to the provision of PRF irrespective of use (clarified in 2000 to be at least 30% of the cost of providing PRF), ensuring the fees are fair, transparent, non-discriminatory and reflect the costs of the facilities and services; and transparency of costing and implementing all figure strongly in sector-based statements.

As with the study on air quality as a factor in differentiated charging, the data and information available for assessment of any economic benefits is far more available than any direct, quantified measures of actual benefits or enhancements to the physical environment itself.

It is interesting to note that although the degree of harmonisation between the current charging models and their application is restricted and far from common-place, there is widespread agreement on the cautions and challenges currently experienced by the sector in this regard.

Recurring comments relate to:

- Relationship between fees and costs remains unclear and lack of transparency as regards the basis of calculation and whether the funds collected are used to cover the costs of PRF.
- Availability of reliable data is limited.
- Role of the port authority differs between EU ports.

- Cost is not everything; good, adequate and easy service is just, if not more important.
- In the case of transparency, bilateral arrangements between the ship and a waste contractor are market-driven. Waste contractors may wish to keep their rates confidential from each other, but they necessarily divulge them to the ship.
- Annex II of the PRF Directive is acknowledged as not being entirely in line with MARPOL (this issue has been responded to in ESSF/PRF Minutes).
- Harmonisation of procedures and operational timescales.
- Importance of Interpretative Guidelines (important for clear understanding and 'level playing-field').
- The challenge of data gathering and the current gaps in knowledge due to the significant differences in procedures, qualifying criteria and the range of factors and parameters involved.

Other concerns include:

- 'PRF shopping' effect.
- Depending on the scheme applied, the economic impact on the Port Authority may be unbalanced and unpredictable depending on the type of traffic, seasonal flux and market trends and degree of competition.
- Challenges of dealing with hazardous waste in No Special Fee (NSF) schemes.
- There may be additional administrative burden for the port (e.g. extra control of operators to ensure quality of service).

The planned legislative revision of the Directive will address the main issues identified in the Evaluation (Update on the revision of Annex II and the IA process for the overall legislative revision ESSF-PRF Subgroup, Brussels, 1st of October, 2015) including:

- Adequacy and availability of the facilities.
- Efficient incentives to increase the delivery of waste to PRF.
- Improve level playing field for ports and port users.
- Decrease unnecessary administrative burden.
- Further harmonisation and update of forms/definitions.
- Remove barriers to effective and efficient enforcement.

ESSF/PRF documents outline the principles and structures currently in place and in broad outline they consist of:

1) No Special Fee Systems, which do not openly state how the 30% issue is covered. All ships pay the same fee irrespective of how much they land. The Fee covers all costs of the port in planning PRF and managing the waste
2) Direct calculation (partial NSF) – the port calculates all costs, divides them between the number of users of the port and then ensures that the actual fee paid by ships is more than 30% of this figure
3) Two-element system (fixed costs) – Total costs are calculated, divided between number of users – 30% of that figure becomes a set element of the fee with a second element based on fixed costs charged for disposal of the waste.
4) Two-element system (direct costs) – Total costs are calculated, divided between number of users – 30% of that figure becomes a set element of the fee with a second element based on the variable costs for disposal of the waste.

ESSF concludes[24] that the principles have been interpreted in significantly different ways and that the methods applied are so integral and linked to the CRS that they may be considered difficult to harmonise.

In conclusion, the Rapporteur (ESSF/PRF) states that "the CRS system structure is not the issue and it has become obvious that one CRS cannot fit the myriad of port waste structures in the EU. Harmonisation of the principles of the Directive in all CRS is needed so that they provide similar incentives and conditions to ships visiting EU ports".

Detailed insights into some of the various models applied including details of fee structure, rates and examples are given in presentations by port representatives as part of the ESSF/PRF study. The pro-active and innovative methods presented include some examples of cost calculation and the cost/benefit within the business plan of the port. Some results of the apparent impact on the commercial profile of the port and the quantities of waste involved are given in a few cases where trends related, for example to waste delivery (Annex 1 and Annex V), waste delivery/annum Annex IV (m^3) total waste delivered/annum (m^3), number of ship calls, ship capacity, and delivery per Annex and ship type may be traced post-CRS coming into force. However, the actual environmental impact of the application of such systems can only be surmised from the inferred interrelationships between cause and effect of the wide range of factors involved in the production, handling, storage, processing and final form or destination of the materials involved as they affect the quality of the environment.

With respect to waste, a general observation of the sector is that, in terms of monitoring fluctuations in waste delivery over time, the actual figures do not seem as significant to the port authorities as the provision of efficient and acceptable services provided by the waste operators. Much of the management is carried out by shipping agents and private, or external operators.

The fact that the ports receive information after the waste handling has taken place (often through monthly reports/statistics) also indicates that their interest in the actual figures is limited. Although the flow of information and statistics between the Port Authorities and the Port State Control (PSC) is not systematic, most ports confirm that when the monitoring and control by the PSC is reinforced the waste delivery behaviour of the ships changes towards a more environmentally friendly and sound behaviour.

In terms of data-gathering, there is apparently no clear relation between waste delivery and the applied waste notification/information system. This is explained by the fact that in many ports, direct contacts are made between shipping agents and external waste operators often bypassing the official notification system and it is therefore difficult to identify any relation to the delivery behaviour.

Albeit not strictly related to environmental charging, the inherent difficulties in monitoring waste have also been recognised in EMSA Study on the Delivery of Ship-generated Waste and Cargo Residues[25]:

"With regard to the volume of SGW and CR delivered, then this figure can be influenced by several factors, such as:

- Traffic to the port;
- Ship size and type of the ship calling the port;
- Maintenance level of the ships calling the port;
- Sailed distance from previous port where waste was delivered;
- Availability of PRFs;

[24] European Sustainable Shipping Forum, 3rd Meeting of the Sub-group on Port Reception Facilities, Brussels 1st October 2015, Meeting Minutes.

[25] Ohlenschlager J. P. and Gordiani G., Study on the Delivery of Ship-generated Waste and Cargo Residues, EMSA, 2012. Available at: http://www.emsa.europa.eu/emsa-documents/latest/download/1972/1607/23.html

- Simplicity for the ship/agent to deliver waste e.g. “one-stop shop” or whether the agent has to deal with several waste operators;
- Price level for the waste collection services;
- Implementation of a cost recovery/fee system which provides incentive to deliver waste in the port;
- Efficiency of the waste collection system in the port;
- Design of the waste notification system;
- Type of port operations; and monitoring and control functions in the port, e.g. on waste notification systems and garbage record books.

Given all these factors and taking into consideration the results from the analysis, it is not possible to say specifically which of the above-mentioned reasons have affected the increase or decrease in the waste volume delivery in the European ports analysed for this study. It is also not possible to make any reliable statistical analysis of the relation between the waste volume delivered and the factors influencing the ships’ behaviour based on the figures provided by the individual ports in the study.

Furthermore, some waste volume figures do not cover the total waste handled in the port as figures from some individual waste operators are not included. Moreover, due to the high number of factors influencing the waste delivery behaviour, it is also very difficult to conclude on factors influencing the delivery behaviour to PRF when analysing the waste volume figures provided by the individual ports. All ports, except one, provided figures for waste “actually delivered”, one on what was “notified”. One port provided both figures. It is therefore not possible to conclude whether the notified figures were higher or lower than what was actually delivered”.

The findings of EMSA’s Study may contribute to explaining why, although a certain number of EU ports have set in place differentiated charging schemes addressing air quality, only few of them seem to reward green ships in relation with waste generation and management (for more details, please see Section I, § 3 of this Report).

To this purpose, special focus should be given to the criteria for applying reduced waste fees to “green ships”. In its Directive 2000/59/EC, the EU Commission highlights that “ships producing reduced quantities of ship-generated waste should be treated more favourably in the cost recovery systems. Common criteria could facilitate the identification of such ships” (Preamble 15), and that “fees may be reduced if the ship’s environmental management, design, equipment and operation are such that the master of the ship can demonstrate that it produces reduced quantities of ship-generated waste” (Article8 (c)).

The principle in itself is quite clear and seems to encourage a form of ‘environmental charging’ that is in line with the scope of this study. Nonetheless, as noted in Section II of this Report, during the survey of environmental charging schemes in EU ports, it clearly emerged that, while many ports quote word by word Article 8(c) of the PRF Directive in their official fee documents, only few of them dictate specific criteria as to how ‘green ships’ may actually be rewarded with lower fees.

It may be argued that the lack of specific criteria descends from the very nature of the directive, which – as normally happens – leaves Member States with a certain amount of leeway as to the exact rules to be adopted. However, in this specific case, the lack of common qualifying criteria to define a green ship risks jeopardising the attainment of the objectives set, as testified by the relatively low number of schemes on waste.

The same problem also emerged during the second conference with stakeholders held in January 2016 for this Study. Several port authorities recognised that the inherent vagueness of the PRF Directive when it comes to green ships is conducive to uncertainty and lack of uniformity, which may ultimately distort competition. Hence, the same port authorities declared they would welcome the introduction of common criteria or minimum requirements in the forthcoming revision of the PRF Directive, without prejudice to leaving Member States free to apply more stringent national measures.

Similar considerations were being put forward in 2005, when the EMSA decided to finance a study to "obtain an inventory of the green technologies (available and prototypes), the management systems and the incentives already existing to identify criteria and propose to the European Commission Guidelines that could be used in cooperation with Member States in defining environmental performance of a ship and to establish a basis for incentive schemes that contribute in making 'green shipping' profitable"[26].

Although the baseline data and information of the EMSA Report reflects the state-of-play and thinking in 2005, many of the principles and options identified have stood the test of time and remain germane particularly with respect to several measures to make a ship 'greener', which go beyond the regulatory requirements, namely:

- Technology, which is the pre-condition for clean shipping. This includes a broad range of technological developments, ranging from new materials, more efficient propulsion, catalysts, to innovative hull design, etc.;
- Best operational practice and/or management systems, as awareness rising has to go in line with the technical development in order to be effective;
- Compliance with environmental best practices, proven by documents and international certificates (e.g. EMAS, ISO 14001);
- Financial or other instruments as incentives to encourage "clean" shipping.

While the first three bullet points cover measures that fall outside the scope of this study, it may be interesting to look at the findings of EMSA's study after eleven years, and establish what has been achieved since then, as well as whether and to what extent the considerations put forward still hold true.

The incentives systems considered in EMSA's study are essentially four:

- Green Award
- The Bonus / Malus System
- U.S. Coast Guard – Qualship 21
- Blue Angel

Green Award, bonus / malus, and Blue Angel are analysed in this study as well, while Qualship 21 falls outside its scope, as it is implemented in the US.

Other initiatives such as the Environmental Ship Index and the Clean Ship Index – which are also analysed in this Report – were not included in EMSA's study as they had not yet been launched at the time of writing.

The study noted that, at the time of writing, a wide range of "green shipping" initiatives existed, but only few of them were compatible with the objective of producing reduced quantities of ships generated waste. Most initiatives considered focus on 'air quality' more than they do on waste. For the sake of consistency with the title and scope of the study, they are reported in this section, although several considerations put forward in the EMSA study do not specifically address waste.

As far as the Green Award is concerned, EMSA's study outlined the following pros and cons:

[26] Study on Ships producing reduced quantities of ships generated waste – present situation and future opportunities to encourage the development of cleaner ships, EMSA /OP/05/05, 2005.

Table 18 – Pros and cons of Green Award, according to EMSA study

Pros		Cons	
EMSA Study	**Today**	**EMSA study**	**Today**
Complex awarding criteria covering a broad range of different aspects of pollution	Still holds true. Compared with other initiatives analysed in the framework of this Study, Green Award stands out as a comprehensive certification. It is worth mentioning that Green Award is imminent to release a revision to its certification criteria on environmentally-friendly waste management, as announced during the conference hold in January 2016 for this Study	*Complicated, surveyors need a special training before auditing*	True, but its classification as a con may be controversial. As discussed in the conference that took place in January 2016 for this Study, verification of results is of absolute importance when granting incentives to ships. Otherwise, the incentives could evaporate without thorough checking of the criteria (see also Recommendation #12 in the third section of this report).
Well-known internationally	Still holds true.	*Limited to tankers and bulk vessels only*	Still holds true
Monetary incentives are provided	Still holds true. As emerged from the inventory carried out in the first phase of the Study, several environmental charging schemes in the EU are based on Green Award's certification levels	*Limited geographical application: certified vessels get discounts in participating ports only*	Still holds true, although in principle valid for all other systems as well. In the framework of 'voluntary implementation' of environmental charging, only participating parts will offer rebates. Furthermore, the number of participating ports has expanded considerably in the last few years.

When it comes to bonus / malus system, EMSA's study mainly refers to the Swedish system of fairway and harbour dues. Recognising the need for abatement measures at sea, the Swedish Maritime Administration, the Swedish Port and Stevedores Association and the Swedish Shipowners Association in 1996 arrived at a Tripartite Agreement to use differentiated fairway and harbour dues to reduce emissions of NO_x and sulphur by 75% within five years. The parties concluded that vessels engaged in dedicated trade and other frequent vessel traffic involving Swedish ports, regardless of flag, should reduce emissions of NO_x by installing SCR or other cost-effective NO_x abating techniques.

Sweden was the first EU Member State to introduce differentiated port and fairway dues. Regardless of the specific solution adopted[27] – which may not necessarily be applicable in other EU Member States – the Swedish system is considered a success example. Without entering into the details, one of the success factor was certainly the cooperation of actors with different objectives toward a common goal. During this Study, some ship owners, albeit in favour of environmental charging, lamented that they are not consulted by port authorities in the decision-making process. If all the actors involved cooperate, it should be easier to reach the desired results.

The system is intended to be revenue-neutral. Therefore, it results in higher dues for some ships and rebates for others; the rebates are intended to compensate ships for the higher operating costs resulting from their emission control measures.

Table 19 – Pros and cons of the Swedish system of fairway and harbour dues according to EMSA study

Pros		Cons	
EMSA Study	**Today**	**EMSA study**	**Today**
High environmental benefits with regard to reduction of air pollutants	Still holds true, although in the meantime the establishment of the SECA area has comparatively reduced the effect of the scheme on SO_x	*Limited to air pollution only*	True for fairway dues, but not true for harbour dues which also consider waste and wastewater.
High monetary incentive for high standard vessels	Still holds true. In our study, it emerged that incentives need to be financially significant to persuade ship owners to 'go greener'.	*Vessels of lower standard pay a "malus" thus paying more on fairway and in the port than the service provided is worth*	During our study, it clearly emerged that, generally speaking, both ports and ship owners do not receive malus-based schemes favourably. For further details, please see the case studies findings in Section 2 of this Report.
Very transparent system	The Swedish model can be considered as a benchmark as far as cooperation of different actors towards a common goal is concerned		

During the conference with stakeholders held in January 2016, it was announced that that the current model will be changed starting from 1 January 2017, as a consequence of the sulphur regulation. Swedish ports and the Swedish Maritime Administration are also looking into existing indexes and initiatives to revise the current system. In this way, a third party will be in charge, thus lowering operating costs. The scheme chosen will have to be simple and reliable.

Finally, pros and cons of Blue Angel are reported in the table below:

[27] While differentiated port dues in Swedish ports have been analysed in the first phase of the Study, for more details on the fairway due system (which is outside the scope of this study), please see Kågeson P., Economic instruments for reducing emissions from sea transport, AIR POLLUTION AND CLIMATE SERIES NO. 11 / T&E REPORT 99/7, 1999. Please also see Ljungström T., The environmental differentiated fairway dues system, Swedish Maritime Administration, 2010.

Table 20 – Pros and cons of Blue Angel, according to EMSA study

Pros		Cons	
EMSA Study	**Today**	**EMSA study**	**Today**
The label awarding criteria are very flexible: 10 binding and 20 optional requirements listed	The number of mandatory and optional requirements has obviously changed, but the principle remains the same and ensures a high degree of flexibility.	*The award criteria are not applicable to all ships: tank ships carrying products as defined in MARPOL Annex I and II (i.e. oil tankers and product carriers, chemical tankers, gas carriers), ships coming under the High Speed Craft Code, fishing vessels, recreational ships and navy ships are not included.*	No longer true for tankers
Criteria are applicable to existent and new ships as well as to different ship types	Still holds true		
Management instruments as well as social conditions, operation and technology are covered	Still holds true		
Each Blue Angel ship emits only half of its previous SO_x-emissions (by obligation) or even about 85% less (optional). The NO_x-share of international shipping in global emissions is estimated at 11 to 13 %, i.e. about 9,3 million tonnes NO_x per year and thereof ca. 1,94 million tonnes in the Northeast Atlantic. Here individual emissions will be reduced by 20% (obligatory) or by more than 50 % (optional)	Not relevant for waste		

As reported above, two more indexes analysed in this Study were not considered by EMSA study. The Environmental Ship Index is not relevant for waste, as it only covers air emissions. The Clean Shipping Index, on the other hand, also include criteria for the use of chemicals, how carriers take care of their wastes on board, and how they treat different discharges to water, such as sewage and ballast water.

Furthermore, there are other considerations put forward in EMSA's study that were confirmed by this Study on differentiated charging:

Incentives are either monetary or non-monetary. Examples could be: positive criteria for Port State Control, good publicity, which leads to better image in public or more charter orders, lower insurance costs, differentiated harbour dues, etc.

The importance of non-monetary incentives is considered in the economic assessment, as enhanced image ultimately yields benefits for ship owners that accrue on top of incentives distributed through rebates. It is nearly impossible to quantify these benefits, although the stakeholders interviewed during the studies are all inclined to agree that they do exist to some extent.

It is often difficult to quantify the benefits of such "clean ships" initiatives, as direct environmental and economic advantages are at times difficult to substantiate.

This challenge emerged clearly when conducting the case studies and the environmental and economic assessment.

Basically, there are only two alternative strategies to achieve desired results, either to impose European normative rules stricter than international standards or to offer commercially interesting solutions. The first alternative would be mandatory for everyone and therefore will be most effective, the second one would be voluntarily and needs to be commercially convincing to achieve a significant participation.

This statement still holds true. A mandatory approach has the advantage of establishing a level playing field (same rules, or at least a basic set of common principles, valid for all ports) and setting the conditions for ship owners to cumulate rebates across different ports in the EU (see Section II - § 6.1 for more details). At the same time, however, one should also consider that, in the panel discussions held for this study, several port authorities declared they would not favour the introduction of regulatory instruments to address environmental charging, lest these might be too prescriptive and not take into account the heterogeneity of the EU port sector. The challenge would thus be to strike an appropriate balance between the need for common rules, which would undoubtedly benefit the shipping industry and strengthen the effectiveness of environmental charging, and the necessary flexibility that the port sector demands.

All things considered, albeit dated, many of the findings of EMSA's study on ships producing reduced quantities of waste are still valid today. This is particularly evident considering that, as reported above, only few ports in the EU actually offer rebates to ships producing reduced quantities of waste, as suggested by Article (8) of the PRF directive.

In view of the forthcoming revision of the PRF directive, it may be useful to link the findings of EMSA's study with the knowledge gathered during this study on environmental charging. The lack of common criteria to define what a green ship is was already acknowledged 11 years ago, and still remains a major challenging that seems to be limiting the effect of Article 8(c) of the PRF directive.

The lessons learned from our study suggest that the situation could be improved in the future if:

- A set of minimum requirements are defined at EU level to establish when a ship can be considered 'green' in terms of waste management. The requirements should be sufficiently clear and detailed to allow for an easy definition, but at the same time should give the necessary leeway to Member States and port authorities for defining their incentive systems based on their special needs and characteristics. This is closely linked with the statement quoted above, according to which rules mandatory for everyone would be more effective.
- Considering the inherent difficulties to establish what is a green ship, it may be useful to rely on existing indexes and certifications, which are perceived as reliable in the shipping sector. With the

benefit of 11 years' hindsight, today it is possible to note that their uptake has increased spontaneously to the point that environmental charging in the EU revolves almost entirely on third party certifications and indexes, for the reasons mentioned in the case studies summary.

- Whatever the system adopted, it should be easy and transparent to implement. Certifications and indexes tend to reduce the workload for port authorities and ship owners, while the Swedish example of stakeholder consultation might serve as a useful model for transparency.
- While ports should remain free to design their incentive mechanisms and assign a budget that it is compatible with their resources, it should be emphasised that the incentives need to have a certain monetary significance to be effective.
- At the same time, since there may also be benefits in terms of positive image, it may be useful to take the necessary measures to make sure that green ships are duly acknowledged as such.

Whether the above considerations should feed into the revision of the PRF Directive it is not for this study to establish. What clearly emerged throughout this study, however, is that there still seems to be an inherent difficulty in accurately interpreting and taking into account in a concise fashion the provisions of Article 8(c) of the PRF Directive. It may be considered ill-advised to dictate criteria that are too stringent, bearing in mind the diversity of the EU port sector, as their effect would probably be counter-productive and rejected by the industry. Nonetheless, more precise guidelines inspired by the above-mentioned considerations may make it easier for port authorities to reward green ships without prejudice to competition across ports.

5.4 Towards an environmental assessment of green charging

As stated previously, the case studies developed in the second phase of this Study have revealed that virtually no port is currently monitoring the impact that their green charging schemes have on the surrounding environment.

Such a complete lack of data can be attributable to several factors. First of all, monitoring of the impact of charging schemes on environmental quality *per se* is not yet established, because the practice of differentiated charging itself is not a sector-wide requirement or considered to be an appropriate option for all ports.

At the same time, it should be noted that the examples from the port of Oslo (p. 65 et seq.) and project APICE (Section II - 5.2.2) show that it is possible to at least estimate emission inventories in ports, which could be particulary useful to assess the environmental impact of differentiated charging.

This lack of data seriously challenges the evidence available on the effectiveness of environmental charging itself, in that it does not allow an assessment of its impact on certain significant environmental aspects, which is ultimately the very *raison d'être* for establishing such a practice in the first place. This is not to argue that environmental charging is an ineffective practice *per* se, but if ports are not able or not willing to determine whether, or to what extent a green charging scheme yields benefits for the environment in terms of reduced pollution, then the paradox is that it becomes controversial to argue in favour of its implementation in the first place, as well as to justify the foregone revenue that a port authority may suffer from its application. This situation triggers a 'vicious circle' whereby EU ports are not monitoring the impact of environmental charging, therefore they do not possess sufficient data to be able to determine whether it is working, and so they often tend to believe that its impact on the environment may be negligible and / or too difficult to measure. However, if attempts were to be made, they might well reveal a different reality, or at least provide solid figures on which to ground an evidence-based opinion.

Having established that there is currently no data available to carry out an environmental assessment based on validated scientific criteria, the option left to assess the actual environmental impact of

differentiated charging is to estimate ballpark figures based on the best information available within given constraints and declared cautions[28].

One way to do this is to start from the consideration that nearly all environmental charging schemes identified in the first phase of this Study are based on discounts applied to ships certified with certain environmental programmes, such as the ESI and Green Award. These types of schemes reward certified vessels on the assumption that they are 'greener' than the rest of the fleet.

The first question to ask is thus 'how much greener is a green ship'? Answering this question poses quite a conundrum, as in principle every ship has her own characteristics, which make it impossible to provide a single value that can apply to the whole green fleet.

An insight is provided by looking at the ESI in order to understand how its score is determined. The ESI Programme distinguishes four groups of emissions:

1. NO_x: mainly dependent on the engine properties
2. SO_x: mainly dependent on the fuel' sulphur content
3. PM: related to SOx emissions
4. CO_2: mainly dependent on the amount of fuel used

NO_x, SO_x and PM have a direct effect on air quality in a port area and they are the main constituents for calculating the ESI score. The ESI score is composed of a set of sub points for each of the three (PM is included in SO_x) emission groups. ESI NO_x and SO_x scores may vary from 0, when a ship's emissions are perfectly compliant with existing legislation, to 100 when a ship virtually produces no emissions of these pollutants at all. The mechanism is thus to 'reward' ships that go beyond the standards set by current legislation. The CO_2 score is calculated differently and will be left aside from this analysis[29].

The overall ESI score is the calculated as follows:

$$\frac{2 \times ESI\ NO_x + ESI\ SO_x + ESI\ CO_2 + ESI\ OPS}{3.1}$$

A vessel fitted with an OPS installation is rewarded with 35 sub points, regardless of its use. For this reason, OPS will not be considered in this estimation either. The overall Score is capped at 100.

All the sub points are separate, and each of them is calculated independently based on the data present; if no data are present for one or more of these parts, the related ESI sub point cannot be calculated, which will result in a lower ESI score.

Back to NO_x and SO_x, if 0 is considered as the amount of emissions produced by a ship that is only just in compliance with the mandatory requirements (IMO regulations), and 100 as the point where none of these pollutants is emitted, then it may be assumed– albeit roughly – that a ship with an ESI NO_x 10 emits 10%

[28] The framework for environmental assessment presented in this paragraph only concerns shipping emissions in ports, and not pollutants concentration in the port area. The reason is that there is an inherent difference between emissions and concentration of pollutants. An emission is the amount of pollutant matter released in the atmosphere from a specific pollutant source and in a specific time interval. A concentration, on the other hand, is the amount of pollutant matter in atmosphere per volume unit (therefore not source specific). While it is technically feasible to estimate emission sources in the port area through proper data collection (the emission inventories compiled by the Port of Oslo and Project APICE are reported above), it may be problematic and controversial to establish the effect of environmental charging on pollutant concentration. Concentration depends on several factors, among which are reduced precipitation, high temperatures, stable atmospheric conditions, wind, etc. Therefore, exogenous variables, including pollution from sources outside the port, may strongly affect concentration, especially in a relatively small area such as a port. It follows that, while any form of environmental charging inevitably reduces emissions, it cannot be taken for granted that pollutant concentration in the port area is reduced accordingly.

[29] CO_2 is of primary importance when it comes to climate change, but is not as equally important for air quality in port areas. For more details, please see Environmental Ship Index (ESI) Fundamentals, 2015, available on the ESI website.

less NO_x than would otherwise be the case. Similarly, an ESI SO_x 10 emits 10% less SO_x. This may hold true of course if it is also assumed that all ships that emit less NO_x and/or SO_x decide to apply for an ESI certificate. Furthermore, it may also be assumed that 10% less SO_x also implies an equal reduction in PM, since studies have demonstrated that there is a linear relation between fuel sulphur and PM emission factors[30].

Based on the inventory of shipping emissions carried out in the first phase of the Study, it is established that in 2005, the emissions from international shipping in European seas were estimated at 2,8 million tonnes of NO_x, 1,7 million tons of SO_2 and 195 thousand tonnes of fine particles ($PM_{2.5}$) (Campling et al. ,2013). Based on specific scenario projections presented in the same study, shipping emissions are expected to decrease by 13% as regards NO_x emissions, and by 80% when it comes to SO_x emissions, due to the current legislative framework. In the same study, a reduction by 35% for $PM_{2.5}$ emissions is estimated as the result of fuel quality improvement until 2020. As may easily be imagined, this decrease may originate from the establishment of SECA regions. However, future trade trends and the corresponding increase of fuel consumption lead to an increase ranging from 40-50% until 2020. Table 21 illustrates the NO_x emissions in thousand tonnes per sea basin.

Table 21 – NO_x emissions (thousand tonnes) from international shipping by sea region (2005: baseline scenario)

Sea Regions	Emissions (estimates based on current legislation)			
	2005	**2020**	**2030**	**2050**
Baltic Sea	220	183	202	250
Bay of Biscay	474	425	488	633
Black Sea	47	36	44	54
Celtic Sea	22	18	20	23
Mediterranean Sea	1294	1116	1255	1587
North Sea (incl. English Channel)	518	449	503	627
Rest of NE Atlantic	246	220	250	319
Total	**2821**	**2447**	**2762**	**3493**

Source: Campling et al. (2013)

The Mediterranean is considered the sea region with the highest amount of exhaust emitted from international shipping. According to 2005 data, the Mediterranean recorded 1.294 thousand tonnes of NO_x emissions, representing almost 46% of the total NO_x emitted in Europe[31], followed by North Sea (18.4%). Until 2020 NO_x emissions are expected to be reduced in all sea regions, with the Black Sea recording the highest reduction values (30%). However, after 2020, NO_x emissions are expected to increase with an average rate of 12% until 2030, and 19.5% until 2050. The allocation pattern of SO_x emissions is similar to that of NO_x. However, the 2020 projections estimate an average reduction of corresponding emissions up to 83.6% for all sea regions, whilst, as mentioned above, the pattern will change in 2050, when an average increase of 32% is expected. It is stressed though that, compared with 2005, total SO_x emissions are estimated to record a decrease of 73%.

[30] See Lee, S.W., He, I., Herage, T., Young, B., Razbin, V., Kelly E., Pomalis, R., (2002). Fuel Sulphur Effects on Particulate Emissions from Fuel Oil Combustion Systems under Accelerated Laboratory Conditions. Work Performed for Environment Canada by the Advanced Combustion Technologies CANMET Energy Technology Centre-Ottawa.
See also United States Environmental Protection Agency., (1998). AP 42, Fifth Edition, Volume I, Chapter 1.3 Fuel Oil Combustion, Natural Resources Canada. Report CETC 02-09(CF).

[31] Baltic Sea, Bay of Biscay, Black Sea, Celtic Sea, Mediterranean Sea, North Sea (+ English Channel Rest of NE Atlantic (within EMEP grid) Rest of NE Atlantic (TNO grid outside EMEP).

Table 22 - SO_x emissions (thousand tonnes) from international shipping by sea region (2005: baseline scenario)

Sea Regions	Emissions (estimates based on current legislation)			
	2005	**2020**	**2030**	**2050**
Baltic Sea	130	6	7	9
Bay of Biscay	282	65	78	103
Black Sea	27	6	8	10
Celtic Sea	14	2	2	3
Mediterranean Sea	764	167	198	254
North Sea (incl. English Channel)	309	15	17	22
Rest of NE Atlantic	143	33	39	51
Total	**1669**	**294**	**349**	**452**

Source: Campling et al. (2013)

As regards $PM_{2.5}$ emissions, until 2020 a decreasing trend (36% in average) is expected, whereas in 2050 emissions volumes are expected to record values similar to 2005 in the Bay of Biscay, Black Sea, Black Sea and North-East Atlantic, while for the Baltic and the North Sea a slight decrease is forecast.

Table 23 - $PM_{2.5}$ emissions (thousand tonnes) from international shipping by sea region (2005: baseline scenario)

Sea Regions	Emissions (estimates based on current legislation)			
	2005	**2020**	**2030**	**2050**
Baltic Sea	14,2	8,7	10,1	12,8
Bay of Biscay	34	22,8	27,3	36
Black Sea	2,9	1,9	2,2	2,8
Celtic Sea	1,5	0,9	1,1	1,3
Mediterranean Sea	87,4	57	67,3	86,3
North Sea (incl. English Channel)	36,5	22,5	26,4	33,5
Rest of NE Atlantic	17,5	11,7	11,7	18
Total	**193,9**	**125,5**	**146,1**	**190,7**

Source: Camplin et al. (2013)

For the sake of simplicity, a scenario may be concocted where all ports in the EU apply a charging scheme that rewards vessels with an ESI score >30. An assumption could also be made that, since the ESI score is composed of several sub points, both ESI NO_x and ESI SO_x have to be >30, although in actuality this is not necessarily true, in that a ship may obtain an ESI score >30 even though her ESI score NO_x or SO_x is lower than 30.

In line with the economic assessment presented in the next section, the charging scheme may be configured so as to give a 10% discount on port dues to vessels that possess an ESI certificate with a score of at least 31. Again, for the sake of simplicity, it is assumed that all vessels will obtain a score of exactly 31 points for NO_x or SO_x.

In the economic assessment baseline (see next section), such a scheme attracts a green fleet that represents 7% of all vessels in the EU (assumption based on data from case studies). Assuming that the estimations above reflect pollution levels from a fleet that is only just in compliance with the existing regulations, this would mean that with the new scheme, 7% of the fleet would emit 31% less NO_x, SO_x and PM, thus modifying emission forecasts as follows:

Table 24 – Potential NO_x emissions (thousand tonnes) from international shipping by sea region (2005: baseline scenario) with and without environmental charging

Sea region	Emissions (estimates based on current legislation)							
	2005		2020		2030		2050	
	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved
Baltic Sea	220	4,8	183	4,0	202	4,4	250	5,4
Bay of Biscay	474	10,3	425	9,2	488	10,6	633	13,7
Black Sea	47	1,0	36	0,8	44	1,0	54	1,2
Celtic Sea	22	0,5	18	0,4	20	0,4	23	0,5
Mediterranean Sea	1294	28,1	1116	24,2	1255	27,2	1587	34,4
North Sea (incl. English Channel)	518	11,2	449	9,7	503	10,9	627	13,6
Rest of NE Atlantic	246	5,3	220	4,8	250	5,4	319	6,9
Total	**2821**	**61,2**	**2447**	**53,1**	**2762**	**59,9**	**3493**	**75,8**

Source: own elaboration

Table 25 – Potential SO_x emissions (thousand tonnes) from international shipping by sea region (2005: baseline scenario) with and without environmental charging

Sea region	Emissions (estimates based on current legislation)							
	2005		2020		2030		2050	
	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved
Baltic Sea	130	2,8	6	0,1	7	0,2	9	0,2
Bay of Biscay	282	6,1	65	1,4	78	1,7	103	2,2
Black Sea	27	0,6	6	0,1	8	0,2	10	0,2
Celtic Sea	14	0,3	2	0,0	2	0,0	3	0,1
Mediterranean Sea	764	16,6	167	3,6	198	4,3	254	5,5
North Sea (incl. English Channel)	309	6,7	15	0,3	17	0,4	22	0,5
Rest of NE Atlantic	143	3,1	33	0,7	39	0,8	51	1,1
Total	**1669**	**36,2**	**294**	**6,4**	**349**	**7,6**	**452**	**9,8**

Source: own elaboration

Table 26 – Potential $PM_{2.5}$ emissions (thousand tonnes) from international shipping by sea region (2005: baseline scenario) with and without environmental charging

Sea region	Emissions (estimates based on current legislation)							
	2005		2020		2030		2050	
	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved
Baltic Sea	14,2	0,3	8,7	0,2	10,1	0,2	12,8	0,3
Bay of Biscay	34	0,7	22,8	0,5	27,3	0,6	36	0,8
Black Sea	2,9	0,1	1,9	0,0	2,2	0,0	2,8	0,1
Celtic Sea	1,5	0,0	0,9	0,0	1,1	0,0	1,3	0,0
Mediterranean Sea	87,4	1,9	57	1,2	67,3	1,5	86,3	1,9
North Sea (incl. English Channel)	36,5	0,8	22,5	0,5	26,4	0,6	33,5	0,7
Rest of NE Atlantic	17,5	0,4	11,7	0,3	11,7	0,3	18	0,4
Total	**193,9**	**4,2**	**125,5**	**2,7**	**146,1**	**3,2**	**190,7**	**4,1**

Source: own elaboration

As can be noted, a more consistent approach to environmental charging would imply a 2,17% reduction in NO_x, SO_x and PM emissions from shipping even if only 7% of the fleet were eligible for a discount. An ESI score > 31 should not be considered unrealistic to achieve, as it was observed as a criterion for eligibility in several schemes identified during the inventory carried out in the first phase of the Study.

What would happen if one or more ports decided to set a higher discount level for ESI-certified ships? The economic assessment (see Section II - § 6) indicates that ship owners react to tariff variations, based on the elasticity of their demand. When demand for port services is elastic to prices (e = 1), a reduction in tariffs results in more ships calling a port, just as an increase in tariffs convince ship owners to call other ports that may have lower tariffs. The more demand is elastic to prices, the more this reaction can be detected. When demand is elastic (e = 1), a reduction by 1% in port tariffs attracts 1% more ships to the port, and vice versa.

Supposing demand is elastic, then, according to this scenario, if the discount level were doubled from 10% to 20% while maintaining ESI score at 31 as a criterion for eligibility, this would automatically double the percentage of 'eligible calls' that could benefit from the discount and pollute less than the rest of the fleet. Thus, the situation would be that 14% of the fleet[32] would emit 31% less NO_x, SO_x and PM.

[32] Furthermore, considering that the ESI was introduced in 2011, and its uptake has been increasing steadily since then, 14% of the fleet with a score ≥ 31 is considered a realistic assumption for the years to come.

Table 27 – Potential NO_x emissions (thousand tonnes) from international shipping by sea region (2005: baseline scenario) with and without environmental charging

Measures applied	Emissions (estimates based on current legislation)							
Sea Region	2005		2020		2030		2050	
	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved
Baltic Sea	220	9,5	183	7,9	202	8,8	250	10,9
Bay of Biscay	474	20,6	425	18,4	488	21,2	633	27,5
Black Sea	47	2,0	36	1,6	44	1,9	54	2,3
Celtic Sea	22	1,0	18	0,8	20	0,9	23	1,0
Mediterranean Se	1294	56,2	1116	48,4	1255	54,5	1587	68,9
North Sea (incl. English Channel)	518	22,5	449	19,5	503	21,8	627	27,2
Rest of NE Atlantic	246	10,7	220	9,5	250	10,9	319	13,8
Total	**2821**	122,4	**2447**	106,2	**2762**	119,9	**3493**	151,6

Source: own elaboration

Table 28 – Potential SO_x emissions (thousand tonnes) from international shipping by sea region (2005: baseline scenario) with and without environmental charging

Measures applied	Emissions (estimates based on current legislation)							
Sea Region	2005		2020		2030		2050	
	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved
Baltic Sea	130	5,6	6	0,3	7	0,3	9	0,4
Bay of Biscay	282	12,2	65	2,8	78	3,4	103	4,5
Black Sea	27	1,2	6	0,3	8	0,3	10	0,4
Celtic Sea	14	0,6	2	0,1	2	0,1	3	0,1
Mediterranean Se	764	33,2	167	7,2	198	8,6	254	11,0
North Sea (incl. English Channel)	309	13,4	15	0,7	17	0,7	22	1,0
Rest of NE Atlantic	143	6,2	33	1,4	39	1,7	51	2,2
Total	**1669**	72,4	**294**	12,8	**349**	15,1	**452**	19,6

Source: own elaboration

Table 29 – Potential $PM_{2.5}$ emissions (thousand tonnes) from international shipping by sea region (2005: baseline scenario) with and without environmental charging

Measures applied	Emissions (estimates based on current legislation)							
Sea Region	2005		2020		2030		2050	
	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved	Baseline	Tonnes saved
Baltic Sea	14,2	0,6	8,7	0,4	10,1	0,4	12,8	0,6
Bay of Biscay	34	1,5	22,8	1,0	27,3	1,2	36	1,6
Black Sea	2,9	0,1	1,9	0,1	2,2	0,1	2,8	0,1
Celtic Sea	1,5	0,1	0,9	0,0	1,1	0,0	1,3	0,1
Mediterranean Se	87,4	3,8	57	2,5	67,3	2,9	86,3	3,7
North Sea (incl. English Channel)	36,5	1,6	22,5	1,0	26,4	1,1	33,5	1,5
Rest of NE Atlantic	17,5	0,8	11,7	0,5	11,7	0,5	18	0,8
Total	**193,9**	8,4	**125,5**	5,4	**146,1**	6,3	**190,7**	8,3

Source: own elaboration

As can be noted, all things being equal, with demand elastic to port tariffs, doubling the discount level would imply doubling the amount of emissions cut. In this case, we would thus obtain a 4,34% reduction in NO_x, SO_x and PM emitted from shipping, through a 20% discount on port dues.

It should be noted that an equal result could be reached by doubling the eligibility score for receiving discounts. In the first case (doubling the discount), the costs for the additional emissions cut are borne by the port industry; in the second (doubling the eligibility score), the costs are borne by ship owners that in theory would have to invest additional resources to achieve the increased level of compliance with stricter environmental standards. Regardless of who bears the cost, when demand to port services is elastic to variation in charges, the result is exactly the same with either options.

However, as shown in the economic assessment, demand of port services traditionally is not considered to be elastic, as several other considerations determine the choice of ports at which to call. It is almost impossible to give an elasticity value that can apply to the whole shipping sector, as elasticities vary to a great extent across ship types. However, in the real world, it is more likely to observe elasticity values closer to 0,5 than to 1.

Therefore, in the real world, to double the emissions cut as in the tables above a discount close to 50% would probably be needed (if elasticity were 1, a 5 times higher discount would attract a 5 times numerous eligible fleet; but with elasticity at 0,5 a 5 times higher discount can only attract a 2,5 times more numerous fleet).

One may also wonder how much these reductions would be worth in economic terms. It should be noted that a significant part of emissions, even outside the port area, direclt affects the quality of life of the people living in the port environs. In a 2007 study by Whall et al.[33] it was estimated that in the Mediterranean 25% of the main emissions types are produced within the 12-mile zone, indicating that coastal areas in general and port areas specifically are also affected by sea-based emissions. In the North

[33] Wall et al. (2007), CONCAWE Ship Emissions Inventory-Mediterranean Sea. Final Report. Entec UK Limited. Retrieved from: http://www.amec-ukenvironment.com/downloads/Concawe_Final_Report_170407_v1_WEB_LOWRES.pdf.

Sea, it is estimated that the emissions generated within 12 miles from the shore correspond to 32% of the total emissions produced, while 89% is produced within 50 nautical miles[34].

It is possible to assign a value to each tonne of pollutants saved by calculating the marginal damage costs of each additional tonne emitted, thus seeking to quantify the extent to which environmental charging may improve the quality of life of people living near ports. The values assigned to each pollutant are inevitably different from country to country and port to port, since a wide array of local factors may impinge on the potential damage caused by each pollutant in a different way.

A study carried out in 2005 by AEA Technology Environment for DG Environment estimated the marginal damage costs of different pollutants in the EU-25[35].

The tables below use the marginal damage costs estimated by AEA Technology Environment so quantify how much money would be saved in the form of reduced emissions. The scenario looked at is the one with a 20% discount on port dues for vessels with an ESI score 31, which attracts a 14% eligible fleet[36]:

Table 30 – Quantification of NO_x emissions reduction in economic terms by sea region

Sea Region	2005	2020	2030	2050
North Sea	from € 114.750.000 to € 315.000.000	from € 99.450.000 to € 273.000.000	from € 111.180.000 to € 305.200.000	from € 138.720.000 to € 380.800.000
North East Atlantic	from € 51.680.000 to € 155.040.000	from € 30.720.000 to € 92.160.000	from € 52.800.000 to € 158.400.000	from € 67.680.000 to € 203.040.000
Baltic Sea	from € 24.700.000 to € 68.400.000	from € 20.540.000 to € 45.030.000	from € 22.880.000 to € 50.160.000	from € 28.340.000 to € 62.130.000
Med Sea	from € 30.846.000 to € 81.480.000	from € 35.404.000 to € 93.520.000	from € 29.892.000 to € 78.960.000	from € 37.736.000 to € 99.680.000

Source: own elaboration

Table 31 - Quantification of SO_x emissions reduction in economic terms by sea region

Sea Region	2005	2020	2030	2050
North Sea	from € 92.450.000 to € 268.000.000	from € 4.830.000 to € 14.000.000	from € 4.830.000 to € 14.000.000	from € 6.900.000 to € 20.000.000
North East Atlantic	from € 41.800.000 to € 119.700.000	from € 9.460.000 to € 27.090.000	from € 11.440.000 to € 32.760.000	from € 14.960.000 to € 42.840.000
Baltic Sea	from € 20.720.000 to € 61.600.000	from € 11.100.000 to € 33.000.000	from € 11.100.000 to € 33.000.000	from € 14.800.000 to € 44.000.000
Med Sea	from € 24.400.000 to € 71.980.000	from € 5.600.000 to € 16.520.000	from € 6.800.000 to € 20.600.000	from € 9.000.000 to € 26.550.000

[34] Hammingh P., Holland M.R., Geilenkirchen G.P., Jonson I.E. and Maas R.J.M (2012), Assessment of the environmental impacts and health benefits of a nitrogen emission control area in the North Sea, PBL Netherlands Environmental Assessment Agency.

[35] Holland M. et al., Damages per tonne emission of PM2.5, NH3, SO2, NOx and VOCs from each EU25 Member State (excluding Cyprus) and surrounding seas, 2005. Available at http://ec.europa.eu/environment/archives/cafe/activities/pdf/cafe_cba_externalities.pdf.

[36] Please note that the regional aggregations used in AEA's study are slightly different from the ones used in the previous tables.

Source: own elaboration

Table 32 - Quantification of PM2.5 emissions reduction in economic terms by sea region

Sea Region	2005	2020	2030	2050
North Sea	from € 44.800.000 to € 128.000.000	from € 28.000.000 to € 80.000.000	from € 30.800.000 to € 88.000.000	from € 42.000.000 to € 120.000.000
North East Atlantic	from € 11.520.000 to € 33.600.000	from € 7.200.000 to € 21.000.000	from € 8.160.000 to € 23.800.000	from € 12.000.000 to € 35.000.000
Baltic Sea	from € 7.200.000 to € 21.000.000	from € 4.800.000 to € 14.000.000	from € 4.800.000 to € 14.000.000	from € 7.200.000 to € 21.000.000
Med Sea	from € 21.840.000 to € 62.400.000	from € 14.560.000 to € 41.600.000	from € 16.800.000 to € 48.000.000	from € 21.280.000 to € 60.800.000

Source: own elaboration

Once again, a fundamental caution to keep in mind is that these results should not be extended to other geographical contexts, as the marginal damage costs may be significantly higher or lower in other countries or regions. The model serves as a conceptual framework to prove the point that a correct environmental assessment should factor in considerations related to the emission reduction targets (efficacy), as well as to the costs incurred to meet them (efficiency).

Taking this model as the concept, it is possible to set several baseline values for eligible fleet, average discount, and elasticity and see how these may affect emissions produced by the shipping industry. However, it should be borne in mind that the above 'ballpark figures' are merely an attempt at trying to delineate a method to assess the environmental impact of differentiated charging. The main assumption of the model, i.e. that with a 10% discount in NO_x and/or SO_x a ship emits exactly 10% less of these pollutants that it would otherwise do, and that the progression is linear, is quite a strong assumption, and not necessarily true.

However, in the absence of any actual field-validated data, it is impossible to gauge how a certain type of scheme affects the environment in the port area. More importantly, without measurements, it is impossible to test the reliability of a model. Therefore, rather than predicting what *will* happen if EU ports start to consistently implement certain environmental charging schemes, this model actually attempts to establish what *should* happen, if certain conditions were respected. Whether the conditions set are realistic, it may be difficult to establish, considering the general lack of data and the assumptions made. Nonetheless, it should be noted that the model was presented during a conference with sector stakeholders that took place in January 2016, and its main underlying assumptions were not questioned. While its results are inevitably not sufficiently accurate from a scientific viewpoint, the model can be a first step towards an environmental assessment of the impact of green charging.

In the framework of this Study, contacts were established with the ESI and Green Award to enquire whether data based on actual measurements is available to determine the environmental performance of their fleet. Knowing 'how much greener' ESI- and Green Award-certified vessels are compared with their non-certified fleet equivalents would be a considerable step forward to refine the model and to produce results closer to presumed reality.

Given the current status of available data, the actual environmental benefits that may be achieved through the application of green charging, in whatever form of scheme it takes, must remain a matter of conjecture in terms of establishing accurate, quantified improvements to environmental quality. The model of Environmental Assessment explained above demonstrates the necessary integration of environmental and economic considerations, and indicates some likely trends of impacts within the stated scenario. Yet, it is critically important to note that without reliable data based on systematic monitoring of appropriate EPIs, current assessments are at best educated guesses that must by definition have low predictive value. The

number of caveats, limitations and cautions inherent in any model are testimony to the complex of interacting components that constitute the trans-boundary, multi-input phenomena that is the regime of port-city-shipping interaction.

It may thus be considered that the current largest gap between policy and practice is the lack of science-based, quantified evidence required to formulate and encourage effective implementation based on proven efficacy of charging models and the benefits delivered to environmental quality. There is strong scope for collaboration between Port authorities, Municipalities and Shipping to monitor to mutual benefit. This would ease the concerns of Port Authorities who see the cost of set-up, staffing and operating such schemes as expensive, provide scope for the 'polluter pays' principle, and generally encourage a systems approach to this trans-boundary, multi-parameter complex of science and technology-based challenges.

A series of Port-specific and Sea-area dedicated environmental monitoring programmes specifically designed to distinguish the impact of the recognition of green shipping may well be the catalyst for wider acceptance and practice of the green charging option, identify the components of common interest and benefit, detect the constituents that may be deemed pre-competitive, and engender consensus on 'who pays'?

5.5 Environmental charging and climate change

Over the last century, the global average surface temperature has increased by around 0,74°C[37]. Climate change is a global challenge and a defining issue of our era, and compelling scientific evidence has moved the issue to the forefront of the international agenda. GHG emissions from shipping have increasingly been drawing attention, as their concentration in the atmosphere and the associated warming effect, together with other sources, are considered to cause climate change. Maritime transport emits around 1 000 million tonnes of CO_2 annually and is responsible for about 2,5% of global greenhouse gas emissions[38].

At the same time, while in absolute terms GHG emissions from international shipping are significant, in relative terms maritime transport – in particular where larger ships are used – surpasses other modes of transport in terms of fuel efficiency and climate friendliness. On a per tonne kilometre basis, and depending on ship size, CO_2 emissions from shipping are lower than emissions from other modes.

Carbon dioxide (CO_2) is produced from all combustion processes in which complete, or nearly complete combustion of a hydrocarbon fuel takes place. The amount of the emissions produced depends on the hydrocarbon composition of the fuel. CO_2 emission is a function of fuel consumption, which consequently is determined by the engine power required, its efficiency, as well as the elemental composition of the fuel being burnt. Number of ships, average annual consumption and the adoption of slow steaming practices are some key drivers affecting the amount of emissions (IMO, 2014).

The table below reports CO_2 emissions generated from shipping compared with the corresponding global amounts.

[37] Intergovernmental Panel on Climate Change. https://www.ipcc.ch/publications_and_data/ar4/wg1/en/faq-3-1.html
[38] Third IMO GHG Study, 2014. Available online at http://www.imo.org/en/OurWork/Environment/PollutionPrevention/AirPollution/Documents/Third%20Greenhouse%20Gas%20Study/GHG3%20Executive%20Summary%20and%20Report.pdf

Table 33 - CO_2 emissions from shipping

Year	Global CO_2	Total shipping CO_2	Percentage of global	International shipping CO_2	Percentage of global
2007	31.409	1.100	3.5%	885	2.8%
2008	32.204	1.135	3.5%	921	2.9%
2009	32.047	978	3.1%	855	2.7%
2010	33.612	915	2.7%	771	2.3%
2011	34.723	1.022	2.9%	850	2.4%
2012	35.640	949	2.7%	796	2.2%
Average	**33.273**	**1.016**	**3.1%**	**846**	**2.6%**

Source: IMO, 2014

CO_2 emissions from international shipping were estimated in 2012 at 796 million accounting for 2.2% of global CO_2 emissions, while for a six-year period (2007-2012) the average contribution of the industry was 3,1% (IMO, 2014). Based on the findings of the Third IMO GHG Study from 2007 and onward, CO_2 presents a slight decreasing trend (from 3,5% in 2007 to 2,7% in 2012) attributed to the wide adoption of slow steaming[39] practices across the sector. In this regard, it is worth mentioning the case of container ships, which are considered to be among the major polluters in the shipping industry (Kontovas and Psaraftis, 2011)[40], and recorded a decrease in their speed, ranging between 60-70% (IMO,2014). Future predictions suggest that seaborne transport will experience a positive growth rate, and, in IMO study's alternative scenarios, CO_2 emissions are projected to increase by 50% to 250% within 2050.

Although predictions based on current trends already suggest an enormous challenge, it must be stressed that there remains an inherent degree of uncertainty associated with any such prediction. Natural systems are complex and non-linear, and there is a very real risk that growing GHG concentrations could trigger various feedback mechanisms that would drive climatic changes and their consequences to levels that are extremely difficult to manage (and predict)[41].

Carbon Dioxide emissions have a significant impact on climate change and ocean acidification. CO_2 is among the major GHGs which absorb energy, preventing the loss of heat to space and thus contributing to global warming, whilst has a long lifetime in the atmosphere (Eyring et al., 2007).

As carbon dioxide concentrations increase and climate warms, a considerable amount of it is absorbed by the oceans. This process results in significant changes to the sea system, altering its chemistry which becomes more acidic. New conditions jeopardise the viability of the various sea organisms. Moreover, the increase of temperature results in the melt of sea ice, increasing sea levels and consequently disrupting marine ecosystem and ocean circulation. Apart from the degradation and alteration of the marine ecosystem, humans are also affected due to the changes in the morphology of shores, weather changes and alteration to production methods.

In 2011, the EU Commission's White Paper on transport set the quantitative targets of the EU regarding CO_2 emissions. Based on that, CO_2 emissions from shipping should be reduced in the EU by 40% (50% if

[39] Since the beginning of the global financial crisis, the industry adopted a new economic model to correspond to high oil prices, low revenues and increased regulations on emissions and efficiency (Sustainable Shipping, 2014).

[41] UNCTAD, Multi-Year Expert Meeting on Transport and Trade Facilitation: Maritime Transport and the Climate Change Challenge, 16–18 February 2009, Geneva, Summary of Proceedings. UNCTAD/DTL/TLB/2009/1

feasible) from 2005 levels by 2050. In 2013, the EU published its Strategy[42], which includes CO_2 reduction policies.

The Strategy consists of three subsequent steps:

- Monitoring, reporting and verification of CO_2 emissions from large ships using EU ports;
- Greenhouse gas reduction targets for the maritime transport sector;
- Additional measures, including Market Based Measures, in the medium to long term.

The Monitoring, Reporting and Verification (MRV) system is the suggested instrument for the monitoring of ship-based emissions to and from the EU ports, which is proposed to apply to shipping activities from 1 January 2018. This system concerns all ships exceeding 5.000 GT irrespectively of their flag, port of registry or home port, and comes as a response to the lack of reliable information on fuel consumption. The implementation of the MRV is expected to contribute to the existing policies, e.g. EEDI and can lead to the reduction of greenhouse gas emissions up to 2% compared to the business as usual scenario, while aggregated net cost can be reduced up to €1,2 billion by 2030. Specifically, the operational components of the proposed MRV system would include:

- Focussing on CO_2 as predominant GHG emitted by ships and on other climate relevant information such as efficiency information to address market barriers for the uptake of cost-efficient mitigation measures and to align MRV with IMO discussion on efficiency standards for existing ships;
- Calculating annual CO_2 emissions, based on fuel consumption and fuel type and energy efficiency using available data from log books, noon reports and bunker delivery notes;
- Using existing structures and bodies of the maritime sector, in particular recognised organisations to verify emission reports and to issue documents for compliance;
- Excluding small emitters (ships below 5000 GT) which represent about 40% of the fleet, but only 10% of the total emissions.

As regards the MRV geographical coverage, Recital 14 of Regulation (EU) 2015/757 on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport states that "all intra-Union voyages, all incoming voyages from the last non-Union port to the first Union port of call and all outgoing voyages from a Union port to the next non-Union port of call, including ballast voyages, should be considered relevant for the purposes of monitoring. CO_2".

The EU and its Member States have a strong preference for a global approach led by the IMO, as it is believed that this will be most effective[43]. Considerable efforts to agree such an approach have been made over recent years within both the IMO and the United Nations Framework Convention on Climate Change (UNFCCC).

In 2011, the IMO adopted the

- Energy Efficiency Design Index (EEDI), which sets compulsory energy efficiency standards for new ships, and
- Ship Energy Efficiency Management Plan (SEEMP), a management tool for ship owners.

The EEDI for new ships is the most important technical measure and aims at promoting the use of more energy efficient (less polluting) equipment and engines. The EEDI requires a minimum energy efficiency level per capacity mile (e.g. tonne mile) for different ship type and size segments. Since 1 January 2013, following an initial two-year phase zero, new ships' design has needed to meet the reference level for their ship type. The level is to be tightened incrementally every five years, and so the EEDI is expected to

[42] COM(2013) 479 final.
Access from: http://ec.europa.eu/clima/policies/transport/shipping/docs/com_2013_479_en.pdf
[43] http://ec.europa.eu/clima/policies/transport/shipping/index_en.htm

stimulate continued innovation and technical development of all the components influencing the fuel efficiency of a ship from its design phase. The EEDI is a non-prescriptive, performance-based mechanism that leaves the choice of technologies to use in a specific ship design to the industry. As long as the required energy efficiency level is attained, ship designers and builders are free to use the most cost-efficient solutions for the ship to comply with the regulations. The EEDI provides a specific figure for an individual ship design, expressed in grams of CO_2 per ship's capacity-mile (the smaller the EEDI the more energy efficient ship design) and is calculated by a formula based on the technical design parameters for a given ship.

The CO_2 reduction level (grams of CO_2 per tonne mile) for the first phase is set to 10% and will be tightened every five years to keep pace with technological developments of new efficiency and reduction measures. Reduction rates have been established until the period 2025 and onwards when a 30% reduction is mandated for applicable ship types calculated from a reference line representing the average efficiency for ships built between 2000 and 2010. The EEDI is developed for the largest and most energy intensive segments of the world merchant fleet and will embrace emissions from new ships covering the following ship types: oil tankers, bulk carriers, gas carriers, general cargo ships, container ships, refrigerated cargo carriers and combination carriers. In 2014, the Marine Environment Protection Committee (MEPC) of the IMO adopted amendments to the EEDI regulations to extend the scope of EEDI to: LNG carriers, ro-ro cargo ships (vehicle carriers), ro-ro cargo ships; ro-ro passenger ships and cruise passenger ships having non-conventional propulsion. These amendments mean that ship types responsible for approximately 85% of the CO_2 emissions from international shipping are incorporated under the international regulatory regime.

The Ship Energy Efficiency Management Plan (SEEMP) is an operational measure that establishes a mechanism to improve the energy efficiency of a ship in a cost-effective manner. The SEEMP also provides an approach for shipping companies to manage ship and fleet efficiency performance over time using, for example, the Energy Efficiency Operational Indicator (EEOI) as a monitoring tool. The guidance on the development of the SEEMP for new and existing ships incorporates best practices for fuel efficient ship operation, as well as guidelines for voluntary use of the EEOI for new and existing ships (MEPC.1/Circ.684). The EEOI enables operators to measure the fuel efficiency of a ship in operation and to gauge the effect of any changes in operation, e.g. improved voyage planning or more frequent propeller cleaning, or introduction of technical measures such as waste heat recovery systems or a new propeller. The SEEMP urges the ship owner and operator at each stage of the plan to consider new technologies and practices when seeking to optimise the performance of a ship.

There is a vast literature on the impact of the EEDI and the SEEMP on future GHG emissions from shipping. A study carried out in 2014 by TNO for the European Commission – DG CLIMA[44] developed a reference scenario for GHG emissions of global and European maritime transport between 2012 and 2030. The reference scenario included the Economy of Scale (gradual growth of average ship size), the implementation of the EEDI and the gradual application of LNG. With the reference scenario, the European maritime GHG emissions (i.e. emissions generated in voyages from/to EU ports) increase moderately from 190 million tonnes CO_2 annually in 2012 to about 208 million tonnes of CO_2 annually in 2030. If the same transport volume were transported with the 2012 vessel characteristics, the annual CO_2 emission would be about 250 million tonnes.

Other authors have noted that the relationship between EEDI and CO_2 emissions is an indirect one, and consequently provide more prudent estimates. The amount of CO_2 emitted by a ship depends not on the fuel consumption at installed power (or 75% of installed power), but on the power that the owner/term charterer actually uses and the fuel consumption at that power. The power that an owner/term charterer will actually use depends on three things:

[44] Lindstad H. et al., GHG emission reduction potential of EU-related maritime transport and on its impacts, TNO, 2014. Available online at:
https://ec.europa.eu/clima/sites/clima/files/transport/shipping/docs/report_ghg_reduction_potential_en.pdf

1. the current ship spot rate;
2. the owner's/term charterer's current fuel cost;
3. the ship's speed/consumption curve.

In any market situation (spot rate and bunker cost), the owner/term charterer will adjust the ship's steaming speed to maximise their daily net earnings, or equivalently for the term charterer, minimise their unit cost of transportation. From this viewpoint, speed reduction is not a measure, but rather the ship owner's reaction to the current spot rate, bunker cost, and speed-fuel curve[45].

Regardless of the measures adopted by the IMO, what is of special significance in the framework of this study is to understand to what extent a practice such as environmental charging can contribute to tackling climate change. With COM(2013) 479 final 'Integrating maritime transport emissions in the EU's greenhouse gas reduction policies', the EC devised a three-step strategy:

1. Monitoring, reporting and verification of CO_2 emissions from large ships using EU ports.
2. Greenhouse gas reduction targets for the maritime transport sector.
3. Further measures, including market-based measures, in the medium to long term.

To all extent and purposes, environmental charging may be considered among the possible market-based measures that could help reduce GHGs emissions. This consideration comes, however, with an important caveat: CO_2 is of primary importance when it comes to climate change, but may not be assigned the same significance by some ports. While high concentrations of pollutants such as NO_x and SO_x have an almost immediate negative effect on the quality of life of people living near port areas, carbon dioxide – whose content in fresh air normally varies between 0,036% (360 ppm) and 0,041% (410 ppm), depending on the location[46] – is not classified as toxic or harmful in accordance with Globally Harmonised System of Classification and Labelling of Chemicals standards of United Nations Economic Commission for Europe by using the OECD Guidelines for the Testing of Chemicals. In concentrations up to 1% (10.000 ppm), it may make some people feel drowsy and give the lungs a stuffy feeling. At higher concentrations, CO_2 may cause asphyxiation, but it should be noted that, even though its atmospheric levels continue to escalate as a driver of climate change, the issue of CO_2 toxicity is not recognised as a global risk by the science community[47].

Therefore, despite the overwhelming consensus among scientists on the causes of global warming, from the viewpoint of a port authority, CO_2 emissions may not necessarily be a top priority to improve the quality of life of the people living in the port area[48]. Furthermore, while taking action on reducing emissions on NO_x and SO_x would have immediate – albeit not necessarily significant – effect on the concentrations measured in the port, any given initiative to reduce CO_2 emissions would not possibly have any appreciable effect whatsoever, if implemented by a port in isolation. In other words, while there may be an incentive for ports to take action on significant environmental aspects such as air quality and waste, the incentive is less evident when it comes to GHGs emissions, because in the short term they do not harm people directly, and because in the long term any action at port level would be pointless without a concerted effort of the entire maritime transport community.

The above considerations do not lead to rule out environmental charging as a possible market-based measure to tackle global warming; in fact, they reinforce the argument that a more consistent approach to the practice is fundamental. The experience with the EEDI may even suggest that, if a large number of

[45] Devanney J., The impact of EEDI on VLCC design and CO_2 emissions, 2011. Available online at http://www.tandfonline.com/doi/abs/10.1080/17445302.2010.546651

[46] http://www.esrl.noaa.gov/gmd/ccgg/carbontracker/

[47] Bierwirth P.N., Carbon dioxide toxicity and climate change: a serious unapprehended risk for human health, 2014.

[48] For a more balanced view, however, it is worth mentioning that large ports are generally committed to reducing CO_2 emissions. See, for instance: Rotterdam (http://www.zeroco2.no/projects/rotterdam-climate-initiative), Antwerp (http://www.portofantwerp.com/nl/node/553), and Hamburg (http://www.hamburg.de/contentblob/4028914/data/booklet-englisch).pdf).

actors took coordinated action, the impact on GHG emissions could be quite significant. The main challenge remains to understand what type of action should be taken through environmental charging, and to what extent it may contribute to reducing emissions of CO_2. Unfortunately, the lack of schemes specifically addressing climate change offer no useful benchmark to conjecture the effect of a scheme on CO_2 emissions.

Nevertheless, during this study, it has been established that environmental charging is particularly effective as an incentive when it comes to the development of new ships (rewarding early compliance, i.e. shipping lines take into account technologies beyond compliance) and the choice of fuel (more environmentally friendly). Interviews with port authorities and the economic assessment in the next chapter confirm this viewpoint. Since a set of reductions has already been established at IMO level with the EEDI until 2025 (pending a comprehensive IMO strategy on reduction of GHG emissions from ships that should be adopted in 2018 and the proposal put forward by the European Parliament to have an Emission Trading System that includes global shipping), it may make sense to propose a system of rebates that incentivises ship owners to adopt more stringent standards even before their entry into force. By way of an example, as of today, it does not necessarily make sense to build a new ship and adopt standards that comply with the requirements set by the EEDI for 2025 onwards. However, a system of rebates may become an incentive to voluntarily adopt more stringent standards. The regulation currently requires most new ships to be 10% more efficient beginning 2015, 20% more efficient by 2020, and 30% more efficient by 2025. Rebates may reward those ship owners who, for instance, decide to be 50% more efficient than required, even though there is no obligation to do so. 50% more efficient than required is an ambitious goal, but not unrealistic. The EEDI database review[49] carried out by the MEPC in 2016 analysed EEDI performance of 1 917 ships from 8 members of the International Association of Classification Societies (IACS) and found that nearly all of them attained an EEDI far above the 10% reduction required until 2019. Several ships are already in compliance with the 20% reduction required from 2020 to 2024, and some are even compliant with the 30% reduction required from 2025 onwards. There are obvious differences between ship categories (for instance, general cargo and container vessels record the highest reduction, on average above 30%), but the general situation is positive to the point that a revision aiming to a higher level of ambition does not seem far-fetched.

As mentioned above, the TNO's study developed a reference scenario for GHG emissions of European maritime transport between 2012 and 2030, which also included the implementation of the EEDI. With the reference scenario, GHG emissions generated in voyages from/to EU port increase moderately from 190 million tonnes CO_2 annually in 2012 to about 208 million tonnes of CO_2 annually in 2030, with a mean annual growth rate of 0,5%[50] (without the gradual reductions set globally, the increase would be far higher). Note that figures refer to CO_2 that would be emitted in voyages from/to EU ports (regardless of ships' flags and ownership).

TNO's scenario, however, could not have foreseen the high degree of early compliance with EEDI requirements that emerges from MEPC's review[51]. Based on the review, the average EEDI reduction has been calculated for the ships segments following:

- General cargo (35%)
- Container ships (34%)
- Bulk carriers (19%)
- Gas carriers (23%)

[49] EEDI database – Review of status of technological development, MEPC 70/INF.14, 19 August 2016.

[50] Compound annual growth rate: $(208/190)^{1/(2030-2012)} - 1$.

[51] In fact, this is partly anticipated in TNO's report, where it is stated that "the results demonstrate that making vessels slenderer gives lower emissions per freight unit transported and that the slenderer the vessels become, the better their EEDI performance becomes. The slenderest of these designs overperforms by 25-35% compared to today's EEDI thresholds, which actually means that they might satisfy foreseen future requirements coming into effect the next 20 years".

- Tankers (24%)

Furthermore, based on a study by Faber et al.[52], the respective contribution of each segment to CO_2 emissions has also been calculated. TNO's reference scenario has thus been adapted accordingly, assuming a linear relation between EEDI reduction and amount of CO_2 emitted by each fleet segment.

Table 34 - CO_2 emissions from shipping in the EU, scenario adjusted based on MEPC's data

Year	CO_2 emissions from shipping (million tonnes)	CO_2 emissions from shipping revised scenario based on MEPC's data (million tonnes)
2012	190,00	190,00
2013	190,96	190,96
2014	191,92	191,92
2015	192,89	165,67
2016	193,86	166,50
2017	194,84	167,35
2018	195,82	168,19
2019	196,81	169,04
2020	197,80	185,55
2021	198,80	186,49
2022	199,80	187,42
2023	200,81	188,37
2024	201,82	189,32
2025	202,84	199,16
2026	203,86	200,16
2027	204,89	201,17
2028	205,92	202,18
2029	206,96	203,20
2030	208,00	204,23

Source: TNO and own elaboration

MEPC's data report the EEDI reductions attained by a representative sample of ships in 2016. Since it is not possible to know when the reduction reported by each ship was attained exactly, it has been assumed that it was attained in 2015 for all of the 5 above-mentioned fleet segments, as soon as EEDI's Phase 1 started. This can be seen in Table 34, where lower amounts of CO_2 are reported from 2015 onwards, compared with TNO's estimations. It is also assumed that the average reduction reported by each fleet segment in 2016 remains the same until 2025 (when EEDI Phase 3 enters into application) or until a new EEDI Phase requires that a higher reduction be attained. This implies that, for example, in the revised scenario, bulk carriers, whose average reduction in 2016 is 19%, emit less CO_2 than previously expected only until 2019 (when the required reduction is still 10%), while from 2020 on their emissions become in line with TNO's scenario. Likewise, with an average reduction by 24%, tankers emit less CO2 than expected until 2024 (end of Phase 2, with a required reduction by 20%), their emissions realigning to TNO's estimations starting from 2025, when the required reduction increases to 30%.

For the sake of comparability with previous scenarios, it may be assumed that an environmental charging scheme is implemented, whereby vessels are granted a 20% rebate on port dues (20% is the same rebate applied by the Port of Singapore to ships exceeding EEDI requirements. For more details, please see Annex

[52] Faber et al. (2009), Technical support for European action to reducing Greenhouse Gas Emissions from international maritime transport. Tender DG ENV.C3/ATA/2008/0016. Retrieved from: http://ec.europa.eu/environment/air/transport/pdf/ghg_ships_%20report.pdf. Detailed figures are also reported in Annex I to this Report.

II to this report), if they are 50% more efficient than the standards set at IMO level. Setting a threshold to reward vessels that are more environmentally-friendly than what required by law is also consistent with the previous scenarios on NO_x, SO_x and PM emissions, where the ESI score is taken as a reference (the ESI gives a 0 score to vessels that are 'just in compliance' and increases as vessels 'go beyond compliance').

According to the above-mentioned review of the EEDI database, as of 2016 20% of the ships in the sample analysed are 50% (or higher) more efficient than the EEDI Phase 2 reduction that will start in 2020. For the purpose of this study, it can be assumed that a 20% rebate in all ports of call may persuade 20% or 30% of the rest of the fleet to exceed EEDI requirements. The table below presents the results, if which all EU ports apply the same scheme:

Table 35 - CO_2 emissions from shipping in the EU with and without environmental charging (20% and 30% of the fleet eligible)

Year	CO_2 emissions from shipping (million tonnes)	CO_2 emissions from shipping with environmental charging 20% eligible fleet (million tonnes)	CO_2 emissions from shipping with environmental charging 30% eligible fleet (million tonnes)
2012	190,00	190,00	190,00
2013	190,96	190,96	190,96
2014	191,92	191,92	191,92
2015	165,67	165,21	164,98
2016	166,50	166,04	165,81
2017	167,35	166,88	166,65
2018	168,19	167,72	167,49
2019	169,04	168,57	168,33
2020	185,55	184,01	183,24
2021	186,49	184,94	184,17
2022	187,42	185,87	185,09
2023	188,37	186,81	186,03
2024	189,32	187,75	186,96
2025	199,16	193,89	191,25
2026	200,16	194,86	192,21
2027	201,17	195,85	193,18
2028	202,18	196,83	194,16
2029	203,20	197,83	195,14
2030	204,23	198,82	196,12

Source: TNO 2014, and own elaboration

In order to have figures comparable with TNO's reference scenario, it is assumed that the rebate has been implemented since 2015, with no modifications. This implies that, in the period analysed, 20% or 30% of the fleet is at least 50% more efficient than the EEDI requirements. The period when each fleet segment starts benefitting from rebates differs, depending on the respective average reduction reported in 2016. By way of an example, categories such as general cargo and container ships on average are already above the requirements for Phase 3; this means that in this scenario, they start benefitting from rebates only from 2025 on, assuming that, as a result of the scheme, part of the fleet (which, in theory, would not need to take any measures, as it is already compliant) decides to become 50% more efficient than requested (i.e. 45% reduction from 2025 on, instead of 30%). As for the other scenarios, it is also assumed that all ships eligible to the rebate are exactly 50% more efficient than required.

The scheme might have the effect of incentivising a part of the rest of the fleet (e.g. including Ro-Ro, ferries, cruise ships, etc.) to adopt a higher EEDI threshold, before this becomes mandatory. As a result, with 20% of the fleet eligible for a rebate, 5,4 million tonnes of CO_2 could be saved in 2030 alone (a reduction by 2,64%), and 42 million over the whole period. If 30% of the fleet were eligible, then tonnes of CO_2 saved could become slightly more than 8 million in 2030 (a reduction by 3,97%) and more than 63,2

million over the whole period. To be noted that the reduction is likely to increase after 2030, reflecting the upward trend in the demand for maritime transport.

Furthermore, it should be noted that the figures reported in the table are conservative estimates; it has been assumed that all ships eligible for the rebate are exactly 50% more efficient than EEDI requirements. In actual facts, some ships already exceed EEDI Phase 3 requirements, and a limited number of them even doubles the requested Phase 3 reduction (30%). The ship owners that already have their fleet (or part thereof) far above Phase 3 requirements may have done so for a variety of reasons such as ethos, corporate social responsibility, economic and financial considerations, but not because of a legal obligation. By definition, any additional financial incentive from an environmental charging scheme will build on top of these considerations, and can only increase the early uptake of more stringent standards.

The impressive number of CO_2 emissions saved should be treated as a ballpark figure, showing the potential of a scheme that builds on top of a set of reductions already agreed at the international level. In the real world, if such a scheme were to be implemented, it may make sense to set different reduction objectives based on ship type and tonnage. The review of the EEDI database shows that there are marked differences as to the achieved reduction across ship categories. Another important element is to avoid setting unrealistic objectives as to the requiremens for eligibility. As noted by the MEPC, shipping is already, by far, the most energy efficient form of commercial transport, and an unrealistic contribution to reduce the sector's absolute CO_2 emissions could lead to a shift to less energy-efficient transport modes. This would clearly be counterproductive with respect to reducing the world's total CO_2 inventory[53]. In the example above, 50% higher efficiency is chosen as a requirement for eligibility, because it is already attained by a number of ships. This means that it is realistic to encourage ship owners to aim for it. A more effective incentive would consist in linking the rebate to the level of efficiency: the more a ship goes beyond the EEDI requirements, the higher the rebate.

There are two main challenges for such an environmental charging scheme. First of all, to be effective, it cannot be implemented by ports individually – which inter alia would have little incentive in doing so – but a concerted effort is necessary. On the one hand, ship owners would most likely not be willing to invest in potentially expensive cleaner technologies without being certain to benefit from rebates in every port of call. On the other hand, since CO_2 does not directly affect the port area, the scale effect on its reduction becomes appreciable only if a remarkable number of ports adopt the same scheme. The above-mentioned scenario hypothesises that all ports in the EU apply the same scheme; if the number of ports implementing the scheme halved, roughly speaking, so would do the amount of emission saved (shipping traffic is not allocated equally across ports, hence, in actual facts, the reduction would depend on *which* ports do not implement the scheme).

The second challenge concerns the lack of data. As recognised by the ESI Working Group, a wide set of data at ship level is necessary to establish how much a ship is increasing her efficiency. Incidentally, however, the entry into force of the MRV Regulation (Regulation (EU) 2015/757 of the European Parliament and of the Council on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport, and amending Directive 2009/16/EC), adopted in 2015, will create an EU-wide legal framework for the monitoring, reporting and verification of CO_2 emissions from maritime transport. The Regulation requires large ships (over 5.000 gross tonnes) calling at EU ports from 1 January 2018 to collect, and later publish, verified annual data on CO_2 emissions and other relevant information. Companies operating large ships visiting EU ports (irrespective of where they are registered) will have to:

- monitor and annually report the verified amount of CO_2 emitted on journeys to, from and between EU ports and also when in EU port;
- monitor and annually report additional parameters, such as distance, time at sea and cargo carried, enabling to determine the ships' average energy efficiency;

[53] http://www.worldshipping.org/public-statements/regulatory-comments/MEPC_70-7-8_-_Development_of_a_road_map_to_determine_IMO_contribution_Aug_2016.pdf

- submit to the Commission an emission report containing externally verified annual aggregated data, which will then be publicly available.

When visiting EU ports, ships must carry a document of compliance issued by an accredited MRV verifier. This might be subject to inspections by Member State authorities.

In other words, if linked to an environmental charging scheme, this framework will make available a remarkable set of data that will make it possible to:

a) know how much and to what extent a vessel is 'going beyond' international standards in the framework of the EEDI;

b) know with a sufficient degree of precision how much CO_2 is emitted (and how much is saved) on a certain journey;

c) as a consequence of a) and b), determine the level of rebate corresponding to the percentage of increased efficiency (or of CO_2 emitted).

None of the schemes surveyed during this study can gauge shipping emissions with such precision, and consequently determine the level of rebate. Amongst other things, the effective application of the MRV Regulation represents an enormous opportunity to increase the effectiveness of environmental charging as an incentive to reduce CO_2 emissions and contribute to reducing the negative effects of climate change. Environmental charging may thus become one of the market-based measures mentioned in the 2013 EU Commission strategy. The role of environmental charging in climate change policies is also envisaged in COM(2013) 0296, which affirms that:

(25) *The variation of port infrastructure charges should be allowed in order to promote short sea shipping and to attract waterborne vessels having an environmental performance or energy and carbon efficiency of the transport operations, notably the off-shore or on-shore maritime transport operations, that is better than average. This should help to contribute to the environmental and climate change policies and the sustainable development of the port and its surroundings notably by contributing to reducing the environmental footprint of the waterborne vessels calling and staying in the port.*

The above examples of CO_2 emissions reduction should be taken as ballpark figures. Nevertheless, its potential is enormous, as it would add up to ambitious reduction standards already set at EU and international level. Whether the scheme can be successful will depend on the concerted effort mobilised by EU ports. Contrary to schemes that address air quality and /or waste, which produce direct effects on the port and its environs, in the case of CO_2 it is paramount to create a 'critical mass' that makes it possible to produce an appreciable effect on carbon emissions and climate change.

Another scenario may take into account the effects of a charging scheme that incentivises ship owners to use OPS while at berth. In Section 2 - § 6.5.1, an assessment is carried out on how environmental charging may become an incentive to increase the uptake of OPS. The assessment also takes into account potential emissions reduction at port level, based on a tool developed by the World Ports Climate Initiative (WPCI). On its website, the WPCI has made available a simple calculation tool that helps develop a feeling for the costs and benefits of OPS. The tool is filled out with characteristic data, but can be readily adapted to any local situation by changing the cost figures and data on the number of ships and their fuel consumption. To understand whether environmental charging can contribute to tackling global warming, one may fill the WPCI's tool with data on the total number of calls of vessels calling main EU ports[54], as available on Eurostat (year of reference 2014).

[54] Unfortunately, data on number and gross tonnage of vessels in the EU is provided only for 'main ports'. A main port is a statistical port which has annual movements of no less than 200 000 passengers or recording more than one million tonnes of cargo. For further details, please see http://ec.europa.eu/eurostat/cache/metadata/en/mar_esms.htm

In 2014, 2 187 560 vessels called in EU-28 main ports[55]; assuming that the average vessel spends 24 hours at berth, and that the electric power is produced with the current EU mix of sources, an environmental charging scheme, such as the one envisaged in Section 2 - § 6.5.1 of this Report, would make it possible to save up to nearly 7,4 million tonnes of CO_2 each year, if adopted by the entire fleet, i.e. 50% less than would otherwise be emitted at berth. The hypothesis that the entire fleet is eligible for the scheme may seem unrealistic. However, if only 7% of the fleet were considered eligible – as is the case in other examples throughout the study – the scheme would still lead to saving 520 thousand tonnes of CO_2 a year. If 14% of the fleet were eligible, the tonnes of CO_2 saved each year would be 1 040 million (7% less than would otherwise be emitted), which, all things being equal, would become 5,2 million over a five-year period. In addition, it should be noted that the use of OPS would also directly improve the quality of life in port cities, as it would also reduce emissions of NO_x, SO_2 and PM[56].

The quantity of CO_2 saved may vary to a great extent depending on ship type, gross tonnage, number of calls per year, hours spent at berth and source of electric power. Nonetheless, this example can give a rough estimate of the benefits from concerted action to fight global warming.

5.6 Main lessons learned

- In the absence of any actual data on the impact of charging schemes on the environment, an estimation has specifically been carried out for this Study. It has emerged that a discount of only 20% on port dues in all EU ports for vessels certified with an ESI score of 30 points may lead up to a 4,34% reduction of current NO_x, SO_x and PM emissions in the EU, if only 14% of the EU fleet were eligible for the discount.
- When it comes to climate change, there is potential for environmental charging to become a market-based measure to reduce GHG emissions. With the effective application of the MRV Regulation, it should be possible to establish an EU-level scheme that rewards ship owners who decide to go beyond current standards for CO_2 reduction. If a rebate is given to vessels that are 50% more efficient than the standards already set until 2025 at IMO level, the scheme would make it possible to reduce CO_2 emissions from voyages from/to EU ports by 3,97% of in 2030 alone, and save up to nearly 63,2 million tonnes from 2018 to 2030, assuming that 30% of the fleet is eligible. To be noted that the reduction is likely to increase after 2030, reflecting the upward trend in the demand for maritime transport. The data collected in the framework of the MRV Regulation will make it possible to link the rebates to the level of efficiency of each ship, and to know with a sufficient degree of precision how much CO_2 is emitted (and how much is saved) on each journey. In contrast to schemes addressing air quality and / or waste, in the case of CO_2 the actual effect would be appreciable if a sufficient critical mass of ports implementing the scheme is created at EU level. A concerted and coordinated effort is thus needed.
- The models developed in the study show that, if external environmental costs are factored in, the benefits from reduced emissions for the people living in the port environs may outweigh the costs incurred by the ports because of the revenue foregone from reduced port dues.
- Although there are many reports on the regulations and limits to control emissions of NO_x, SO_x and GHGs there are apparently no definitive or substantive statements on the sum of total benefits that may accrue to the environment from the recognition, by any means, of so-called 'green shipping' certification *per se.*
- An overall conclusion for the port sector is that any of the environmental monitoring systems in place are not measuring the impact of the charging scheme on air and water quality. There is no

[55] Main ports are ports handling more than 1 million tonnes of goods or 200 000 passengers annually.
[56] For further details, please see § 6.5.1.

data at all that could be used to gauge how, and if, an existing charging scheme has actually had any tangible effect on the environment.

- Several port authorities believe that it may be extremely difficult to tease out the effect of a charging scheme in improving air quality. There is a multitude of factors that impinge on air quality in a port area, and it is costly and technically challenging to set up a monitoring system that can gauge with extreme precision the effect of the several initiatives set in place by a port authority.
- In its Final report, the Clean North Sea Shipping project (March, 2014) recommended that harbours estimate emissions from ships in port, including manoeuvring, as this would help to improve reliability and comparability between different harbours, and test the effectiveness of different incentive schemes.
- In order to calculate and accurately assess the actual environmental benefits that may accrue from the recognition of any, one, green shipping index or certification, a far more coherent, comprehensive and science-based monitoring and reporting mechanism would be required with all the attendant costs, technologies, and skills that such methodologies imply. This is especially true for large port cities which have major environmental concerns.
- The variations in the criteria upon which such indices and certifications are based, the variables involved, and the diversity and multiplicity of ship-types involved means that best-estimate of trends is a more likely outcome of any attempted modelling and monitoring rather than absolute impacts.
- Examples from several ports and projects show that, in contrast to common opinion, it is technically possible to use modelling techniques that can estimate emission sources in a port area at a sufficient level of detail, also taking into account meteorological confounding factors. If these exercises are repeated constantly over the years, the availability of time series may make it possible to estimate the impact of introducing an environmental charging scheme with a reasonable degree of reliability.

6 Economic assessment

The second part of the Study calls for estimating the economic impact of environmental charging across the EU. As part of this work, a set of what-if scenarios are presented to illustrate what may happen when one or more ports adopt an environmental charging scheme. The scenarios are based as much as possible on (confidential) data made available by port authorities when conducting the case studies. However, as noted above, not all ports agreed to disclose the requested information with the study team, therefore, when needed, external sources were also used. Furthermore, in order to generalise to the whole EU port and shipping sector what would have otherwise been port-specific scenarios, certain assumptions had to be made. When used, both external sources and assumptions are clearly stated in each scenario. Data from case studies, on the other hand, are disclosed only for port authorities which agreed to do so.

Over the course of the Study, it emerged that there is a general belief among port authorities and ship owners that, as it is currently applied in the EU, environmental charging may not always be strong enough as an incentive to actually change shipping lines behaviour in the short run, and persuade them to go greener beyond what they are already doing in accordance with the current legislation.

Nevertheless, this argument has never been tested against actual data, inter alia because, as emerged during the Study, several port authorities do not monitor the economic impact of their environmental charging schemes.

The aim of this section is to quantify the potential benefits that ship owners may reap from environmental charging in such a way as to determine how strong an incentive it could be, and/or under which conditions it could increase its strength. In doing so, it should be borne in mind that there is a multitude of operators, and, in principle, there can be several environmental charging schemes, whose characteristics are inherently different, thus making it extremely difficult to reach conclusions that equally apply to all possible combinations.

To overcome these problems, the issue is analysed through a set of scenarios that consider very specific situations.

6.1 Introduction

In order to define the green incentive scheme scenario, the following information is necessary:

1) The port tariff for which the rebate can be implemented;
2) The type of rebate used;
3) The percentage of rebate applied;
4) Whether the rebate can be cumulated.

1) Port tariff

Ports use a variety of charging schemes and can be divided into two main categories: dues on vessels and dues on cargo. Port dues on vessels, mostly depend on the vessel's characteristics such as length and/or tonnage, and include: quay dues, harbours dues that apply to the dues for buoyage, anchorage, dredged channels, etc. Cargo-related dues, mostly measured by tonne or freight, usually include handling dues, storage charges after free time, further quay dues. The table below, adapted from UNCTAD (1995), shows some of the typical port charging schemes adopted.

Table 36 – Most common items charged by ports

Charge item	Function	Charging Unit	Differentiation
Pilotage	To cover the variable costs of pilots and the pilot boats	Vessel movement	-
Towage	To cover the variable costs of tugboats and crew	Vessel movement	Vessel GRT, NRT, Length*Beam*Draft
Berthing / unberthing, mooring	To cover the variable costs of the gangs	Vessel movement	Vessel GRT, NRT, Length*Beam*Draft
Stevedoring, wharf-handling, receiving / delivery	To cover the variable costs for the cargo-handling labour and equipment	Freight ton, metric ton, cubic metre, TEU, Box	Form of cargo
Equipment hire	To cover the fixed and variable costs for the equipment and its operators	Half-hour, hour, shift, half-day	Type of equipment
Cargo processing	To cover the variable costs for the cargo-handling labour and equipment	Freight tonne, metric tonne, cubic Metre	Form of cargo before and after
Fuel, utilities	To cover the direct cost for the amount consumed	Kwh, metric tonne, cubic metre	Capacity provided

Source: UNCTAD, 1995

In principle, port charges aim to recovery costs, although a variety of other charging principles can be used (see Meersman et al. 2004 or Acciaro, 2014 for a review of the literature).

As far as green port charges are concerned, as of today, there are very few examples of differentiated charges based on some environmental parameter. As reported in Annex II, the majority of these schemes refer to port dues either as a form of differentiated charges or as a form of rebates on the existing charging scheme.

2) Rebates

Rebate schemes are the most common form of differentiated charging (or incentives, more precisely) based on environmental criteria observed in ports. Most rebate schemes make use of well-known indexes / certifications, the most common being the ESI, Green Award, Blue Angel (BA), the CSI, and – especially in North America – Rightship. According the various rankings or scores that these indexes assign to a ship, each port authority offers a rebate, which usually varies between 0.5% and 20% of the otherwise payable port dues. In rarer instances, rebates up to 50% have been observed.

The majority of ports using a rebate system are in the EU, with the ESI being the most used type of index. The majority of ports apply rebates on fees levied proportionally to ship size, while, in a smaller number of ports, levies are fixed per vessel depending on various parameters or combinations of parameters. Some ports (Vancouver and Prince Rupert, Swedish Fairway dues) apply different charging schemes according to the type of vessel. Some ports (e.g. Los Angeles) apply a fixed rebate independently of vessel size.

The various schemes can be represented in the table below, which also summarises decision parameters and how the alternative scheme can be implemented.

Table 37 - Summary of alternative charging schemes for port

Alternative	Implementation	Decision Parameters
Rebate	Fixed amount	Amount allocation criteria
	Percentage rebate on GT	Selection of index/certification % tiering
	Percentage rebate on GT and cargo	Selection of index/certification % tiering
	Tier system	Tiering
Charge	Direct charge	Charge determination
	Redistribution scheme	Charge determination
Fund	Charging and redistribution scheme	Charge determination Redistribution scheme

Source: own elaboration

a) Differentiated charges:

A basic rate is calculated and a variety of criteria contribute to the definition of a tier. Each ship can be classified in a tier. Being part of a tier (gold, silver, bronze) provides a discount on the basic harbour dues. A basic harbour fee can virtually be applied only to vessels with very low environmental standards, essentially introducing a penalty on poor environmental performance. It is a clear and easy-to-implement system that makes it possible to single out bad performers. However, it pushes the competitive nature of port charges and may decrease the number of calls.

b) Rebate/reward system:

A common way of providing incentives for 'greener ships' is through percentage rebates on port dues. For instance, a port may offer a 10% discount on port dues for an environmentally friendly vessel. Some tariffs could also favour certain types of vessels (e.g. short-sea vessels vs. ocean-going vessels), so the record of calling vessels size needs be reviewed carefully in order to set up an appropriate percentage of rebate on port fees.

The port of Amsterdam, for instance, uses two individual incentive schemes for sea-going vessels and inland barges. Ship owners can be rewarded by presenting a Green Award certificate for their vessels. A 6% rebate on the port fees can be granted for sea-going ships: Crude oil/Product Tankers and for Cargo Bulk Carriers. Different percentage of discounts can be granted to inland barges on the basis of the type of Green Award certificate: Bronze - 5%, Silver - 10%, and Gold – 15%.

c) Fixed amount of rebate:

Some ports may apply a fixed-amount rebate. In this case, the yearly budget allocated for green incentives can be estimated easily. This case can be exemplified by the port of Los Angeles. The port offers three different programmes: rebates based on ESI score are divided into four tiers: $ 250 for ESI-score 25-29, $ 750 for ESI-score 30-34, $ 1.000 for ESI-score 35-39, and $1.250 for ESI-score 40 or higher. The second programme is the 'Ocean Going Vessel 5' (hereinafter refer to as OGV5) for IMO Tier II or Tier III Standards: (1) An incentive of $ 750 per call with an IMO Tier II main engine. (2) An incentive of $ 3.250 per call with an IMO Tier III main engine. Additionally, the 'Technology Advancement Program Demonstration', also named OGV6 programme, is the third programme implemented in this port. The port authority offers an incentive of $ 750 per call for ocean-going vessels that can demonstrate to be equipped with an emission reduction technology

which reduces Diesel Particulate Matter (DPM) and NO_x emissions. One of the disadvantages of this system is that the fixed-amount rebate might be considered too weak an incentive by large vessels. Indeed, when a port applies a fixed-amount rebate, there is no difference between large and small vessels. Therefore, the rebate amount becomes relatively small for large vessels.

3) The percentage of rebate applied

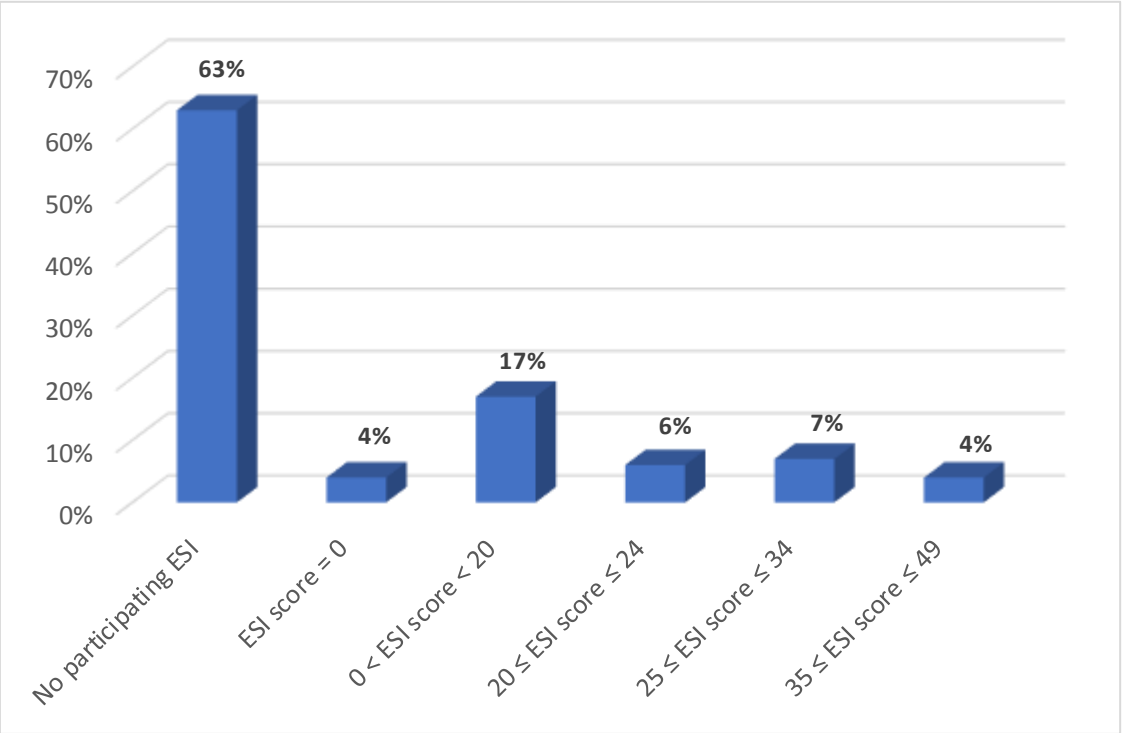
The percentage of rebate applied changes from port to port, and is generally revised on a regular basis. An effective system of course needs to align the percentage rebate with the benefits obtainable from the rebate, the total budget available for the scheme, the total number of calls from vessels eligible for the scheme, pricing policies of neighbouring ports. There is a great variety of percentage reductions observable in ports, ranging from half a percentage point to 50% of total fees. Typically, the 'greener' the vessels, the higher the rebate.

4) Cumulability of rebates

Certain indexes / certifications or measures can entitle a ship to multiple types of rebates in different ports. It is fundamental to establish whether these rebates can be cumulated or not, as small rebates can account for sizable incentives when cumulated.

Comparing the vessels (211) listed by Green Award with those listed by the ESI (4.254), it is possible to determine how many of them possess both certifications. The results are shown in the figure below, illustrating the distribution of ESI score for the Green Award vessels. According to the distribution of ESI approximately 63% of Green Award-certified vessels do not participate in the ESI system. Moreover, 83% of Green Award certificate holders have an ESI score lower than 20 (including the 63% which are not certified at all). Since very few ports apply rebates for vessels with an ESI score lower than 20, this means that several Green Award certificate holders cannot benefit from ESI-based rebates.

Figure 9 – Distribution of ESI score for the Green Award vessels



Source: own elaboration, based on publicly available data (2015). N.B. the total is 101% due to a rounding error

6.2 Scenario on potential amounts obtainable through environmental discounts

In order to estimate the potential economic incentives obtainable through environmental charging, the calculation on the amounts obtainable can be simplified by considering the total benefits (individual or cumulated) that can be reaped by a single vessel. The case of a fixed-amount rebate is obvious and thus can be excluded from the analysis. In this scenario, ten examples of vessels are looked at, and, based on some indicative tariffs, the potential incentives obtainable through a rebate system are calculated. The scenario considers the most common form of charging based on gross tonnage (GT), and assumes, as is often the case, different charges for intra-EU trade and extra-EU trade. The scenarios are developed for four types of vessels (tankers, container, Ro-Ro and ferries) and for different sizes. The calculations in relation to GT are only indicative, as GT is specific to each individual vessel, but they are representative of the sizes selected. We also assume that there is a ceiling for port dues at 120.000 tonnes.

The characteristics of the vessels used for the scenario are listed below.

Table 38: Ship assumptions and some port dues.

	Ship type	Size	Destination	GT	EUR per GT	Port dues
1	Tanker	VLCC	Out of Europe	120.000	€ 0,4848	€ 58.176
2	Tanker	Suezmax	Out of Europe	81.000	€ 0,4848	€ 39.269
3	Container	13000 TEU	Out of Europe	135.000	€ 0,2327	€ 27.924
4	Container	7500 TEU	Out of Europe	100.000	€ 0,2327	€ 23.270
5	Container	4000 TEU	Out of Europe	46.000	€ 0,2272	€ 10.451
6	Container	1700 TEU	Out of Europe	11.165	€ 0,2198	€ 2.454
7	Container	500 TEU	Europe	4.000	€ 0,0574	€ 230
8	Container	850 TEU	Europe	8.900	€ 0,1148	€ 1.022
9	Ro-Ro	Small	Europe	8.000	€ 0,0422	€ 338
10	Ro-Ro	Large	Europe	60.000	€ 0,0476	€ 2.856
11	Ferry	Large	Europe	38.000	€ 0,1155	€ 4.389
12	Ferry	Small	Europe	8.000	€ 0,1155	€ 924

Source: own elaboration

The following table shows the percentage rebates in case of rebate from 5% to 50% on a single call.

Table 39: Rebates (EUR) obtainable per call for different rebate percentages.

	Ship type	Size	5%	10%	15%	20%	25%	30%	35%	40%	45%	50%
1	Tanker	VLCC	2.909	5.818	8.726	11.635	14.544	17.453	20.362	23.270	26.179	29.088
2	Tanker	Suezmax	1.963	3.927	5.890	7.854	9.817	11.781	13.744	15.708	17.671	19.635
3	Container	13000 TEU	1.396	2.792	4.189	5.585	6.981	8.377	9.773	11.170	12.566	13.962
4	Container	7500 TEU	1.164	2.327	3.491	4.654	5.818	6.981	8.145	9.308	10.472	11.635
5	Container	4000 TEU	523	1.045	1.568	2.090	2.613	3.135	3.658	4.180	4.703	5.226
6	Container	1700 TEU	123	245	368	491	614	736	859	982	1.104	1.227
7	Container	500 TEU	12	23	35	46	58	69	81	92	104	115
8	Container	850 TEU	51	102	153	204	256	307	358	409	460	511
9	Ro-Ro	Small	17	34	51	68	85	101	118	135	152	169
10	Ro-Ro	Large	143	286	428	571	714	857	1.000	1.142	1.285	1.428
11	Ferry	Large	€ 219	€ 439	€ 658	€ 878	€ 1.097	€ 1.317	€ 1.536	€ 1.756	€ 1.975	€ 2.195
12	Ferry	Small	€ 46	€ 92	€ 139	€ 185	€ 231	€ 277	€ 323	€ 370	€ 416	€ 462

Source: own elaboration

The discount percentages are based on those observed during the first task of the Study. The vast majority of ports that have differentiated infrastructure charges apply rebates which on average vary from 5% to 20% of port dues. A limited number of ports also offer 50% rebates upon certain conditions. While no ports were detected offering rebates between 20% and 50%, it may be interesting to calculate the incentives deriving from these percentages, should some ports decide to apply them in the future.

The most widely used rebate percentages may seem to offer a rather limited financial incentive in case of a single call. However, when the rebates are cumulated across a higher number of calls, obviously the total benefits grow accordingly. In order to assess the value of a rebate scheme, therefore, calculations are presented to highlight the impact of multiple calls. In this case, 1, 4, 10, 20 and 40 calls a year are selected, with the last two scenarios only relevant for vessels on scheduled operations. Another important issue relates to the overall size of the rebate that is proportional to the total port dues, which in turn are a function of ship size.

The tables following show the cases for a 10%, 20%, 30%, 40% and 50% rebate.

Table 40. Comparison among cumulated rebates obtainable for multiple calls for a 10% rebate

	Ship type	Size	1 call	4 calls	10 calls	20 calls	40 calls
1	Tanker	VLCC	€ 5.818	€ 23.270	€ 58.176	€ 116.352	€ 232.704
2	Tanker	Suezmax	€ 3.927	€ 15.708	€ 39.269	€ 78.538	€ 157.076
3	Container	13000 TEU	€ 2.792	€ 11.170	€ 27.924	€ 55.848	€ 111.696
4	Container	7500 TEU	€ 2.327	€ 9.308	€ 23.270	€ 46.540	€ 93.080
5	Container	4000 TEU	€ 1.045	€ 4.180	€ 10.451	€ 20.902	€ 41.804
6	Container	1700 TEU	€ 245	€ 982	€ 2.454	€ 4.908	€ 9.816
7	Container	500 TEU	€ 23	€ 92	€ 230	€ 460	€ 920
8	Container	850 TEU	€ 102	€ 409	€ 1.022	€ 2.044	€ 4.088
9	Ro-Ro	Small	€ 34	€ 135	€ 338	€ 676	€ 1.352
10	Ro-Ro	Large	€ 286	€ 1.142	€ 2.856	€ 5.712	€ 11.424
11	Ferry	Large	€ 439	€ 1.756	€ 4.389	€ 8.778	€ 17.556
12	Ferry	Small	€ 92	€ 370	€ 924	€ 1.848	€ 3.696

Source: own elaboration

Table 41 - Comparison among cumulated rebates obtainable for multiple calls for a 20% rebate

	Ship type	Size	1 call	4 calls	10 calls	20 calls	40 calls
1	Tanker	VLCC	€ 11.635	€ 46.541	€ 116.352	€ 232.704	€ 465.408
2	Tanker	Suezmax	€ 7.854	€ 31.415	€ 78.538	€ 157.076	€ 314.152
3	Container	13000 TEU	€ 5.585	€ 22.339	€ 55.848	€ 111.696	€ 223.392
4	Container	7500 TEU	€ 4.654	€ 18.616	€ 46.540	€ 93.080	€ 186.160
5	Container	4000 TEU	€ 2.090	€ 8.361	€ 20.902	€ 41.804	€ 83.608
6	Container	1700 TEU	€ 491	€ 1.963	€ 4.908	€ 9.816	€ 19.632
7	Container	500 TEU	€ 46	€ 184	€ 460	€ 920	€ 1.840
8	Container	850 TEU	€ 204	€ 818	€ 2.044	€ 4.088	€ 8.176
9	Ro-Ro	Small	€ 68	€ 270	€ 676	€ 1.352	€ 2.704
10	Ro-Ro	Large	€ 571	€ 2.285	€ 5.712	€ 11.424	€ 22.848
11	Ferry	Large	€ 878	€ 3.511	€ 8.778	€ 17.556	€ 35.112
12	Ferry	Small	€ 185	€ 739	€ 1.848	€ 3.696	€ 7.392

Source: own elaboration

Table 42 - Comparison among cumulated rebates obtainable for multiple calls for a 30% rebate

	Ship type	Size	1 call	4 calls	10 calls	20 calls	40 calls
1	Tanker	VLCC	€ 17.453	€ 69.811	€ 174.528	€ 349.056	€ 698.112
2	Tanker	Suezmax	€ 11.781	€ 47.123	€ 117.807	€ 235.614	€ 471.228
3	Container	13000 TEU	€ 8.377	€ 33.509	€ 83.772	€ 167.544	€ 335.088
4	Container	7500 TEU	€ 6.981	€ 27.924	€ 69.810	€ 139.620	€ 279.240
5	Container	4000 TEU	€ 3.135	€ 12.541	€ 31.353	€ 62.706	€ 125.412
6	Container	1700 TEU	€ 736	€ 2.945	€ 7.362	€ 14.724	€ 29.448
7	Container	500 TEU	€ 69	€ 276	€ 690	€ 1.380	€ 2.760
8	Container	850 TEU	€ 307	€ 1.226	€ 3.066	€ 6.132	€ 12.264
9	Ro-Ro	Small	€ 101	€ 406	€ 1.014	€ 2.028	€ 4.056
10	Ro-Ro	Large	€ 857	€ 3.427	€ 8.568	€ 17.136	€ 34.272
11	Ferry	Large	€ 1.317	€ 5.267	€ 13.167	€ 26.334	€ 52.668
12	Ferry	Small	€ 277	€ 1.109	€ 2.772	€ 5.544	€ 11.088

Source: own elaboration

Table 43 - Comparison among cumulated rebates obtainable for multiple calls for a 40% rebate

	Ship type	Size	1 call	4 calls	10 calls	20 calls	40 calls
1	Tanker	VLCC	€ 23.270	€ 93.082	€ 232.704	€ 465.408	€ 930.816
2	Tanker	Suezmax	€ 15.708	€ 62.830	€ 157.076	€ 314.152	€ 628.304
3	Container	13000 TEU	€ 11.170	€ 44.678	€ 111.696	€ 223.392	€ 446.784
4	Container	7500 TEU	€ 9.308	€ 37.232	€ 93.080	€ 186.160	€ 372.320
5	Container	4000 TEU	€ 4.180	€ 16.722	€ 41.804	€ 83.608	€ 167.216
6	Container	1700 TEU	€ 982	€ 3.926	€ 9.816	€ 19.632	€ 39.264
7	Container	500 TEU	€ 92	€ 368	€ 920	€ 1.840	€ 3.680
8	Container	850 TEU	€ 409	€ 1.635	€ 4.088	€ 8.176	€ 16.352
9	Ro-Ro	Small	€ 135	€ 541	€ 1.352	€ 2.704	€ 5.408
10	Ro-Ro	Large	€ 1.142	€ 4.570	€ 11.424	€ 22.848	€ 45.696
11	Ferry	Large	€ 1.756	€ 7.022	€ 17.556	€ 35.112	€ 70.224
12	Ferry	Small	€ 370	€ 1.478	€ 3.696	€ 7.392	€ 14.784

Source: own elaboration

Table 44 - Comparison among cumulated rebates obtainable for multiple calls for a 50% rebate

	Ship type	Size	1 call	4 calls	10 calls	20 calls	40 calls
1	Tanker	VLCC	€ 29.088	€ 116.352	€ 290.880	€ 581.760	€ 1.163.520
2	Tanker	Suezmax	€ 19.635	€ 78.538	€ 196.345	€ 392.690	€ 785.380
3	Container	13000 TEU	€ 13.962	€ 55.848	€ 139.620	€ 279.240	€ 558.480
4	Container	7500 TEU	€ 11.635	€ 46.540	€ 116.350	€ 232.700	€ 465.400
5	Container	4000 TEU	€ 5.226	€ 20.902	€ 52.255	€ 104.510	€ 209.020
6	Container	1700 TEU	€ 1.227	€ 4.908	€ 12.270	€ 24.540	€ 49.080
7	Container	500 TEU	€ 115	€ 460	€ 1.150	€ 2.300	€ 4.600
8	Container	850 TEU	€ 511	€ 2.044	€ 5.110	€ 10.220	€ 20.440
9	Ro-Ro	Small	€ 169	€ 676	€ 1.690	€ 3.380	€ 6.760
10	Ro-Ro	Large	€ 1.428	€ 5.712	€ 14.280	€ 28.560	€ 57.120
11	Ferry	Large	€ 2.195	€ 8.778	€ 21.945	€ 43.890	€ 87.780
12	Ferry	Small	€ 462	€ 1.848	€ 4.620	€ 9.240	€ 18.480

Source: own elaboration

This brief overview shows that sizable rebates can only be obtained for large vessels or for a high number of calls, implying that the system can be beneficial either for vessels that repeatedly call at ports, or for vessels that are particularly large. In the latter case, it should be noted that the costs of adopting 'greener' technologies are generally proportional to the size of the vessel. In the former case, it should be also noted that, generally speaking, short-sea shipping benefits of lower tariffs. Lower tariffs imply that any percentage discount is also lower.

Quite logically, as the discount percentages and the number of calls increase, the benefits for ship owners increase accordingly, and their dimension makes them far more attractive as an incentive. This is even more evident if the yearly values above are multiplied by a longer period of time. By way of an example, the table below shows the cumulated rebates obtainable for multiple calls and a 50% rebate over a time period of 5 years:

Table 45 - Comparison among cumulated rebates obtainable for multiple calls for a 50% rebate over a 5-year period

	Ship type	Size	1 call	4 calls	10 calls	20 calls	40 calls
1	Tanker	VLCC	€ 145.440	€ 581.760	€ 1.454.400	€ 2.908.800	€ 5.817.600
2	Tanker	Suezmax	€ 98.173	€ 392.690	€ 981.725	€ 1.963.450	€ 3.926.900
3	Container	13000 TEU	€ 69.810	€ 279.240	€ 698.100	€ 1.396.200	€ 2.792.400
4	Container	7500 TEU	€ 58.175	€ 232.700	€ 581.750	€ 1.163.500	€ 2.327.000
5	Container	4000 TEU	€ 26.128	€ 104.510	€ 261.275	€ 522.550	€ 1.045.100
6	Container	1700 TEU	€ 6.135	€ 24.540	€ 61.350	€ 122.700	€ 245.400
7	Container	500 TEU	€ 575	€ 2.300	€ 5.750	€ 11.500	€ 23.000
8	Container	850 TEU	€ 2.555	€ 10.220	€ 25.550	€ 51.100	€ 102.200
9	Ro-Ro	Small	€ 845	€ 3.380	€ 8.450	€ 16.900	€ 33.800
10	Ro-Ro	Large	€ 7.140	€ 28.560	€ 71.400	€ 142.800	€ 285.600
11	Ferry	Large	€ 10.973	€ 43.890	€ 109.725	€ 219.450	€ 438.900
12	Ferry	Small	€ 2.310	€ 9.240	€ 23.100	€ 46.200	€ 92.400

Source: own elaboration

6.3 Extending the scenario at EU level

It might be useful to assess the overall impact of the incentives obtainable by ports at European level, if all of them were to apply an incentive scheme. At the same time, one may also want to consider the overall contribution that can be generated for the shipping sector making use of port rebates. Such an exercise obviously requires an extensive set of hypotheses but might be useful to assess the potential of differentiated port charging for improving the environmental performance of the sector. For this generalised scenario the following base line assumptions are made:

- total amount of ship calls and GT in the EU ports based on EUROSTAT data (2013 and 2014) (data for France are estimated on the basis of the total traffic and the number of calls in the port of Le Havre).
- In the base scenario, it is assumed that only 7% of ships are eligible for a discount (multiple alternatives are looked at)
- The discount is calculated at 10% of total port dues (multiple alternatives are looked at)
- The dues per tonne are calculated as € 0,20/GT, multiple alternatives are included in the analysis.

Total incentives amount to € 22,5 million and are subdivided among European countries in view of the total number of GT calling in the country (Table 46). This figure would result on average to € 155 per eligible call.

Table 46 - Total benefits obtainable from a 10% discount on all ports assuming a 7% of eligible ships and average port tariff of € 0.20/GT (in '000)

Country	2013 Total	2013 Only SSS	2014 Total	2014 Only SSS
EU (including Norway and Turkey)	**€ 22.476**	**€ 16.026**	**€ 22.155**	**€ 15.694**
Belgium	€ 790	€ 437	€ 793	€ 439
Bulgaria	€ 44	€ 37	€ 44	€ 37
Denmark	€ 1.505	€ 1.341	€ 1.168	€ 1.041
Germany	€ 1.637	€ 958	€ 1.647	€ 964
Estonia	€ 474	€ 322	€ 465	€ 316
Ireland	€ 292	€ 243	€ 310	€ 258
Greece	€ 1.575	€ 1.261	€ 1.648	€ 1.319
Spain	€ 2.486	€ 1.236	€ 2.614	€ 1.299
France	€ 461	€ 266	€ 461	€ 266
Croatia	€ 382	€ 312	€ 368	€ 300
Italy	€ 3.458	€ 2.545	€ 3.167	€ 2.331
Cyprus	€ 45	€ 38	€ 40	€ 34
Latvia	€ 119	€ 101	€ 115	€ 97
Lithuania	€ 81	€ 63	€ 83	€ 64
Malta	€ 302	€ 271	€ 302	€ 271
Netherlands	€ 1.005	€ 471	€ 1.016	€ 477
Poland	€ 232	€ 194	€ 257	€ 215
Portugal	€ 277	€ 156	€ 294	€ 166
Romania	€ 73	€ 46	€ 74	€ 47
Slovenia	€ 55	€ 28	€ 56	€ 29
Finland	€ 1.037	€ 949	€ 1.024	€ 937
Sweden	€ 1.589	€ 1.476	€ 1.630	€ 1.514
United Kingdom	€ 3.038	€ 2.078	€ 3.131	€ 2.142
Norway	€ 564	€ 494	€ 473	€ 415
Turkey	€ 955	€ 703	€ 975	€ 717

Source: own elaboration based on EUROSTAT data

Based on EUROSTAT data, Table 46 also provides a breakdown for short-sea shipping only. It should be noted that short-sea shipping is often priced lower that deep-sea shipping, mainly because vessels on SSS tend to call a port several times a year. However, we have maintained the same tariff and number of calls also for short-sea shipping as it may be assumed that the tariff is lowered proportionally to the increasing number of calls, and so on average the two effects should tend to compensate each other.

It may be interesting to compare the € 22,2 million potential incentives with the total revenue from port dues at EU level. Unfortunately, to our knowledge, there are no harmonised and transparent financial figures available for port authorities which would allow for more detailed impact calculations. Therefore, a rough estimate is provided, based on the average fee per tonne charged in the ports of Amsterdam, Antwerp and Rotterdam in the year 2013, for which sufficient data is available on the internet. By multiplying this value for the total tonnage of goods in EU ports based on EUROSTAT data, a value of circa €

2,5 billion is obtained. This would mean that potential incentives obtainable from a 10% discount on all ports, assuming a 7% of eligible ships and average port tariff of € 0.20/GT, could amount to ca. 0,9% of the total revenue from port dues collected in the whole EU. Incidentally, this percentage is compatible with the budget allocated to finance environmental charging schemes by the case-study ports that shared their financial data with the study team[57].

By aggregating the benefits reported in Table 46 above at sea basin level, the situation would be as follows:

Table 47 - Total benefits at sea basin level obtainable from a 10% discount on all ports assuming a 7% of eligible ships and average port tariff of € 0.20/GT (in '000)

Sea basin	2013	2014
Atlantic Ocean	€ 2.485	€ 2.593
North Sea	€ 6.867	€ 6.843
Baltic Sea	€ 4.287	€ 4.008
Mediterranean Sea	€ 8.242	€ 8.106
Black sea	€ 595	€ 606

Source: own elaboration

As one may expect, when the discount level and the percentage of eligible calls increase, the incentives increase accordingly. This is exemplified in the table below which offers examples of incentives for the shipping sector at EU level according to different average discount and number of eligible calls.

Table 48 - Potential benefits for the shipping sector depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000), data for 2014

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	6.330	9.495	12.660	15.825	18.990	22.155	25.320	28.485	31.650
	4%	12.660	18.990	25.320	31.650	37.980	44.310	50.640	56.970	63.300
	6%	18.990	28.485	37.980	47.475	56.970	66.465	75.960	85.455	94.950
	8%	25.320	37.980	50.640	63.300	75.960	88.620	101.280	113.940	126.600
	10%	31.650	47.475	63.300	79.125	94.950	110.775	126.600	142.425	158.250
	12%	37.980	56.970	75.960	94.950	113.940	132.930	151.920	170.911	189.901
	14%	44.310	66.465	88.620	110.775	132.930	155.085	177.241	199.396	221.551
	16%	50.640	75.960	101.280	126.600	151.920	177.241	202.561	227.881	253.201
	18%	56.970	85.455	113.940	142.425	170.911	199.396	227.881	256.366	284.851
	20%	63.300	94.950	126.600	158.250	189.901	221.551	253.201	284.851	316.501
	25%	79.125	118.688	158.250	197.813	237.376	276.938	316.501	356.064	395.626
	30%	94.950	142.425	189.901	237.376	284.851	332.326	379.801	427.276	474.751
	35%	110.775	166.163	221.551	276.938	332.326	387.714	443.101	498.489	553.877
	40%	126.600	189.901	253.201	316.501	379.801	443.101	506.402	569.702	633.002

Source: own elaboration

[57] For further details, please see Annex III to this document.

High average discount levels may be unrealistic to achieve in the near future, as they would imply an enormous increase in the level of rebates throughout Europe, nonetheless it may be useful to calculate what would happen in such scenarios.

The benefits in terms of contribution to the shipping sector are calculated for the totality of European countries between € 6,33 million and € 633 million. Most likely amounts are in the range of € 10 million to € 50 million, since, with higher discounts, tighter rules for number of eligible calls are to be expected, or lower discounts with higher number of eligible ships.

Another table presents benefits for short-sea shipping vessels only:

Table 49 - Potential benefits for the shipping sector (short-sea shipping only) depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000), data for 2014

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	4.494	6.741	8.989	11.236	13.483	15.730	17.977	20.224	22.472
	4%	8.989	13.483	17.977	22.472	26.966	31.460	35.954	40.449	44.943
	6%	13.483	20.224	26.966	33.707	40.449	47.190	53.932	60.673	67.415
	8%	17.977	26.966	35.954	44.943	53.932	62.920	71.909	80.897	89.886
	10%	22.472	33.707	44.943	56.179	67.415	78.650	89.886	101.122	112.358
	12%	26.966	40.449	53.932	67.415	80.897	94.380	107.863	121.347	134.830
	14%	31.460	47.190	62.920	78.650	94.380	110.110	125.841	141.571	157.301
	16%	35.954	53.932	71.909	89.886	107.863	125.841	143.818	161.796	179.773
	18%	40.449	60.673	80.897	101.122	121.347	141.571	161.796	182.020	202.244
	20%	44.943	67.415	89.886	112.358	134.830	157.301	179.773	202.244	224.716
	25%	56.179	84.268	112.358	140.447	168.537	196.626	224.716	252.805	280.894
	30%	67.415	101.122	134.830	168.537	202.244	235.951	269.659	303.366	337.073
	35%	78.650	117.976	157.301	196.626	235.951	275.277	314.602	353.927	393.253
	40%	89.886	134.830	179.773	224.716	269.659	314.602	359.545	404.488	449.431

Source: own elaboration

One may multiply the yearly incentives (Table 48) by a longer time period (5 years) to have an idea of their financial dimension. The table below presents the cumulated incentives for a 5-year period, based on EUROSTAT data for 2014.

Table 50 - Potential benefits for the shipping sector over a 5-year period, depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000). Based on 2014 data

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	31.650	47.475	63.300	79.125	94.950	110.775	126.600	142.425	158.250
	4%	63.300	94.950	126.600	158.250	189.901	221.551	253.201	284.851	316.501
	6%	94.950	142.425	189.901	237.376	284.851	332.326	379.801	427.276	474.751
	8%	126.600	189.901	253.201	316.501	379.801	443.101	506.402	569.702	633.002
	10%	158.250	237.376	316.501	395.626	474.751	553.877	633.002	712.127	791.252
	12%	189.901	284.851	379.801	474.751	569.702	664.652	759.602	854.553	949.503
	14%	221.551	332.326	443.101	553.877	664.652	775.427	886.203	996.978	1.107.753
	16%	253.201	379.801	506.402	633.002	759.602	886.203	1.012.803	1.139.404	1.266.004
	18%	284.851	427.276	569.702	712.127	854.553	996.978	1.139.404	1.281.829	1.424.254
	20%	316.501	474.751	633.002	791.252	949.503	1.107.753	1.266.004	1.424.254	1.582.505
	25%	395.626	593.439	791.252	989.066	1.186.879	1.384.692	1.582.505	1.780.318	1.978.131
	30%	474.751	712.127	949.503	1.186.879	1.424.254	1.661.630	1.899.006	2.136.382	2.373.757
	35%	553.877	830.815	1.107.753	1.384.692	1.661.630	1.938.569	2.215.507	2.492.445	2.769.384
	40%	633.002	949.503	1.266.004	1.582.505	1.899.006	2.215.507	2.532.008	2.848.509	3.165.010

Source: own elaboration

Taking into account short-sea shipping only, the incentives for the sector over a 5-year period would be:

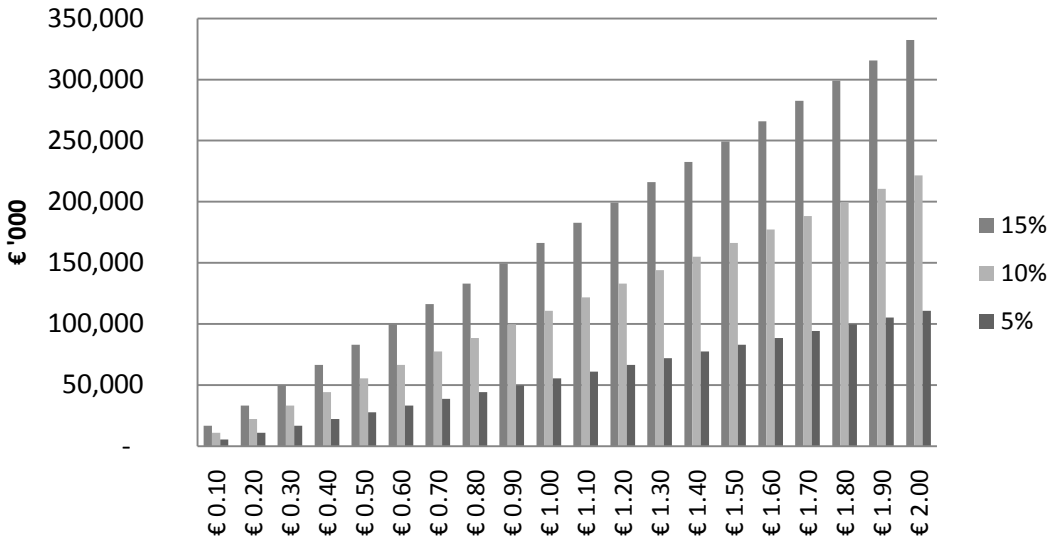
Table 51 - Potential benefits for the shipping sector (short-sea shipping only) over a 5-year period, depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000). Based on 2014 data

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	22.472	33.707	44.943	56.179	67.415	78.650	89.886	101.122	112.358
	4%	44.943	67.415	89.886	112.358	134.830	157.301	179.773	202.244	224.716
	6%	67.415	101.122	134.830	168.537	202.244	235.951	269.659	303.366	337.073
	8%	89.886	134.830	179.773	224.716	269.659	314.602	359.545	404.488	449.431
	10%	112.358	168.537	224.716	280.894	337.073	393.253	449.431	505.610	561.789
	12%	134.830	202.244	269.659	337.073	404.488	471.903	539.317	606.733	674.147
	14%	157.301	235.951	314.602	393.253	471.903	550.553	629.204	707.854	786.505
	16%	179.773	269.659	359.545	449.431	539.317	629.204	719.090	808.977	898.863
	18%	202.244	303.366	404.488	505.610	606.733	707.854	808.977	910.099	1.011.220
	20%	224.716	337.073	449.431	561.789	674.147	786.505	898.863	1.011.220	1.123.579
	25%	280.894	421.342	561.789	702.237	842.684	983.131	1.123.579	1.264.026	1.404.473
	30%	337.073	505.610	674.147	842.684	1.011.220	1.179.757	1.348.294	1.516.831	1.685.367
	35%	393.253	589.879	786.505	983.131	1.179.757	1.376.384	1.573.010	1.769.636	1.966.263
	40%	449.431	674.147	898.863	1.123.579	1.348.294	1.573.010	1.797.726	2.022.441	2.247.157

Source: own elaboration

The total contribution depends on the average tariff that is used for the exercise, as shown in Figure 10 below. The figure shows the total European contribution, given a 7% number of eligible ships, for different average tariffs per GT and three discounts. The higher the tariff, the higher is the difference between discounts.

Figure 10 - Comparison of different charges per GT, with 5%, 10% and 15% average discounts



Furthermore, based on EUROSTAT data, the potential benefits for the shipping sector may also be broken down by type of ship. To make this scenario consistent with the previous ones, an average fee of € 0,20 per tonne is kept. A series of tables below show potential yearly benefits broken down by different ship categories. It should be noted that, due to confidentiality, full data are not available for every country and ship type. Therefore, below are only presented the ship types for which a complete or nearly complete dataset is available on EUROSTAT:

Table 52 - Potential yearly benefits for liquid bulk tankers, depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000). Based on 2014 data

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	616	925	1.233	1.541	1.849	2.158	2.466	2.774	3.082
	4%	1.233	1.849	2.466	3.082	3.699	4.315	4.932	5.548	6.164
	6%	1.849	2.774	3.699	4.623	5.548	6.473	7.397	8.322	9.247
	8%	2.466	3.699	4.932	6.164	7.397	8.630	9.863	11.096	12.329
	10%	3.082	4.623	6.164	7.706	9.247	10.788	12.329	13.870	15.411
	12%	3.699	5.548	7.397	9.247	11.096	12.945	14.795	16.644	18.493
	14%	4.315	6.473	8.630	10.788	12.945	15.103	17.261	19.418	21.576
	16%	4.932	7.397	9.863	12.329	14.795	17.261	19.726	22.192	24.658
	18%	5.548	8.322	11.096	13.870	16.644	19.418	22.192	24.966	27.740
	20%	6.164	9.247	12.329	15.411	18.493	21.576	24.658	27.740	30.822
	25%	7.706	11.558	15.411	19.264	23.117	26.970	30.822	34.675	38.528
	30%	9.247	13.870	18.493	23.117	27.740	32.364	36.987	41.610	46.234
	35%	10.788	16.182	21.576	26.970	32.364	37.758	43.151	48.545	53.939
	40%	12.329	18.493	24.658	30.822	36.987	43.151	49.316	55.480	61.645

Source: own elaboration

Table 53 - Potential yearly benefits for dry bulk carriers, depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000). Based on 2014 data

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	315	473	630	788	945	1.103	1.261	1.418	1.576
	4%	630	945	1.261	1.576	1.891	2.206	2.521	2.836	3.151
	6%	945	1.418	1.891	2.364	2.836	3.309	3.782	4.254	4.727
	8%	1.261	1.891	2.521	3.151	3.782	4.412	5.042	5.672	6.303
	10%	1.576	2.364	3.151	3.939	4.727	5.515	6.303	7.091	7.878
	12%	1.891	2.836	3.782	4.727	5.672	6.618	7.563	8.509	9.454
	14%	2.206	3.309	4.412	5.515	6.618	7.721	8.824	9.927	11.030
	16%	2.521	3.782	5.042	6.303	7.563	8.824	10.084	11.345	12.606
	18%	2.836	4.254	5.672	7.091	8.509	9.927	11.345	12.763	14.181
	20%	3.151	4.727	6.303	7.878	9.454	11.030	12.606	14.181	15.757
	25%	3.939	5.909	7.878	9.848	11.818	13.787	15.757	17.727	19.696
	30%	4.727	7.091	9.454	11.818	14.181	16.545	18.908	21.272	23.635
	35%	5.515	8.272	11.030	13.787	16.545	19.302	22.060	24.817	27.575
	40%	6.303	9.454	12.606	15.757	18.908	22.060	25.211	28.362	31.514

Source: own elaboration

Table 54 - Potential yearly benefits for container ships, depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000). Based on 2014 data

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	1.003	1.504	2.006	2.507	3.009	3.510	4.012	4.513	5.015
	4%	2.006	3.009	4.012	5.015	6.018	7.020	8.023	9.026	10.029
	6%	3.009	4.513	6.018	7.522	9.026	10.531	12.035	13.540	15.044
	8%	4.012	6.018	8.023	10.029	12.035	14.041	16.047	18.053	20.059
	10%	5.015	7.522	10.029	12.537	15.044	17.551	20.059	22.566	25.073
	12%	6.018	9.026	12.035	15.044	18.053	21.061	24.070	27.079	30.088
	14%	7.020	10.531	14.041	17.551	21.061	24.572	28.082	31.592	35.102
	16%	8.023	12.035	16.047	20.059	24.070	28.082	32.094	36.105	40.117
	18%	9.026	13.540	18.053	22.566	27.079	31.592	36.105	40.619	45.132
	20%	10.029	15.044	20.059	25.073	30.088	35.102	40.117	45.132	50.146
	25%	12.537	18.805	25.073	31.341	37.610	43.878	50.146	56.415	62.683
	30%	15.044	22.566	30.088	37.610	45.132	52.654	60.176	67.698	75.220
	35%	17.551	26.327	35.102	43.878	52.654	61.429	70.205	78.981	87.756
	40%	20.059	30.088	40.117	50.146	60.176	70.205	80.234	90.263	100.293

Source: own elaboration

Table 55 - Potential yearly benefits for specialised carriers, depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000). Based on 2014 data

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	178	267	356	445	534	623	712	801	890
	4%	356	534	712	890	1.068	1.245	1.423	1.601	1.779
	6%	534	801	1.068	1.334	1.601	1.868	2.135	2.402	2.669
	8%	712	1.068	1.423	1.779	2.135	2.491	2.847	3.203	3.558
	10%	890	1.334	1.779	2.224	2.669	3.114	3.558	4.003	4.448
	12%	1.068	1.601	2.135	2.669	3.203	3.736	4.270	4.804	5.338
	14%	1.245	1.868	2.491	3.114	3.736	4.359	4.982	5.604	6.227
	16%	1.423	2.135	2.847	3.558	4.270	4.982	5.693	6.405	7.117
	18%	1.601	2.402	3.203	4.003	4.804	5.604	6.405	7.206	8.006
	20%	1.779	2.669	3.558	4.448	5.338	6.227	7.117	8.006	8.896
	25%	2.224	3.336	4.448	5.560	6.672	7.784	8.896	10.008	11.120
	30%	2.669	4.003	5.338	6.672	8.006	9.341	10.675	12.010	13.344
	35%	3.114	4.670	6.227	7.784	9.341	10.898	12.454	14.011	15.568
	40%	3.558	5.338	7.117	8.896	10.675	12.454	14.234	16.013	17.792

Source: own elaboration

Table 56 - Potential yearly benefits for general cargo (not specialised), depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000). Based on 2014 data

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	3.283	4.925	6.567	8.208	9.850	11.492	13.134	14.775	16.417
	4%	6.567	9.850	13.134	16.417	19.700	22.984	26.267	29.550	32.834
	6%	9.850	14.775	19.700	24.625	29.550	34.475	39.401	44.326	49.251
	8%	13.134	19.700	26.267	32.834	39.401	45.967	52.534	59.101	65.668
	10%	16.417	24.625	32.834	41.042	49.251	57.459	65.668	73.876	82.084
	12%	19.700	29.550	39.401	49.251	59.101	68.951	78.801	88.651	98.501
	14%	22.984	34.475	45.967	57.459	68.951	80.443	91.935	103.426	114.918
	16%	26.267	39.401	52.534	65.668	78.801	91.935	105.068	118.202	131.335
	18%	29.550	44.326	59.101	73.876	88.651	103.426	118.202	132.977	147.752
	20%	32.834	49.251	65.668	82.084	98.501	114.918	131.335	147.752	164.169
	25%	41.042	61.563	82.084	102.606	123.127	143.648	164.169	184.690	205.211
	30%	49.251	73.876	98.501	123.127	147.752	172.377	197.003	221.628	246.253
	35%	57.459	86.189	114.918	143.648	172.377	201.107	229.836	258.566	287.296
	40%	65.668	98.501	131.335	164.169	197.003	229.836	262.670	295.504	328.338

Source: own elaboration

Table 57 - Potential yearly benefits for cruise ships depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000). Based on 2014 data

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30,0%	35%	40%	45%	50%
	2%	324	486	648	810	972	1.134	1.296	1.458	1.620
	4%	648	972	1.296	1.620	1.944	2.268	2.593	2.917	3.241
	6%	972	1.458	1.944	2.430	2.917	3.403	3.889	4.375	4.861
	8%	1.296	1.944	2.593	3.241	3.889	4.537	5.185	5.833	6.481
	10%	1.620	2.430	3.241	4.051	4.861	5.671	6.481	7.291	8.102
	12%	1.944	2.917	3.889	4.861	5.833	6.805	7.778	8.750	9.722
	14%	2.268	3.403	4.537	5.671	6.805	7.940	9.074	10.208	11.342
	16%	2.593	3.889	5.185	6.481	7.778	9.074	10.370	11.666	12.963
	18%	2.917	4.375	5.833	7.291	8.750	10.208	11.666	13.125	14.583
	20%	3.241	4.861	6.481	8.102	9.722	11.342	12.963	14.583	16.203
	25%	4.051	6.076	8.102	10.127	12.152	14.178	16.203	18.229	20.254
	30%	4.861	7.291	9.722	12.152	14.583	17.013	19.444	21.874	24.305
	35%	5.671	8.507	11.342	14.178	17.013	19.849	22.684	25.520	28.356
	40%	6.481	9.722	12.963	16.203	19.444	22.684	25.925	29.166	32.406

Source: own elaboration

Table 58 - Potential yearly benefits for passenger ships (excluding cruise), depending on a general discount available on eligible ships in all ports of the EU (23 Member States plus Turkey and Norway), assuming an average port fee of € 0.20/GT, (amounts in € '000). Based on 2014 data

		% average discount								
Number of eligible calls		10%	15%	20%	25%	30%	35%	40%	45%	50%
	2%	392	589	785	981	1.177	1.374	1.570	1.766	1.962
	4%	785	1.177	1.570	1.962	2.355	2.747	3.140	3.532	3.925
	6%	1.177	1.766	2.355	2.943	3.532	4.121	4.710	5.298	5.887
	8%	1.570	2.355	3.140	3.925	4.710	5.494	6.279	7.064	7.849
	10%	1.962	2.943	3.925	4.906	5.887	6.868	7.849	8.830	9.812
	12%	2.355	3.532	4.710	5.887	7.064	8.242	9.419	10.596	11.774
	14%	2.747	4.121	5.494	6.868	8.242	9.615	10.989	12.363	13.736
	16%	3.140	4.710	6.279	7.849	9.419	10.989	12.559	14.129	15.698
	18%	3.532	5.298	7.064	8.830	10.596	12.363	14.129	15.895	17.661
	20%	3.925	5.887	7.849	9.812	11.774	13.736	15.698	17.661	19.623
	25%	4.906	7.359	9.812	12.264	14.717	17.170	19.623	22.076	24.529
	30%	5.887	8.830	11.774	14.717	17.661	20.604	23.548	26.491	29.435
	35%	6.868	10.302	13.736	17.170	20.604	24.038	27.472	30.906	34.340
	40%	7.849	11.774	15.698	19.623	23.548	27.472	31.397	35.322	39.246

Source: own elaboration

6.4 Assessing the impact for port authorities

In order to assess the impact on a specific port authority the following parameters need to be defined:

- No of calls
- Average GT per call
- Average tariff per GT
- Percentage of eligible calls
- Percentage discount (if applicable)
- Surcharge (if applicable)
- Base index / certification (ESI, GA, RS, BE, CSI)
- Quantity earmarked (if applicable)
- Price elasticity of demand
- Price elasticity of environmental change (percentage change in the number of eligible call on the percentage change of charges/rebates)

In order to compare the impact of the schemes on the finances of the port authority, a base line needs to be defined. The parameters selected for the base line are listed in the table below.

Table 59 – Baseline assumptions

Assumptions	
No of calls	12.000
Average ships size	64.000
Average tariff per GT	€ 0,2144
Discount	10%
Surcharge	1%
Available budget	€ 100.000
Percentage of eligible calls	1%
Price elasticity of demand	-1
Price elasticity of environmental change	0

Source: own elaboration

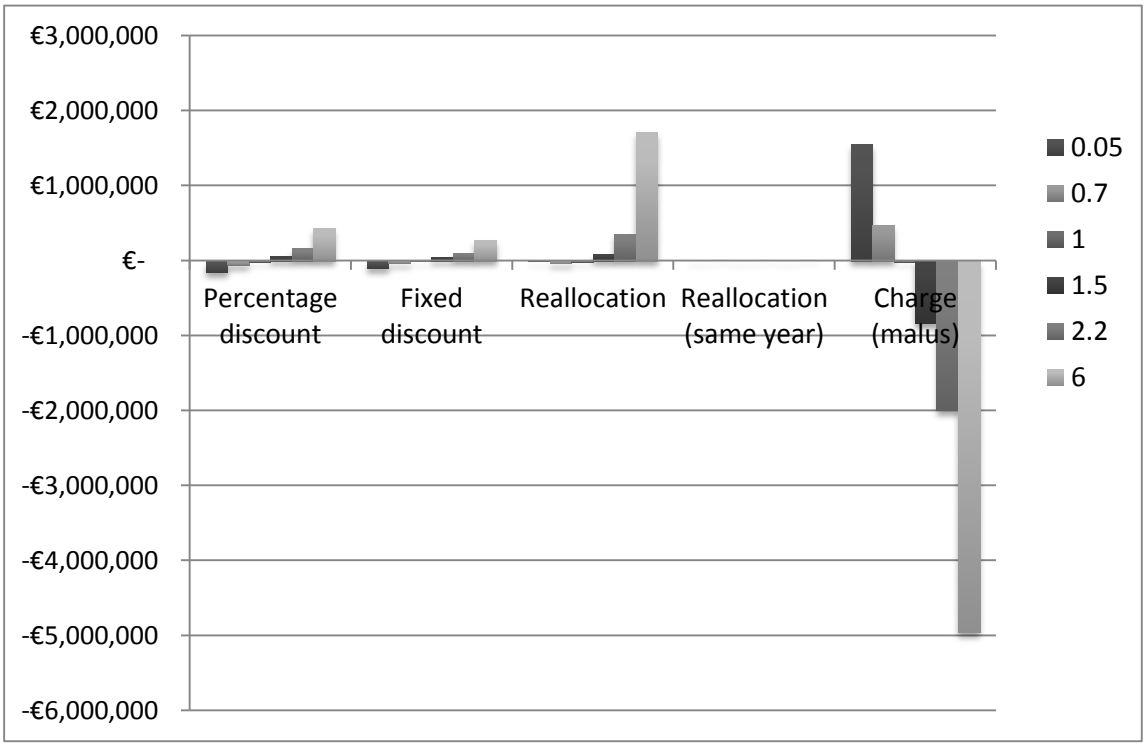
Starting from the baseline, multiple what-if scenarios can be defined to assess the impact of such a scheme on the port authority. The scenarios look at the dependence of results and optimality of a scheme for multiple elasticity values, differences in the rebate percentage or values of a charge, and, in the case of a fixed budget, the available budget. It is important to consider that an important parameter is the response of the shipping sector to green charges in terms of implementation of green technologies. In this case, a very low response is considered, assuming that at least in the short run it is not possible to modify the structure of the fleet.

The scenarios looked at are: (i) how the regular tariffs need to be amended to apply the scheme, and (ii) how the regular tariffs differ from the differentiated tariff. The scenarios also look at the average tariff and discount per call. Using an economic set of assumptions, the change in the number of calls is also calculated. It is important to stress that tariff setting in ports is not done in a vacuum, and competition issues are very relevant especially among ports serving the same hinterland. Finally, the total changes in the port revenues are also estimated.

The first parameter to look at is elasticity. Inelastic demand (elasticity value lower than 1) implies little responsiveness of the sector to changes in prices, while elastic demand (elasticity value higher than 1) implies that owners have other options for loading and unloading. In case of high elasticities, schemes can reach budget parity, but it should be stressed that limits exist on the amount of discounts that can be offered. Furthermore, shipping segments have different elasticity values that change over time, and thus an accurate estimation is difficult also when a detailed market study is available.

The figure below shows the changes in the total revenue for the port authority with respect to the baseline.

Figure 11 - Comparison of multiple schemes on the revenues of the port authority with different elasticity figures



Source: own elaboration

As can be noted, when it comes to systems based on discounts, low elasticities tend to result in (moderate) losses for port. This is because, as explained above, when ship owners are not significantly responsive to tariffs changes, the scheme is not able to attract many new ships to the port. Vice versa, when elasticity is high (ship owners are quite sensitive to tariff variations) discounts tend to attract a higher number of green ships that want to benefit from reduced port dues, to the point of actually generating revenue for the port.

The opposite is true when the scheme is based on a surcharge (malus) for more polluting ships. In this case, when elasticity is low and ship owners tend to be insensitive to tariff variations, the surcharge has the effect of increasing port revenue, since it results in a higher average tariff. Likewise, as elasticity increases, ship owners may decide to call other ports that offer lower tariffs, thus generating significant losses for the port.

It should also be noted that the reallocation within the same year, as it is based on perfect budget neutrality, is completely independent from elasticities. These types of schemes, however, result in uncertainty for ship owners, who do not know until the end of the year whether they will receive a rebate and what such a rebate will be.

The same results exemplified in Figure 11 can be seen in the following table.

Table 60 - Revenue losses depending on the scheme and market elasticities

Type of scheme	Elasticities values					
	- 0.05	- 0.7	- 1	- 1.5	- 2.2	- 6
Percentage discount	-€78,419	-€27,580	-€4,116	€34,990	€89,739	€230,523
Fixed discount	-€48	-€15	-€0	€25	€60	€150
Reallocation	-€3,923	-€19,310	-€4,117	€52,474	€197,318	€920,788
Reallocation (same year)	-€0	€0	€0	€0	€0	€0
Charge (malus)	€1,547,805	€477,627	-€16,301	-€839,515	-€1,992,014	-€4,955,583

Source: own elaboration

In light of the above, it can be argued that an important issue relates to the ability of the port to attract new green ships by offering them discounts. This is a short-term impact, as it has to be assumed that ships will be substituted from one port to another when possible. Such substitution also depends from the demand elasticity and change with respect to the baseline (120 calls) is shown in the table below.

Table 61 - Change in eligible (green) calls (base line 120 calls)

Elasticity	5% rebate	10% rebate	15% rebate	20% rebate	30% rebate	40% rebate	50% rebate
0,05	120,30	120,60	120,90	121,20	121,80	122,40	123,00
0,7	124,20	128,40	132,60	136,80	145,20	153,60	162,00
1	126,00	132,00	138,00	144,00	156,00	168,00	180,00
1,5	129,00	138,00	147,00	156,00	174,00	192,00	210,00
2,2	133,20	146,40	159,60	172,80	199,20	225,60	252,00
4	144,00	168,00	192,00	216,00	264,00	312,00	360,00

Source: own elaboration

A distinction needs to be made in case the port opted for a fixed budget. Clearly the higher the budget the higher should be the loss for the port authority. However, in case of an elastic demand, the increase in the number of calls due to the rebate can reduce the impact on the total revenue, although this will not be detected in the port authority accounts, as it will be confounded in the change in the number of yearly calls. An example of the impact of different fixed budgets on the finances of the port authority is given in the following table.

Table 62 - Example of changes in different fixed budgets for larger ports (elasticity -1)

Necessary Budget (€)	Discount per call (€)	New normal tariff (€)	Green tariff (€)	New average tariff (€)	New regular calls	New eligible calls	New no of calls	Loss or profit (€)	% on total revenue
0	0	0,2144	0,2144	0,2144	12.000	0	12.000	-	0,000%
10.000	83,33	0,2144	0,2131	0,2144	11.880	121	12.001	-61	0,000%
50.000	416,67	0,2144	0,2079	0,2143	11.880	124	12.004	-1.518	-0,001%
100.000	833,33	0,2144	0,2014	0,2143	11.880	127	12.007	-6.073	-0,004%
150.000	1.250,00	0,2144	0,1949	0,2142	11.880	131	12.011	-13.665	-0,008%
200.000	1.666,67	0,2144	0,1884	0,2141	11.880	135	12.015	-24.293	-0,015%

Source: own elaboration

Table 62 above is based on the baseline at the opening of this section, which represents a rather large port. In case we considered a smaller port (4.000 calls and an average ship size of 30.000 tonnes), the situation would be as follows:

Table 63 - Example of changes in different fixed budgets for smaller ports (elasticity -1)

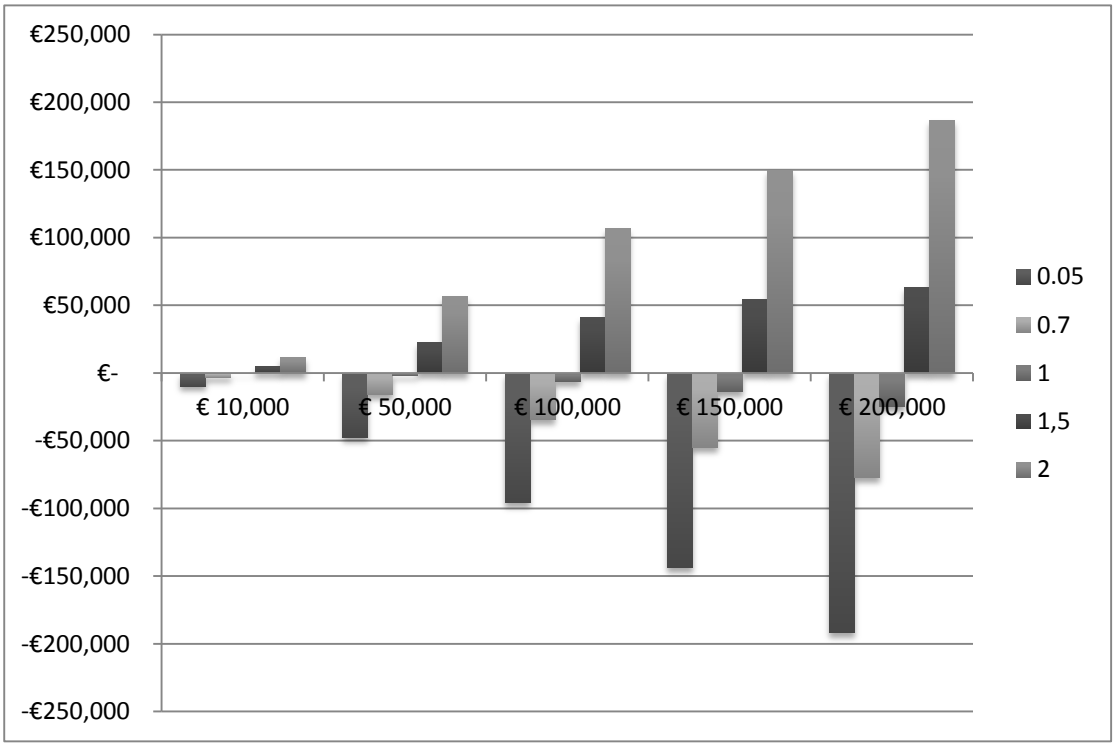
Necessary Budget (€)	Discount per call (€)	New normal tariff (€)	Green tariff (€)	New average tariff (€)	New regular calls	New Eligible calls	New no of calls	Loss or profit (€)	% on total revenue
0	0,00	0,2144	0,2144	0,2144	4000	0	4.000	0	0,000%
10.000	250,00	0,2144	0,2061	0,2143	3960	42	4.002	-389	-0,002%
50.000	1.250,00	0,2144	0,1727	0,2140	3960	48	4.008	-9.717	-0,038%
100.000	2.500,00	0,2144	0,1311	0,2136	3960	56	4.016	-38.868	-0,151%
150.000	3.750,00	0,2144	0,0894	0,2132	3960	63	4.023	-87.453	-0,340%
200.000	5.000,00	0,2144	0,0477	0,2127	3960	71	4.031	-155.473	-0,604%

Source: own elaboration

The reduced number of calls results in a higher discount per eligible call that pushes down the green tariff as the budget increases. This is especially evident when the budget set aside for the scheme is higher than € 100.000. A green tariff so close to € 0 obviously results in higher losses for ports, which cannot be partially compensated by an increased number of green ships starting to call at the port due to lower tariffs. This shows that, when adopting this type of scheme, ports may want to set a level of budget compatible with their expected number of new eligible calls in order to minimise losses. As one could have expected, larger ports can afford higher budgets for environmental charging, not merely because they tend to be 'richer', but mainly because, when the demand is elastic to tariffs, they can more effectively counteract losses through revenues generated by an increased number of green ships calling at the port on account of lower tariffs.

The impact of the budget, too, depends on elasticity, as shown in the figure below. For higher elasticities, the increase in the number of calls can largely compensate the costs of the scheme. It should be noted, however, that, in general, demand for port services is rather inelastic to prices, as a result of competition effects and of the derived nature of demand for transport.

Figure 12 - Sensitivity to different fixed budgets on total budget



Source: own elaboration

In the last two paragraphs, the impact of environmental charging on the shipping industry and on ports is analysed. Even though when cumulated across several calls rebates tend to reach a significant financial dimension, one of the first considerations that may come to mind is that port dues are only a fraction of the total costs borne by a ship owner. It has been estimated that they may account from 3% to 15% of operating costs for cargo ships[58].If other costs are factored in, the benefits of environmental charging may become less evident, and so would the incentive to become greener. Hence one may be tempted to conclude that even a more consistent approach to environmental charging across the EU may not necessarily have an appreciable impact on the shipping industry, in that the economic benefits generated, compared with the total costs that ship owners bear, may not be as strong an incentive as to alter ship owners' behaviour.

However, from the point of view of a port, harbouring cleaner ships would mean to improve (or try to) significant environmental aspects such as air quality and waste basically at the cost of the environmental charging scheme budget, or at no cost at all in the case of revenue-neutral schemes. From the ship owners' viewpoint, on the other hand, while there may be little economic incentive in becoming greener if only taxes and tariff reductions are taken into account, one should also consider that the shipping industry has long been on an effort to reduce its environmental footprint, also on account of significant criticisms voiced by environmental organisations as to the negative impact of shipping in port cities. As part of this effort, several shipping lines have already taken measures to adopt more stringent standards than those required by law. The costs connected with the process that in the scenario would also make the ship eligible for rebates should be analysed within the wider context of 'becoming greener', and not simply as a way to pay lower tariffs.

If one takes into account the overall framework, different considerations are to be made. A more consistent approach to environmental charging might be considered as a weak incentive for ship owners to become greener from a merely economic perspective. Nonetheless, albeit not particularly significant, the incentive still exists and would make it possible to save a certain amount of money in port dues per each call.

[58] See Alderton, P. M., Reeds Sea Transport, Operations and Economics, 2011, p. 138. See also Trujillo, L. and Nombela, G. (1999), Privatisation and Regulation of the Seaport Industry. Policy Research Working Paper No 2181. The World Bank. Washington D.C.

Furthermore, acquiring an environmental certification, or participating in an index, may yield substantial benefits in terms of image, and could also be seen as one of the steps to reduce the overall environmental footprint of the industry; an effort whose costs would be partly compensated by the reduced port dues.

In other words, a more consistent approach to environmental charging could be seen as a 'win-win' situation, where basically none of the parties has anything to lose, while all of them can harvest the benefits of cleaner air and better waste management, both in terms of reduced environmental footprint and improved reputation.

6.5 The impact of environmental charging on ship owners' investments

In this section, a set of scenarios are developed to establish whether and to what extent environmental charging may constitute an economic incentive that can persuade ship owners to invest in greener technologies.

6.5.1 Investing in on-shore power supply

It may be interesting to assess whether and to what extent environmental charging can contribute to making an investment in on-shore power supply (OPS) more profitable.

OPS is a technology that enables vessels to replace the use of auxiliary engines whilst at berth. The technology is sometimes also referred to as Cold Ironing, Alternative Maritime Power (AMP), or High/Low Voltage Shore Connection (HVSC/LVSC).

Whilst in port, vessels require electricity for various activities, including loading and discharging cargo, heating, lighting and air conditioning. The required power is normally generated by diesel-fuelled auxiliary engines emitting sulphur dioxide (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), particulate matter (PM), carbon dioxide (CO_2) and other greenhouse gases (GHG), negatively affecting air quality of local communities. Low frequency noise from auxiliary engines is another local environmental problem in ports. Instead of generating the power on-board, by means of auxiliary engines, there are technologies enabling vessels to connect to the local electricity grid. As environmental awareness and concern have grown in the shipping sector and stricter requirements on emissions have been enforced, OPS technology is generating increasing interest amongst ports, ship owners and local communities as a way to mitigate emissions and noise problems[59].

There is ongoing debate over the effectiveness of on-shore power supply in reducing emissions. While it is obvious that generating power via the local electricity grid clearly reduces emissions in port area, one may object that emissions are in fact only 'moved' from the port area to the place where the electric power plant is located. Furthermore, if electric power is not generated by renewable sources, it may be argued that the use of OPS may pollute even more than auxiliary engines. Nonetheless, OPS in ports is generally regarded as a green technology, mainly because the energy mix in most EU Member States is being diversified with an ever-increasing share of renewable sources. Moreover, even if electric energy were produced from fossil fuels, it should be noted that power plants tend to be located far from the coast in less densely populated areas, their emissions thus potentially affecting a lower number of people. Finally, it should also be noted that even when OPS is generated through fossil-fuelled power plants, these are subject to EU legislation (Directive on Medium Combustion Plants or the Directive on Industrial Emissions, notably Large Combustion Plants). Such installations are subject to permitting and employ trained professionals dealing with the stack emissions, whereas this is likely not the case on a vessel.

[59] Clean North Sea Shipping, Onshore Power Supply (OPS) Survey, March 2014.

On its website, the World Ports Climate Initiative (WPCI) has made available a simple calculation tool that helps develop a feeling for the costs and benefits of OPS. The tool is filled out with characteristic data, but can be readily adapted to any local situation by changing the cost figures and data on the number of ships and their fuel consumption.

The tool can be used for two main specific goals: (i) to calculate the annual costs and benefits of OPS, and (ii) to calculate the annual emission reduction. In addition, the tool makes it possible to estimate the effects of different parameters on costs and emissions, thus providing insights into cost effectiveness[60].

Since OPS requires an investment both on the side of the port and the shipping company, in this scenario cost effectiveness is evaluated for the integral project, and not for individual parties. Subsequently, the analysis will seek to understand whether and how environmental charging can be used as a leverage by ports to convince shipping lines to invest in OPS.

WPCI's tool makes it possible to calculate the costs and benefits of OPS for different types of ships. However, the business case for OPS is most attractive for ships that have a high electricity demand per berthing. High energy consumption in ports and low peak power demand would further improve the business case. The business case for SSE is found to be most attractive for cruise ships, container ships and RoRo[61]. The scenario will thus focus on a 25.000-GT RoRo vessel that requires a 1,5 MVA connection.

It is assumed that the vessel calls a port 30 times a year and spends an average time of 24 hours at berth per call.

Considering an interest rate at 6% and a depreciation period of 10 years, the total yearly costs can be broken down as follows:

Investment costs terminal:

1. High voltage connection from grid (including transformer): € 200.000
2. Cable installation: € 225.000
3. Total investment: € 425.000
4. Maintenance, contract and electricity transport costs (15%): € 63.750
5. **Total yearly investment costs for terminal: € 121.494**

Investment costs ship:

1. Transformer: € 200.000
2. Main switchboard control panel: € 100.000
3. Cabling: € 3.000
4. Cable reel system: € 152.000
5. Total investment: € 455.000
6. **Total yearly investment costs for ship: 61.820**

[60] For more details on the tool and the methodology adopted, please see http://wpci.iaphworldports.org/onshore-power-supply/implementation/ops-calculation-tool.html

[61] Potential for Shore Side Electricity in Europe, Ecofys, January 2015. Available online at http://www.ecofys.com/files/files/ecofys-2014-potential-for-shore-side-electricity-in-europe.pdf

The first step is to calculate whether in this specific example there is a business case for the ship owner, regardless of environmental charging. To do so, it is necessary to compare the operating costs of OPS with the operating costs of generating electricity at berth by burning HFO or marine diesel.

Assuming an electricity price of 0,08m €/kWh, a tax of 0,03 €/kWh and a consumption of 800 kWh, the yearly operating costs of OPS for the vessel considered would be:

1. Electricity costs: € 60.480
2. Saved engine maintenance: € 3.456
3. **Total yearly operating costs: € 57.024**

These costs should then be compared with the costs of generating electricity through auxiliary engines. With the oil price remarkably low as at the time of writing, we may assume a price of marine diesel of $ 350 per tonne and a consumption of 0,2 tonnes per hour. The total yearly costs would be € 29.272.

One may argue that there is no point in calculating the payback period of the investment. Operating OPS from vessel side is more expensive than using auxiliary engines by € 27.752 a year. Unless oil price skyrocketed again, under these conditions the investment cannot possibly be paid back.

The question to ask is thus whether environmental charging can make the investment profitable, by compensating higher operating costs of OPS with possible incentives from rebates on port dues.

For the sake of consistency with the previous scenarios, once again an average fee per GT of € 0,2144 is assumed. In the first phase of the study, it was observed that some ports offer rebates up to 50% of total port dues to vessels that use OPS rather than auxiliary engines at berth. Considering that port dues are the main source of revenue for ports, a 50% rebate, albeit observable in the real world, may seem unrealistic. Therefore, for our analysis a 30% rebate to vessels that use OPS is assumed.

For the ship owner, the resulting incentives would change the situation as follows:

Table 64 - Comparison between OPS payback periods with and without incentives from a 30% rebate on port dues for a ship that calls 30 ports a year

Year	Annual investment costs	Operating costs OPS	Savings from saved maintenanc	Rebates from green charging	Savings from fuel	Payback	Payback without rebates
0	€ 455.000	€ 60.480	€ 3.456	€ 48.240	€ 29.272	€ 434.512	€ 482.752
1	-	€ 120.960	€ 6.912	€ 96.480	€ 58.544	€ 414.024	€ 510.504
2	-	€ 181.440	€ 10.368	€ 144.720	€ 87.816	€ 393.536	€ 538.256
3	-	€ 241.920	€ 13.824	€ 192.960	€ 117.088	€ 373.048	€ 566.008
4	-	€ 302.400	€ 17.280	€ 241.200	€ 146.360	€ 352.560	€ 593.760
5	-	€ 362.880	€ 20.736	€ 289.440	€ 175.632	€ 332.072	€ 621.512
6	-	€ 423.360	€ 24.192	€ 337.680	€ 204.904	€ 311.584	€ 649.264
7	-	€ 483.840	€ 27.648	€ 385.920	€ 234.176	€ 291.096	€ 677.016
8	-	€ 544.320	€ 31.104	€ 434.160	€ 263.448	€ 270.608	€ 704.768
9	-	€ 604.800	€ 34.560	€ 482.400	€ 292.720	€ 250.120	€ 732.520
10		€ 665.280	€ 38.016	€ 530.640	€ 321.992	-€ 225.368	€ 305.272

Source: own elaboration

Payback period does not take into account the time value of money. To do that, discounted payback period should be used. However, for the sake of simplicity the time value of money, as well as the interest rate of the loan (if any) is excluded from our analysis.

A rebate of 30% would result in € 48.240 saved by the ship owner every year. In other words, the rebate is tantamount to lowering the operating costs of OPS to the point of making it less expensive than generating electricity through auxiliary engines.

In the example above, the investment is paid back one year after its depreciation period, thus suggesting that OPS needs to be used after its useful life. However, should the rebate be increased to 50%, the investment would be fully paid back before its useful life:

Table 65 - Comparison between OPS payback periods with and without incentives from a 50% rebate on port dues for a ship that calls 30 ports a year

Year	Annual investment costs	Operating costs OPS	Savings from saved maintenanc	Rebates from green charging	Savings from fuel	Payback	Payback without rebates
0	€ 455.000	€ 60.480	€ 3.456	€ 80.400	€ 29.272	€ 402.352	€ 482.752
1	-	€ 120.960	€ 6.912	€ 160.800	€ 58.544	€ 349.704	€ 510.504
2	-	€ 181.440	€ 10.368	€ 241.200	€ 87.816	€ 297.056	€ 538.256
3	-	€ 241.920	€ 13.824	€ 321.600	€ 117.088	€ 244.408	€ 566.008
4	-	€ 302.400	€ 17.280	€ 402.000	€ 146.360	€ 191.760	€ 593.760
5	-	€ 362.880	€ 20.736	€ 482.400	€ 175.632	€ 139.112	€ 621.512
6	-	€ 423.360	€ 24.192	€ 562.800	€ 204.904	€ 86.464	€ 649.264
7	-	€ 483.840	€ 27.648	€ 643.200	€ 234.176	€ 33.816	€ 677.016
8	-	€ 544.320	€ 31.104	€ 723.600	€ 263.448	-€ 18.832	€ 704.768
9	-	€ 604.800	€ 34.560	€ 804.000	€ 292.720	-€ 71.480	€ 732.520

Source: own elaboration

It is clear from the example above that environmental charging may be a powerful leverage to persuade ship owners to switch to OPS. Without environmental charging, in the current scenario of low oil prices, OPS may never make a good business case. At the same time, it should be borne in mind that the scenario analysed above applies to a specific type of ship with specific characteristics, whereas other ships may not find OPS as profitable. It is virtually impossible to estimate the costs and benefits of OPS as well as of environmental charging for every type of ship in the EU, as the different possibilities are endless. The above analysis serves as a conceptual framework to evaluate the costs and benefits of OPS in combination with environmental charging for a specific type of ship, and, while the model may be easily adapted to analyse other ships, its results should not be generalised.

On a different note, one should also consider that the investment in OPS has a cost for ports as well, as they have to make available the infrastructure at berth and, in line with our example above, they have to set aside a certain amount in their budget for rebates to green ships.
According to WPCI's tool, an investment such as the one necessary to satisfy the energy needs of the RoRo vessel in our example would cost a port € 121.494 per year (6% interest rate, depreciation period 10 years).

Naturally, OPS in the port will not only serve RoRo, but all the other vessels equipped to connect to the electricity grid at berth. Supposing that over the course of a year there are 9 more RoRo vessels that use OPS in the same port with the same frequency as above, this would mean that environmental charging would cost the port (€ 80.400 * 10 vessels) further € 804.000.

The total cost for the port would be (€ 121.494 + € 804.000) € 925.494. It is a quite significant investment that may discourage many port authorities from investing in OPS. However, since the use of OPS significantly cuts emissions in the port area, one should take into account the economic benefits from cleaner air in the port and its environs. WPCI's tool estimates the following emission cut per year for ten RoRo vessels that use OPS in a port:

Table 66 – Comparison between emissions generated at berth with and without OPS

Pollutants	Tonnes emitted with OPS	Tonnes emitted with Diesel
CO_2	2.016,00	4.055,04
NO_x	2,02	86,17
PM	0,02	2,66
SO_x	2,65	6,34

Source: own elaboration based on WPCI's tool

In economic terms, it is possible to assign a value to each tonne saved by calculating the marginal damage costs of each additional tonne emitted. The value assigned to each pollutant are inevitably different from country to country and port to port, since a wide array of local factors may impinge on the potential damage caused by each pollutant in a different way.

A study carried out in 2005 by AEA Technology Environment for DG Environment estimated the marginal damage costs of different pollutants in the EU-25[62]. If the port were located in the North Sea, according to AEA study, the cumulated savings resulting from reduced emissions through OPS could amount up to € 1.911.974,40[63]. Once again, a fundamental caution to keep in mind is that these results should not be extended to other geographical contexts, as marginal damage costs may be significantly higher or lower in other countries or regions. The model serves as a conceptual framework to prove the point that a correct environmental assessment should factor in considerations related to the emission reduction targets (efficacy), as well as to the costs incurred to meet them (efficiency).

In the example considered, if external environmental costs are factored in, the savings from reduced emissions in the port area outweigh the costs connected with the investment in OPS and the rebates for environmental charging.

It can be concluded that OPS is thus one of those green technologies for which environmental charging is suitable to play a decisive role to increase its uptake.

6.5.2 Installation of an LNG solution

Before actually developing these scenarios, it should be borne in mind that, given current evidence, the choice to make significant investments such as an LNG solution or a scrubber may not be based on the discounts that a ship owner expects to obtain through environmental charging schemes. This is even truer if one considers that in SECAs vessels are legally required to comply with a sulphur limit for fuel of 0,1% m/m, and thus are literally obliged either to burn cleaner fuels or to make an investment in a cleaner technology. Therefore, the scenarios considered simply seek to establish whether environmental charging can have an impact on the payback period of certain investments. The choice whether to make an investment in a scrubber or an LNG solution, or to burn cleaner fuel rests with ship owners.

In addition, it should be noted that the question whether scrubbers can be considered environmentally-friendly is controversial (more details below). For the purpose of this report, it is assumed that installing a scrubber simply is a valid option to be allowed to sail in a SECA.

[62] Holland M. et al., Damages per tonne emission of PM2.5, NH3, SO2, NOx and VOCs from each EU25 Member State (excluding Cyprus) and surrounding seas, 2005.
Available at http://ec.europa.eu/environment/archives/cafe/activities/pdf/cafe_cba_externalities.pdf.

[63] Please note that AEA's report does not estimate the marginal damage cost of a tonne of CO_2. This has been estimated at € 220 per tonne, based on a paper by Moore F. and Diaz, D., 'Temperature impacts on economic growth warrant stringent mitigation policy', Nature Climate Change, 2015.

As of 1 January 2015, sulphur content allowed in Sulphur Emission Control Areas (SECA) decreased from 0.1% m/m. To comply with such a stringent requirement, vessels sailing insides SECAs are required to either use distillate fuel such as marine gas oil (MGO), which is poorer in sulphur content and more expensive than regular heavy fuel oil (HFO), or find other ways of being compliant.

The most environmentally-friendly alternative to burning distillate fuel for being allowed to sail in SECAs is to install an LNG solution.

In light of the above, a scenario is concocted to establish whether and to what extent hypothetic incentives from environmental charging can influence the decision to invest in such a technology. The sources used for the scenario are:

- Den Boer E., Hoen M., Scrubbers – An economic and ecological assessment, prepared for NABU in 2015
- Acciaro M., A real option application to investment in low-sulphur maritime transport, in International Journal Shipping and Transport Logistics, vol. 6, n. 2, 2014

If we assume that LNG is an alternative to MGO in order to be allowed to sail in SECAs, the deciding factors influencing the investment decision for retrofitting to LNG are the fuel cost spread and the time spent in a SECA. The lower the spread between MGO and LNG, the less profitable is LNG, because the savings from burning cheaper fuel (LNG) rather than distillate can compensate the upfront cost of the investment over a comparatively longer period of time, to the point of not compensating it at all in case MGO and LNG should reach the same price.

Similarly, the longer the time spent in a SECA, the more profitable LNG is. If an LNG-fuelled vessel spends 100% of its time in a SECA, it means that, without LNG, it would have to burn the more expensive MGO for 100% of its time.

Another element to evaluate when deciding whether to retrofit is the remaining commercial life of the vessel. Older vessels with shorter commercial life may not have sufficient time to repay the costs of the upfront investment.

In this scenario, we consider a ship (product tanker or bulk carrier) with the following characteristics:

Gross tonnage	35.00 tonnes
Power	8 MW
LNG fuel consumption	6.162 tonnes per year
MGO fuel consumption	7.538 tonnes per year
Time spent in a SECA	100%

As of today, it is quite difficult to estimate the price of LNG, given that only few vessels are equipped to burn it as a fuel. Consequently, it is also equally difficult to estimate its future evolution. In our scenario, a price of EUR 6,48 per mmBTU for LNG is considered, while the price of MGO is at$ 500 dollars per tonne. However, with an ever-declining price of oil as in late 2015 / early 2016, $ 500 dollars per tonne might soon be considered an unrealistically high price. The exchange rate is also a factor to be considered carefully, as it can affect the payback period of the investment. However, as of today, it is not the main concern.

LNG price	€ 6,48 per mmBTU
MGO price	$ 500 per tonne
Exchange rate €/$	1,05

Based on the literature analysis carried out, it is estimated that retrofitting a vessel with the above characteristics may cost up to EUR € 17.142.857. As can be seen in the following scenario, the upfront cost of retrofitting to LNG is significantly higher than installing a scrubber, and naturally this reflects on the payback period of the investment. The initial upfront costs are so high that for vessels with a short commercial life ahead, it is clear that LNG is not a viable investment even without venturing into calculating its profitability.

As emerged from the first part of the Study, however, a ship owner could acquire a certification from a widely recognised environmental programme that certifies that their ship abides by stricter environmental standards than required by legislation. Ports that apply an environmental charging scheme would then apply a rebate on port dues each time the ship calls at them. The amount of the rebate would most likely be related to the 'environmental score' given to the ship by the certification body.

This is indeed the most common form of environmental charging applied in EU ports, where port authorities usually apply rebates to ships certified with the ESI, Green Award, the CSI, etc.

It is assumed that, while sailing in SECA, the ship only calls at ports that apply an environmental charging scheme. Moreover, for the sake of simplicity, it is also assumed that all ports called applied the same scheme and the same tariff. This situation is quite unlikely, as the often-quoted mantra that 'each port is unique' clearly implies a great variability in tariffs and schemes across ports. However, factoring in a different scheme for each port called would be tantamount to pure speculation, and thus, for the sake of simplicity it is advised to assume that all ports be applying the same scheme, however unlikely that may be.

Likewise, the specific environmental programme considered is irrelevant in the analysis, as any of them would produce the same results in our model.

If it is assumed that a ship that spends 100% of her time in SECA, and a 10% rebate on port dues (average tariff EUR 0,2144 per tonne) is applied on a total number of 30 calls per year, the payback period of retrofitting is as follows:

Table 67 - Comparison between LNG payback periods with and without incentives from a 10% rebate on port dues for a ship that spends 100% of time in SECA and calls 30 ports a year

Year	Initial investment	Savings from fuel spread	Rebates from green charging	Payback	Payback without rebates
0	€ 17.142.857,14	€ 1.434.253,16	€ 22.512,00	-€ 15.686.091,98	-€ 15.708.603,98
1	-	€ 2.868.506,32	€ 45.024,00	-€ 14.229.326,83	-€ 14.274.350,83
2	-	€ 4.302.759,48	€ 67.536,00	-€ 12.772.561,67	-€ 12.840.097,67
3	-	€ 5.737.012,64	€ 90.048,00	-€ 11.315.796,51	-€ 11.405.844,51
4	-	€ 7.171.265,79	€ 112.560,00	-€ 9.859.031,35	-€ 9.971.591,35
5	-	€ 8.605.518,95	€ 135.072,00	-€ 8.402.266,19	-€ 8.537.338,19
6	-	€ 10.039.772,11	€ 157.584,00	-€ 6.945.501,03	-€ 7.103.085,03
7	-	€ 11.474.025,27	€ 180.096,00	-€ 5.488.735,87	-€ 5.668.831,87
8	-	€ 12.908.278,43	€ 202.608,00	-€ 4.031.970,71	-€ 4.234.578,71

Year	Initial investment	Savings from fuel spread	Rebates from green charging	Payback	Payback without rebates
9	-	€ 14.342.531,59	€ 225.120,00	-€ 2.575.205,56	-€ 2.800.325,56
10	-	€ 15.776.784,75	€ 247.632,00	-€ 1.118.440,40	-€ 1.366.072,40
11	-	€ 17.211.037,91	€ 270.144,00	**€ 338.324,76**	**€ 68.180,76**

Source: own elaboration

With such high upfront costs for retrofitting, LNG is an investment that should be pondered carefully. In the scenario considered, it takes 12 years to pay back the investment, with or without benefitting from environmental charging discounts.

LNG would thus seem to be a profitable investment only for ships that have a long commercial life ahead and only sail in SECA. In the example above, environmental charging does not seem to be a major decisive factor for investing. But what would happen if the average discount were raised?

In the scenario, it takes a 60% discount for environmental charging to have a noticeable impact on the payback period:

Table 68 - Comparison between LNG payback periods with and without incentives from a 60% rebate on port dues for a ship that spends 100% of time in SECA and calls 30 ports a year

Year	Initial investment	Savings from fuel spread	Rebates from green charging	Payback	Payback without rebates
0	€ 17.142.857,14	€ 1.434.253,16	€ 135.072,00	-€ 15.573.531,98	-€ 15.708.603,98
1	-	€ 2.868.506,32	€ 270.144,00	-€ 14.004.206,83	-€ 14.274.350,83
2	-	€ 4.302.759,48	€ 405.216,00	-€ 12.434.881,67	-€ 12.840.097,67
3	-	€ 5.737.012,64	€ 540.288,00	-€ 10.865.556,51	-€ 11.405.844,51
4	-	€ 7.171.265,79	€ 675.360,00	-€ 9.296.231,35	-€ 9.971.591,35
5	-	€ 8.605.518,95	€ 810.432,00	-€ 7.726.906,19	-€ 8.537.338,19
6	-	€ 10.039.772,11	€ 945.504,00	-€ 6.157.581,03	-€ 7.103.085,03
7	-	€ 11.474.025,27	€ 1.080.576,00	-€ 4.588.255,87	-€ 5.668.831,87
8	-	€ 12.908.278,43	€ 1.215.648,00	-€ 3.018.930,71	-€ 4.234.578,71
9	-	€ 14.342.531,59	€ 1.350.720,00	-€ 1.449.605,56	-€ 2.800.325,56
10	-	€ 15.776.784,75	€ 1.485.792,00	**€ 119.719,60**	-€ 1.366.072,40
11	-	€ 17.211.037,91	€ 1.620.864,00	**€ 1.689.044,76**	**€ 68.180,76**

Source: own elaboration

A 60% discount is not observed frequently, although it is not altogether unrealistic. In the inventory of environmental charging across EU ports carried out in the first phase of the Study, it emerged that the port of Valencia applies a 50% discount on port dues to LNG-fuelled vessel. Because of the characteristics and legislation of the Spanish port sector, it is believed that other Spanish ports may apply the same reduction (tariffs are decided at central level). 60% may thus become a realistic discount in the near future, especially if more ship owners start thinking to LNG as a viable option to sail in SECAs.

Naturally, rebates from environmental charging may influence the payback period to a greater extent if a ship that calls a higher number of ports were considered, as in the table below:

Table 69 - Comparison between LNG payback periods with and without incentives from a 60% rebate on port dues for a ship that spends 100% of time in SECA and calls 80 ports a year

Year	Initial investment	Savings from fuel spread	Rebates from green charging	Payback	Payback without rebates
0	€ 17.142.857,14	€ 1.434.253,16	€ 360.192,00	-€ 15.348.411,98	-€ 15.708.603,98
1	-	€ 2.868.506,32	€ 720.384,00	-€ 13.553.966,83	-€ 14.274.350,83
2	-	€ 4.302.759,48	€ 1.080.576,00	-€ 11.759.521,67	-€ 12.840.097,67
3	-	€ 5.737.012,64	€ 1.440.768,00	-€ 9.965.076,51	-€ 11.405.844,51
4	-	€ 7.171.265,79	€ 1.800.960,00	-€ 8.170.631,35	-€ 9.971.591,35
5	-	€ 8.605.518,95	€ 2.161.152,00	-€ 6.376.186,19	-€ 8.537.338,19
6	-	€ 10.039.772,11	€ 2.521.344,00	-€ 4.581.741,03	-€ 7.103.085,03
7	-	€ 11.474.025,27	€ 2.881.536,00	-€ 2.787.295,87	-€ 5.668.831,87
8	-	€ 12.908.278,43	€ 3.241.728,00	-€ 992.850,71	-€ 4.234.578,71
9	-	€ 14.342.531,59	€ 3.601.920,00	**€ 801.594,44**	-€ 2.800.325,56
10	-	€ 15.776.784,75	€ 3.962.112,00	**€ 2.596.039,60**	-€ 1.366.072,40
11	-	€ 17.211.037,91	€ 4.322.304,00	**€ 4.390.484,76**	**€ 68.180,76**

Source: own elaboration

With 80 calls a year, the payback period is further shortened by one year. However, it should be borne in mind that such a high number of calls may be quite unlikely for a tanker or a bulk carrier. This number of calls can be realistic for ferries, but, for this very reason, ferries are normally charged lower tariffs.

The baseline to gauge the impact of environmental charging on the payback period of the investment in an LNG solution has so far been based on a ship that spend 100% of her time in a SECA. What would happen to a ship that spent only 50% in a SECA? As one may expect, the payback period increases dramatically, as a result of reduced savings from fuel spread (outside SECAs the sulphur content allowed in fuel is higher, thus making it possible to not install a scrubber or an LNG solution and neither to burn the more expensive MGO fuel). The payback period increases to such an extent (24 years) that LNG would not be considered a profitable investment at all.

However, by looking at the table below, what is interesting is that if incentives from environmental charging are factored in, the payback period is shortened to 21 years. Considering such a long period inevitably carries far too many and too strong assumptions. The assumptions here are that the fuel spread, the tariffs and the discounts remain constant over the years, all of which are extremely unlikely.

Table 70 - Comparison between LNG payback periods with and without incentives from a 50% rebate on port dues for a ship that spends 50% of time in SECA and calls 30 ports a year

Year	Initial investment	Savings from fuel spread	Rebates from green charging	Payback	Payback without rebates
0	€ 17.142.857,14	€ 717.126,58	€ 112.560,00	-€ 16.313.170,56	-€ 16.425.730,56
1	-	€ 1.434.253,16	€ 225.120,00	-€ 15.483.483,98	-€ 15.708.603,98
2	-	€ 2.151.379,74	€ 337.680,00	-€ 14.653.797,40	-€ 14.991.477,40
3	-	€ 2.868.506,32	€ 450.240,00	-€ 13.824.110,83	-€ 14.274.350,83
4	-	€ 3.585.632,90	€ 562.800,00	-€ 12.994.424,25	-€ 13.557.224,25
5	-	€ 4.302.759,48	€ 675.360,00	-€ 12.164.737,67	-€ 12.840.097,67
6	-	€ 5.019.886,06	€ 787.920,00	-€ 11.335.051,09	-€ 12.122.971,09
7	-	€ 5.737.012,64	€ 900.480,00	-€ 10.505.364,51	-€ 11.405.844,51
8	-	€ 6.454.139,21	€ 1.013.040,00	-€ 9.675.677,93	-€ 10.688.717,93
9	-	€ 7.171.265,79	€ 1.125.600,00	-€ 8.845.991,35	-€ 9.971.591,35
10	-	€ 7.888.392,37	€ 1.238.160,00	-€ 8.016.304,77	-€ 9.254.464,77
11	-	€ 8.605.518,95	€ 1.350.720,00	-€ 7.186.618,19	-€ 8.537.338,19
12	-	€ 9.322.645,53	€ 1.463.280,00	-€ 6.356.931,61	-€ 7.820.211,61
13	-	€ 10.039.772,11	€ 1.575.840,00	-€ 5.527.245,03	-€ 7.103.085,03
14	-	€ 10.756.898,69	€ 1.688.400,00	-€ 4.697.558,45	-€ 6.385.958,45
15	-	€ 11.474.025,27	€ 1.800.960,00	-€ 3.867.871,87	-€ 5.668.831,87
16	-	€ 12.191.151,85	€ 1.913.520,00	-€ 3.038.185,29	-€ 4.951.705,29
17	-	€ 12.908.278,43	€ 2.026.080,00	-€ 2.208.498,71	-€ 4.234.578,71
18	-	€ 13.625.405,01	€ 2.138.640,00	-€ 1.378.812,13	-€ 3.517.452,13
19	-	€ 14.342.531,59	€ 2.251.200,00	-€ 549.125,56	-€ 2.800.325,56
20	-	€ 15.059.658,17	€ 2.363.760,00	€ 280.561,02	-€ 2.083.198,98
21	-	€ 15.776.784,75	€ 2.476.320,00	€ 1.110.247,60	-€ 1.366.072,40
22	-	€ 16.493.911,33	€ 2.588.880,00	€ 1.939.934,18	-€ 648.945,82
23	-	€ 17.211.037,91	€ 2.701.440,00	€ 2.769.620,76	€ 68.180,76

Source: own elaboration

21 years is still an incredible long payback period, and most likely no investor would make such an imprudent choice, considering the long time horizon ahead, which makes the investment fraught with uncertainty. After all, as further explained in the following scenario on scrubbers, it is evident that environmental charging alone cannot be a decisive factor for a ship owner to make an investment.

Nonetheless the table above is quite useful to show what benefits environmental charging can yield in the long term. This is perfectly in line with what was reported by port authorities during the development of the case studies, i.e. that although in the short term environmental charging may not necessarily lead to

altered behaviour of ship owners, the incentive may be effective when it comes to the development of new ships (rewarding early compliance, i.e. shipping lines take into account technologies beyond compliance) and the choice of fuel (more environmentally friendly). As a result, the real impact of the scheme should be considered in a long-term perspective.

6.5.3 Installation of a scrubber

Another solution to be allowed to sail in SECAs could be to install a scrubber, i.e. a ship exhaust gas-cleaning device that reduces sulphur (SO_2) and particulate emissions from ship engines, generators and boilers, so to meet sulphur emission limits as required by IMO MARPOL Annex VI regulations without switching to the more expensive MGO.

It should be noted that the question on whether and to what extent a scrubber can be considered as an environmentally-friendly solution is subject to debate. Due to their specific functioning, for instance, scrubbers cannot reduce the amount of CO_2 emitted. Furthermore, they generate variable fractions of other emission parameters that can be found in the wash water effluent, as well as sludge which needs to be disposed of[64]. Finally, it should also be pointed out that, on board ship types such as very large container ships and some ferries, it is not possible today to use scrubbers[65]. However, as the efficiency and impact of scrubbers are outside the scope of this Study, these issues have not been addressed, assuming that installing a scrubber simply is a valid option to be allowed to sail in a SECA.

As with the previous scenario, the deciding factors influencing the investment decision for installation of a scrubber are the fuel cost spread and the time spent in a SECA. The lower the spread between MGO and HFO, the less profitable is the scrubber, because the savings from burning cheaper fuel (HFO) rather than distillate can compensate the upfront cost of the investment over a comparatively longer period of time, to the point of not compensating it at all in case MGO and HFO should reach the same price.

Similarly, the longer the time spent in a SECA, the more profitable the scrubber is. If a scrubber-equipped vessel spends 100% of its time in a SECA, it means that, without a scrubber, it would have to burn the more expensive MGO for 100% of its time. In such a scenario, it is clear that a scrubber makes it possible to maximise the savings from burning cheaper fuel.

Another element to evaluate when deciding whether to install a scrubber is the remaining commercial life of the vessel. Older vessels with shorter commercial life may not have sufficient time to repay the costs of the upfront investment. Once again, since it is outside the scope of this Study to establish when it is financially viable to install a scrubber, this consideration is left out of the analysis for the sake of brevity.

There is high uncertainty regarding scrubber costs due to the limited number of scrubbers currently in operation and the application of available cost data (in terms of € per installed kW) to different engine sizes. A literature analysis was carried out to estimate the costs of installing an operating a scrubber, mainly based on the following sources:

- Den Boer E., Hoen M., Scrubbers – An economic and ecological assessment, prepared for NABU in 2015
- Låtun K., SO_x scrubbers; a profitable investment, presentation during the 2015 GREEN4SEA Forum (N.B. the author is VP Sales & Marketing at Yara Marine Technologies AS, a scrubber supplier)
- BIMCO Business Case: Marine gas oil or scrubbers when operating in an ECA? 2013

[64] For a comprehensive overview of the efficiency and impact of scrubbers, please see Kjølholt J. et al., Assessment of possible impacts of scrubber water discharges on the marine environment, Danish Environmental Protection Agency, Environmental Project No. 1431, 2012.

[65] See BIMCO Business Case: Marine gas oil or scrubbers when operating in an ECA? Available on line at https://www.bimco.org/en/Reports/Market_Analysis/2013/0424_ECAStory.aspx

The scenario is largely based on the one developed in the NABU study and considers a ship (which may be a product tanker or a bulk carrier) with the following characteristics:

Gross tonnage	38.500 tonnes
Power	12,36 MW
HFO fuel consumption	8003 tonnes per year
MGO fuel consumption	7538 tonnes per year
Time spent in a SECA	100%

As mentioned above, special attention should be paid to the spread between MGO and HFO, as these are crucial variables to measure the payback period of the investment. In this scenario, a relatively close gap between the two prices is assumed, resembling the situation as of late 2014 / early 2015:

HFO price	300 $ per tonne
MGO price	500 $ per tonne
Exchange rate €/$	1,05

It is quite difficult to forecast the evolution of the spread between HFO and MGO, so it is assumed that the spread will remain constant over the years. The exchange rate is also a factor to be considered carefully, as it can affect the payback period of the investment. However, as of today, it is not the main concern.

Based on the literature analysis carried out, the costs for installing and operating a scrubber on a ship with the above characteristics are estimated at:

Equipment	€ 171.428,57 per MW
Installation	75,00% of equipment cost
Maintenance	ca. € 40.000 per year
Additional fuel costs	1,5% of fuel consumption HFO
Slurry disposal costs	€ 0,49 per kg

It should be noted that the additional fuel cost is due to the fact that MGO has a higher energy content (5% per tonne) and is therefore more efficient than HFO. Slurry production is estimated at 2,83 kg per tonne of HFO.

Furthermore, it should be noted that the equipment and installation costs reported above refer to a newly built vessel. Retrofitting a scrubber is considered to be more expensive, with an additional investment cost of € 50 per kW.

Based on the above data, the table overleaf calculates the payback period of the investment[66]:

[66] Since the scope of this Study is not to evaluate the profitability of installing a scrubber or and LNG solution *per se*, for the sake of simplicity, the risk-free interest rate and the internal firm discount rate are not factored in the calculation of the payback period.

Table 71 – Payback period of a scrubber investment for a ship that spends 100% of the time in SECA

Year	Cumulated capital and operational costs				Cumulated savings	Payback
	Initial investment	Maintenance	Additional fuel cost	Slurry disposal	Difference between MGO and HFO	
0	€ 3.708.000,00	€ 40.000,00	€ 34.298,57	€ 11.078,15	€ 1.302.952,38	**-€ 2.490.424,34**
1	-	€ 80.000,00	€ 68.597,14	€ 22.156,31	€ 2.605.904,76	**-€ 1.272.848,69**
2	-	€ 120.000,00	€ 102.895,71	€ 33.234,46	€ 3.908.857,14	**-€ 55.273,03**
3	-	€ 160.000,00	€ 137.194,29	€ 44.312,61	€ 5.211.809,52	**€ 1.162.302,63**
4	-	€ 200.000,00	€ 171.492,86	€ 55.390,76	€ 6.514.761,90	**€ 2.379.878,28**
5	-	€ 240.000,00	€ 205.791,43	€ 66.468,92	€ 7.817.714,29	**€ 3.597.453,94**

Source: own elaboration

It should be noted that the revenue foregone due to the installation period (the ship cannot operate) is not taken into account, as it would not change the picture to a great extent: Greenship (2012) estimates the off-hire costs of a 38.500 GT product tanker at $ 340.000 for a period of 20 days.

As can be seen, despite the relatively low spread between MGO and HFO, the investment is fully repaid from the fourth year on, meaning that installing a scrubber seems to be a quite profitable solution for the ship to be allowed to sail in SECAs. This should not come as a surprise, because it is assumed that the ship spends 100% of her time in a SECA.

Should one, for instance, consider a ship that spends only 50% of her time in SECAs, then the situation would change completely, with a payback period of 7 years:

Table 72 - Payback period of a scrubber investment for a ship that spends 50% of the time in SECA

Year	Cumulated capital and operational costs				Cumulated savings	Payback
	Initial investment	Maintenance	Additional fuel cost	Slurry disposal	Difference between MGO and HFO	
0	€ 3.708.000,00	€ 40.000,00	€ 34.298,57	€ 11.078,15	€ 651.476,19	**-€ 3.141.900,53**
1	-	€ 80.000,00	€ 68.597,14	€ 22.156,31	€ 1.302.952,38	**-€ 2.575.801,07**
2	-	€ 120.000,00	€ 102.895,71	€ 33.234,46	€ 1.954.428,57	**-€ 2.009.701,60**
3	-	€ 160.000,00	€ 137.194,29	€ 44.312,61	€ 2.605.904,76	**-€ 1.443.602,13**
4	-	€ 200.000,00	€ 171.492,86	€ 55.390,76	€ 3.257.380,95	**-€ 877.502,67**
5	-	€ 240.000,00	€ 205.791,43	€ 66.468,92	€ 3.908.857,14	**-€ 311.403,20**
6	-	€ 280.000,00	€ 240.090,00	€ 77.547,07	€ 4.560.333,33	**€ 254.696,26**

Source: own elaboration

Having established how long it takes for the ship owner to repay their investment, it is possible to consider whether any benefits may be reaped by taking advantage from ports that reward greener ships (thus assuming that a ship with a scrubber is a greener ship) by applying rebates on port dues.

To calculate what economic benefits may be reaped through environmental charging, a scheme is assumed whereby ships are normally taxed at € 0,2144 per tonne, with a 10% rebate for greener ships that are certified with a specific environmental programme. The exact amounts of benefits of course will depend on how many ports the ship calls throughout the year: we have assumed 30 calls in total, which would affect the payback period of the investment as follows:

Table 73 – Comparison between scrubber payback periods with and without incentives from a 10% rebate on port dues for a ship that spends 100% of time in SECA and a fuel spread of $ 200

Year	Savings from fuel spread	Rebates from green charging	Payback with rebates	Payback without rebates
0	€ 1.302.952,38	€ 24.763,20	**-€ 2.465.661,14**	**-€ 2.490.424,34**
1	€ 2.605.904,76	€ 49.526,40	**-€ 1.223.322,29**	**-€ 1.272.848,69**
2	€ 3.908.857,14	€ 74.289,60	**€ 19.016,57**	**-€ 55.273,03**
3	€ 5.211.809,52	€ 99.052,80	**€ 1.261.355,43**	**€ 1.162.302,63**
4	€ 6.514.761,90	€ 123.816,00	**€ 2.503.694,28**	**€ 2.379.878,28**
5	€ 7.817.714,29	€ 148.579,20	**€ 3.746.033,14**	**€ 3.597.453,94**

Source: own elaboration

In this specific example, rebates from environmental charging result in a shorter payback period. This is however purely accidental, as the rebates from environmental charging are outweighed by those resulting from the spread between MGO and HFO.

What happens in a scenario where the gap between MGO ($ 350) and HFO ($ 200) reduces, thus making the investment in a scrubber less profitable? The situation would change as follows:

Table 74 - Comparison between scrubber payback periods with and without incentives from a 10% rebate on for a ship that spends 100% of time in SECA and a fuel spread of $ 150

Year	Savings from fuel spread	Rebates from green charging	Payback with rebates	Payback without rebates
0	€ 988.285,71	€ 24.763,20	**-€ 2.768.894,95**	**-€ 2.793.658,15**
1	€ 1.976.571,43	€ 49.526,40	**-€ 1.829.789,91**	**-€ 1.879.316,31**
2	€ 2.964.857,14	€ 74.289,60	**-€ 890.684,86**	**-€ 964.974,46**
3	€ 3.953.142,86	€ 99.052,80	**€ 48.420,19**	**-€ 50.632,61**
4	€ 4.941.428,57	€ 123.816,00	**€ 987.525,24**	**€ 863.709,24**
5	€ 5.929.714,29	€ 148.579,20	**€ 1.926.630,28**	**€ 1.778.051,08**

Source: own elaboration

Savings from fuel spread plummet, while rebates of course remain the same, although they are still outweighed by the former. The payback period actually increases, as it is far more sensitive to fuel spread than it is to a 10% rebate on port dues.

Variations in fuel spread only affect the profitability of scrubber as an investment, regardless of the rebates on port dues. What would thus make environmental charging more attractive?

As one may expect, the first element that would make it more attractive is a higher discount on port dues:

Table 75 - Comparison between scrubber payback periods with and without incentives from a 50% rebate on port dues for a ship that spends 100% of time in SECA and a fuel spread of $ 200

Year	Savings from fuel spread	Rebates from green charging	Payback with rebates	Payback without rebates
0	€ 1.302.952,38	€ 123.816,00	-€ 2.366.608,34	-€ 2.490.424,34
1	€ 2.605.904,76	€ 247.632,00	-€ 1.025.216,69	-€ 1.272.848,69
2	€ 3.908.857,14	€ 371.448,00	€ 316.174,97	-€ 55.273,03
3	€ 5.211.809,52	€ 495.264,00	€ 1.657.566,63	€ 1.162.302,63
4	€ 6.514.761,90	€ 619.080,00	€ 2.998.958,28	€ 2.379.878,28
5	€ 7.817.714,29	€ 742.896,00	€ 4.340.349,94	€ 3.597.453,94

Source: own elaboration

A 50% rebate on port dues – not frequent but not even completely unrealistic according to the findings of this Study – still does not influence the payback period dramatically, but creates incentives that amount to 9,5% of savings from fuel spread, adding up to the profitability of the investment.

Another element that makes environmental charging more interesting as an economic incentive is the number of port calls that a ship makes throughout the year. More calls translate into higher incentives from rebates. If one (unrealistically)considered 80 calls per year, the result would be:

Table 76 - Comparison between scrubber payback periods with and without incentives from a 50% rebate on port dues for a ship that spends 100% of time in SECA and calls 80 port a year

Year	Savings from fuel spread	Rebates from green charging	Payback with rebates	Payback without rebates
0	€ 1.302.952,38	€ 330.176,00	-€ 2.160.248,34	-€ 2.490.424,34
1	€ 2.605.904,76	€ 660.352,00	-€ 612.496,69	-€ 1.272.848,69
2	€ 3.908.857,14	€ 990.528,00	€ 935.254,97	-€ 55.273,03
3	€ 5.211.809,52	€ 1.320.704,00	€ 2.483.006,63	€ 1.162.302,63
4	€ 6.514.761,90	€ 1.650.880,00	€ 4.030.758,28	€ 2.379.878,28
5	€ 7.817.714,29	€ 1.981.056,00	€ 5.578.509,94	€ 3.597.453,94

Source: own elaboration

Other things being equal, a dramatic increase in the number of port calls makes the investment significantly more profitable.

Back to a more realistic situation, what happens if a 30% rebate on port dues is factored in for a ship that only spends 50% of her time in a SECA?

Table 77 - Comparison between scrubber payback periods with and without incentives from a 30% rebate on port dues for a ship that spends 50% of time in SECA and calls 30 port a year

Year	Savings from fuel spread	Rebates from green charging	Payback with rebates	Payback without rebates
0	€ 651.476,19	€ 74.289,60	-€ 3.067.610,93	-€ 3.141.900,53
1	€ 1.302.952,38	€ 148.579,20	-€ 2.427.221,87	-€ 2.575.801,07
2	€ 1.954.428,57	€ 222.868,80	-€ 1.786.832,80	-€ 2.009.701,60
3	€ 2.605.904,76	€ 297.158,40	-€ 1.146.443,73	-€ 1.443.602,13
4	€ 3.257.380,95	€ 371.448,00	-€ 506.054,67	-€ 877.502,67
5	€ 3.908.857,14	€ 445.737,60	**€ 134.334,40**	-€ 311.403,20

Source: own elaboration

The scenario here is very similar to Table 72, with the fuel spread at $200, the ship spending 50% of her time in SECA and calling 30 ports a year, but this time the rebate at 30%. Environmental charging here contributes to reducing the payback period by one year. Naturally, it is to be assumed that the ship is still being given rebates even when calling ports outside SECA.

Albeit halved, savings from fuel spread still outweigh rebates from green charging. The situation would not change considerably, even by setting the rebate at 50%.

What lessons can be learned from the above scenario?

1. Installing a scrubber may be a profitable investment besides being a viable option for vessels that want to sail in SECA.
2. The investment profitability increases as the fuel spread and the time spent in SECA increase as well.
3. Regardless of the discount level, rebates from environmental charging tend to be outweighed by the savings from fuel spread. This is because port dues are only a fraction of the money spent in fuel.
4. Particular combinations such as large fuel spread, reduced time in SECAs, and relatively high rebates for greener ships contribute to increasing the impact of environmental charging on the payback period of the investment.
5. Under no circumstances, environmental charging can be a decisive factor for deciding to 'go greener' by installing a scrubber. It is worth mentioning that even a (completely unrealistic) rebate of 100% in port dues for a ship that spends only half of her time in SECA would simply reduce the payback period of one year, compared with a ship that is applied a rebate of 30%.

Does this mean that environmental charging is ineffective as an economic incentive? Answering this question may be slightly more complicated. Despite not being a decisive factor, incentives connected to rebates add on top of savings from fuel spread, contributing to making the investment more profitable. The higher the rebates, the more profitable the investment may be. Obviously, this is especially true for vessels that have a longer commercial life ahead of them.

It has been mentioned that EU ports tend to give rebates to ship certified by widely acknowledged environmental programmes. The certification process comes at a cost for ship owners. However, this cost is

generally speaking remarkably low compared with the incentives created through rebates. For instance, on its website Green Award reports the following costs for dry cargo bulk carriers (depending on ship size):

Application fee	€ 4.855 (one-off)
Annual fee	€ 3.025
Audit fee	€ 840 per day per person + reimbursement of travel, accommodation and subsistence expenses

These costs are not considered in our model as they would not have any impact whatsoever. Nonetheless, in the above scenarios, when 'going greener' is the response to a legislative obligation (sailing in SECAs) rather than an individual choice made by ship owners, it is against these costs that the benefits from environmental charging should be assessed. In any of the scenarios considered, these costs of 'going greener' are outweighed by the incentives distributed through rebates, with the latter adding on top of savings from fuel spread.

Therefore, despite not possibly being the decisive factor for installing a scrubber, the conclusion from the above scenario is that environmental charging may not be an extremely strong incentive, yet, depending on the circumstances, it still may increase the profitability of the investment, albeit to a small extent.

6.6 Main lessons learned

- Should all ports in the EU (plus Norway and Turkey) apply their own environmental charging scheme, an average 30% rebate on port dues for 'green ships' could result in financial incentives for the shipping sector up to 1,4 billion euro over a 5-year period[67]. These projections are based on the hypothesis that 30% of calls in EU ports are eligible for a discount.
- When it comes to verifying whether incentives from environmental charging can contribute to making investments in greener technologies (e.g. installation of a scrubber or LNG solution, or investment in OPS) more profitable, it emerges that under certain circumstances they may shorten the payback period of the investment by one or more years.
- Certain indexes or certain measures taken by the ship can entitle- to multiple rebates in different ports. The condition of whether these rebates can be cumulated or not is important as small rebates can be compounded to sizable financial incentives when cumulated.
- The cost related to certification processes are negligible and easily compensated by the incentives distributed through rebates.
- In line with the case studies findings, the economic assessment also suggests that, although in the short run environmental charging may not necessarily lead to altered behaviour of ship owners, the incentive may be effective when it comes to the development of new ships (rewarding early compliance, i.e. shipping lines take into account technologies beyond compliance) and the choice of

[67] When trying to estimate the economic impact of an environmental charging scheme, it is paramount to consider a realistic '**elasticity**' value. By 'elasticity' it is meant the responsiveness of the quantity demanded of port services to a change in their price. When demand is elastic to port charges, a 10% reduction/discount will result in 10% more port calls, or likewise a 10% increase will result in 10% fewer port calls. Demand elasticity to port services is difficult to estimate for the whole sector, as it may vary considerably across geographical areas and ship types. While it is considered to be rather high in the container sector, especially in areas served by many ports, it may also be relatively low in other sectors.

fuel (more environmentally friendly). As a result, the real impact of the scheme should be considered in a long-term perspective.

- Furthermore, environmental charging may also carry positive implications in terms of image (which could ultimately yield economic benefits) for both ports and ship owners, and could also be seen as one of the steps to reduce the overall environmental footprint of the industry; an effort whose costs would be partly compensated by the improvement of significant environmental aspects in port areas and the incentives from reduced port dues.
- When implementing a scheme, ship owners have suggested that if they got more involved by ports in the decision-making process, this might contribute to making the incentive more attractive to them.

Section III - Recommendations and guidelines

7 Methodology

The last task of the Study builds on the information gathered and collected in the previous analysis steps with the aim to formulate a series of recommendations and guidelines in order to support policy makers and port authorities in the definition of environmental charging practices.

The recommendations are logically derived from the findings of the study team as well as from interaction with stakeholders, thanks to two panel discussions that took place during the Study.

The first panel discussion took place between the first and the second task of the Study, to present the preliminary findings of the research team and to shape the methodology for the economic and environmental assessment of green charging.

Subsequently, stakeholders had the opportunity to discuss the findings of the first two tasks of the study[68] during a second panel discussion, which took place on 20 January 2016. For the study team, the conference with stakeholders was a fundamental step in the research path, in that it made it possible to validate the preliminary findings and establish the key principles on which to base the recommendations and guidelines.

Several considerations were put forward during the conference, which informed the last task of the Study. First of all, it was reaffirmed that environmental charging should remain a voluntary practice – although it should be noted that this idea was never challenged throughout the study. The EU port sector is too diversified and there was wide consensus that a single, top-down approach would inevitably fail. Ports have different governance models, types of traffic, and budgets. Even more to it, they also protect different significant environmental aspects. Therefore, while environmental charging becomes more effective as a practice if it is applied consistently across countries and ports, it is in the best interest of the sector that better coordination is achieved through a bottom-up process.

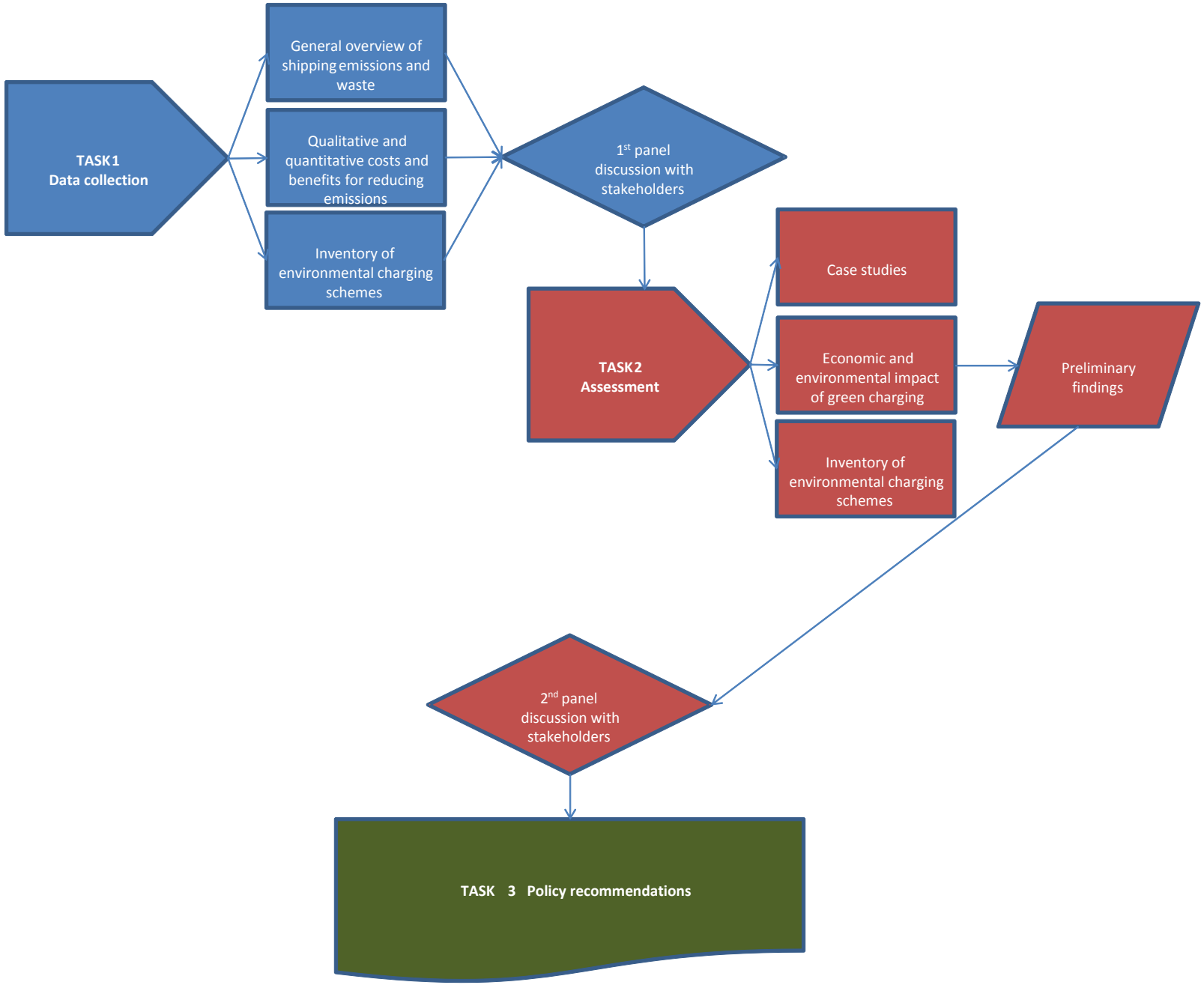
By combining the findings of the study with the feedback from the stakeholders[69], it was possible to identify a list of critical issues to promote environmental charging in the EU. Each recommendation is numbered, and it is clearly indicated whether it is addressed to port authorities, national authorities or the EU.

The flow chart overleaf outlines the logical process that led to formulating the recommendations.

[68] See Section I § 3.4, and Section II § 4.1, § 5.6 and § 6.6.

[69] A series of position papers were also received from stakeholders such as the British Ports Associations, the Cruise Lines International Association, the European Sea Ports Organisation, and Maersk Line. Other stakeholders were contacted but without success. The position papers are attached as separate Annexes (not publically available as the information in it may be regarded as confidential) to this report.

Figure 13 – Logical diagram showing the process that led to formulating the recommendations



8 Recommendations

#1 - Port authorities and national authorities

Consider environmental charging as part of a broader policy to support the uptake of alternative fuels for waterborne transport

Directive 2014/94/EU of the European Parliament and of the Council of 22 October 2014 on the deployment of alternative fuels infrastructure establishes a common framework of measures for the deployment of alternative fuels infrastructure in the EU in order to minimise dependence on oil and to mitigate the environmental impact of transport. Alternative fuels serve, at least partly, as a substitute for fossil oil sources in the energy supply to transport, contribute to its decarbonisation and enhance the environmental performance of the transport sector.

Among other things, the Directive sets clear goals when it comes to ports:

- Article 4.5 of the Directive states that Member States shall ensure that the need for shore-side electricity supply for inland waterway vessels and seagoing ships in maritime and inland ports is assessed in their national policy frameworks. Such shore-side electricity supply shall be installed as a priority in ports of the TEN-T Core Network, and in other ports, by 31 December 2025, unless there is no demand and the costs are disproportionate to the benefits, including environmental benefits.
- Article 6.1 states that Member States shall ensure, by means of their national policy frameworks, that an appropriate number of refuelling points for LNG are put in place at maritime ports, to enable LNG inland waterway vessels or seagoing ships to circulate throughout the TEN-T Core Network by 31 December 2025. Member States shall cooperate with neighbouring Member States where necessary to ensure adequate coverage of the TEN-T Core Network.

The deployment of facilities for OPS and LNG requires significant investments from both port authorities and ship owners. The question is analysed more in detail in Section II - § 6.5 of this Report. While rebates from environmental charging alone cannot be a decisive factor to persuade ship owners to adopt these technologies, this Study found out that under certain conditions they can reduce the payback period of the investment. It is thus suggested that, in view of implementing the Directive at national level, besides focusing on deploying the necessary infrastructure, Member States and port authorities use environmental charging as one of the possible tools to foster the uptake of alternative fuels, and make sure that the infrastructure is actually used by ships.

#2 - EU

Consider environmental charging as a market-based measure for reducing greenhouse gas emissions from shipping

During this study, it has been established that environmental charging is particularly effective as an incentive when it comes to the development of new ships (rewarding early compliance, i.e. shipping lines take into account technologies beyond compliance) and the choice of fuel (more environmentally friendly). Since a framework to increase ship efficiency in such a way as to reduce GHG emissions has already been established at IMO level with the EEDI until 2025, it may make sense to propose a system of rebates that can incentivise ship owners to adopt more stringent standards even before their entry into force. By way of an example, as of today, it does not make sense to build a new ship in compliance with the requirements set by the EEDI for 2025 onwards. However, a system of rebates may become an incentive to voluntarily adopt more stringent standards. The regulation currently requires most new ships to be 10% more efficient beginning 2015, 20% more efficient by 2020, and 30% more efficient by 2025. Rebates may reward those

ship owners who, for instance, decide to exceed by 50% current requirements so to encourage early compliance with future requirements, even though there is no obligation to do so. The higher the efficiency, the higher the rebate. Incidentally, while the EEDI applies to newbuilds, the charging scheme may work in such a way as to also reward existing ships, e.g. by linking the rebate to their environmental performance as measured by the EEOI.

To be effective, such a scheme cannot be implemented by ports individually, but a concerted effort is necessary. One the one hand, ship owners would most likely not be willing to invest in potentially expensive cleaner technologies without being certain to benefit from rebates in every port of call. On the other hand, since CO_2 does not directly affect the port area, the scale effect on its reduction becomes appreciable only if a remarkable number of ports adopt the same scheme.

Furthermore, in 2018 the effective application of the MRV Regulation, adopted in 2015, will create an EU-wide legal framework for the monitoring, reporting and verification of CO_2 emissions from maritime transport. The impact of the MRV Regulation should also be analysed against the wider international framework, further to the formal adoption by the MEPC of a mandatory data collection system for fuel consumption of ships. The MEPC also agreed that an initial but comprehensive IMO strategy on reduction of GHG emissions from ships should be adopted in 2018.

If linked to an environmental charging scheme, this framework will make available a remarkable set of data that will make it possible to:

a) know how much and to what extent a vessel is 'going beyond' international standards in the framework of the EEDI;

b) know with a sufficient degree of precision how much CO_2 is emitted (and how much is saved) on a certain journey;

c) as a consequence of a) and b), determine the level of rebate corresponding to the percentage of increased efficiency (or of CO_2 emitted).

None of the schemes surveyed during this study can gauge shipping emissions with such precision, and consequently determine the level of rebate. Amongst other things, the effective application of the MRV Regulation represents an enormous opportunity to increase the effectiveness of environmental charging as an incentive to reduce CO_2 emissions and contribute to reducing the negative effects of climate change. The potential of this scheme could be enormous, as it would add up to ambitious reduction standards already set at EU and international level. Whether the scheme can be successful will depend on the concerted effort mobilised by EU ports. Contrary to schemes that address air quality and /or waste, which produce direct effects on the port and its environs, in the case of CO_2 it is paramount to create a 'critical mass' that can produce an appreciable effect on carbon emissions and climate change. The EU could be the subject to start this process, which however requires close coordination with the ports.

#3 - EU, **Port authorities and / or national authorities, depending on the governance model**

Assess the feasibility of defining common criteria for environmental charging across the EU.

One of the recurring topics analysed during the study is whether also a more consistent application of environmental charging should be fostered at EU/national level. On the one hand, several port authorities firmly believe that any centralised coordination, especially if based on a top-down approach, would be detrimental to the sector, in that it might fail to acknowledge the inherent diversity of EU ports in terms of ownership, organisation, management, size, functions, and geographical location, and conflict with free competition. At the opposite end of the spectrum, some stakeholders have recognised that a more coordinated approach across the EU may make environmental charging more effective, since ship owners would benefit from the application of consistent standards, thus cumulating rebates across each port of call.

This is recognised also by the 2013 EC Communication on ports policy 'Ports: an engine for growth', which states that "Although existing schemes introduced on a voluntary basis by a number of ports to raise their environmental image should continue to be supported, a more consistent application of such environmental variation of port infrastructure charges at a European or regional level would help to increase their effectiveness". Furthermore, the Regulation of the European Parliament and of the Council establishing a framework on market access to port services and financial transparency of ports (Regulation (EU) 2017/352) states that "The Commission, in cooperation with Member States, should elaborate guidance on common classification criteria for vessels for the purpose of voluntary environmental charging, taking into account internationally agreed standards" (Recital 51), and that "[…] port infrastructure charges may vary in accordance with the port's economic strategy and the port's spatial planning policy, related inter alia to certain categories of users, or in order to promote a more efficient use of the port infrastructure, short sea shipping or a high environmental performance, energy efficiency or carbon efficiency of transport operations (Art. 13.4).

By way of an example, an EU-level register could list under which conditions green ships should be entitled a rebate in EU ports. Similarly, in view of creating a level playing field, it may be useful to define a list of green initiatives (certification schemes, indexes, etc.) that could give entitlement to rebates. A good solution could be to refrain from dictating rigid requirements, but rather to list possible options that entitle to rebates and ranges for discounts. In this way, it should be possible to combine a more consistent approach to environmental charging, while maintaining a certain leeway for Member States and port authorities alike. The Spanish experience (see Section I - § 3.2) can be a useful benchmark, in that ship owners and port authorities can negotiate an agreement that entitles to rebates, provided that the agreement fulfils certain conditions defined at the central level by a State agency.

The economic and the environmental assessments carried out in the framework of this Study show that the advantages of improved coordination may be appreciable, their order of magnitude increasing along with the number of ports that join the common initiative. Defining common criteria for environmental charging would make it possible to:

(i) Create a "level playing" field for ports;

(ii) Simplify the rules for ship owners to be eligible for rebates;

(iii) Simplify the rules for ship owners to be eligible for rebates;

(iv) Reducing NO_x, SO_x, PM and CO_2 emissions to a greater extent.

In the current scenario, where only limited coordination has been achieved spontaneously through bottom-up initiatives, environmental charging is likely to remain a fairly weak incentive to alter ship owners' behaviour, characterised by uncertainty and implicit costs against only moderate benefits.

#4 - Port authorities and / or national authorities, depending on the governance model

When environmental charging schemes are designed, they should (i) be simple to understand and to implement, (ii) clearly state the goals to be achieved, and (iii) be monitored throughout their implementation.

(i) There clearly is a choice between straightforward systems – which are not administratively too complicated and costly – versus very sophisticated schemes, often not transparent or relatively difficult to be understood by stakeholders. The latter are also costlier to be implemented, and this may become a major bottleneck for smaller and medium size ports. Therefore, any successful incentive system needs to be easily understandable by port stakeholders. Adhering to these principles also keeps the implementation costs down. The Study demonstrates that most ports in the EU prefer to link the rebates envisaged in their environmental charging schemes to certifications and / or scores assigned to vessels by widely acknowledged environmental initiatives and programmes (ESI, Green Award, CSI, Blue Angel, etc.). This practice makes it possible to keep the scheme relatively easy to understand, while at the same time

reduces the administrative burden for port authorities and ship owners that can delegate the verification of requirements to third party certification bodies. While 'original schemes', i.e. not based on any index or certification, are not to be discouraged *per se*, it is highly recommended that these follow the same principles that have persuaded a large number of ports to revolve their schemes around well-known indexes or certifications: transparency, clarity, and lack of administrative burden.

(ii) The Study shows that, albeit in some cases modest, environmental charging does indeed have an impact on significant environmental aspects, as well as on ship owners' behaviour. However, it also emerges that most ports do not set clear goals as to what they expect to achieve through environmental charging. This lack of planning ultimately undermines the effectiveness of environmental charging itself, in that it conceals what may be achieved through it. Without clear goals, it is also virtually impossible to adjust a scheme based on its performance, as there is no reference to benchmark with. While one should keep realistic expectations as to the economic and environmental that can be achieved through environmental charging, it is fundamental to at least attempt at estimating the desired effects prior to its implementation. Such an exercise should be conducted jointly with local and regional authorities, because rather than being isolated environments, ports and cities are complex and integrated systems with multiple interactions. Port activities may often be a source of pollution, but this also holds true for non-port activities that take place in the port environs. Any strategy to improve the environmental footprint of a port cannot succeed if carried out in isolation from the city.

(iii) As a corollary to point (ii), it is strongly recommended that the broad sector and the ports develop the capacity at local level to evaluate the impact of the charging system. During the Study, it emerged that many ports do not specifically monitor either the environmental or the economic impact of their charging schemes. Lack of data makes it impossible to establish whether a scheme is having any effect on the environment and / or on the portfolio of ships calling the port.

At the same time, it should be borne in mind that many port authorities expressed their concerns as to the feasibility of teasing out the effect of a charging scheme on the environment. Ships are not the only source of pollution in ports and port cities; moreover, pollution levels are strongly influenced by weather conditions. These two considerations alone may suggest that, with the current knowledge at hand, it is relatively difficult to gauge the impact that a charging scheme has on the environment, because, for instance, it would not be easy to determine with absolute certainty whether a reduction in pollution levels is attributable to differentiated charging, to other policies, or to weather conditions. Nonetheless, it is suggested that, in the absence of detailed data, the competent authorities (not necessarily port authorities) at least make available data on air quality regularly. Having comparable time series of air quality data across ports would make it possible to apply mathematics and statistical methods and tease out the effect of an environmental charging scheme, by controlling for confounding factors and comparing results between similar ports.

The results of such an exercise could be shared by ports through the platform proposed in recommendation #7.

#5 - Port authorities and / or national authorities, depending on the governance model

Make sure to involve all the relevant actors in the decision-making process.

While ports should be left free to decide whether to differentiate their charges based on environmental criteria, it should be ensured that all the potentially interested parties are duly involved in the decision-making process. An environmental charging scheme should be agreed with all the actors involved, who would thus cooperate to achieve a common goal. Considering the different ownership and governance model of EU ports, this is also the responsibility of Member States.

In terms of number and type of actors involved, the list should include at least the port authority, shippers, forwarders, shipping companies, and terminal operators. Furthermore, the municipality and / or other

administrative units should also be involved in the consultation process, as the people living in a port city are ultimately the main beneficiaries of improved air quality.

A comprehensive consultation process, when it comes to port infrastructure charges, is also envisaged in Art. 15 of the 'Regulation of the European Parliament and of the Council establishing a framework on market access to port services and financial transparency of ports' (Regulation (EU) 2017/352), which includes provisions as to the regular consultation of port users and other relevant stakeholders, amongst other things, on environmental matters, including the change and definition of port infrastructure charges.

It may be useful to take as an example the Swedish experience with environmental charging. Recognising the need for abatement measures at sea, the Swedish Maritime Administration, the Swedish Port and Stevedores Association and the Swedish Shipowners Association in 1996 arrived at a Tripartite Agreement to use differentiated fairway and harbour dues to reduce emissions of NO_x and sulphur by 75% within five years. The parties concluded that vessels engaged in dedicated trade and other frequent vessel traffic involving Swedish ports, regardless of flag, should reduce emissions of NO_x by installing SCR or other cost-effective NO_x abating techniques.

Sweden is the first EU Member State that introduced differentiated port and fairway dues. Regardless of the specific solution adopted[70] – which may not necessarily be applicable in other EU Member States – the Swedish system is considered a success case. Without entering into the details, one of the success factor was certainly the cooperation of actors with different objectives toward a common goal. During this Study, some ship owners, albeit in favour of environmental charging, lamented that in some cases they are not consulted by port authorities in the decision-making process. If all the actors involved cooperated, it should be easier to reach the desired results. Port authorities should seek to identify alliances with all stakeholders that have a liability or responsibility towards aspects related to green shipping /differentiated charging schemes in order to share knowledge, experience and some of the costs. Such collaboration is at the heart of the EcoPort concept where ports share experience and avoid 're-inventing the wheel'.

#6 - Port authorities and national authorities

The total costs for financing a differentiated charging scheme should be balanced with the environmental benefits yielded by it.

When the principle of revenue neutrality is not respected, financing an environmental charging scheme might result in foregone revenue for the port authority, unless the reduced tariffs attract a larger number of 'green vessels', so as to make up for the loss of money. However, regardless of the specific situation, the costs incurred by the port to finance a scheme should not be seen in isolation, but balanced with the environmental benefits yielded by it. Among other things, this is another reason why it is paramount to set clear goals and establish a monitoring system. If the implementation of an environmental charging scheme contributes to reducing emissions in the port area, it follows that that scheme has improved the quality of life of the people living nearby. With precise data on the emissions saved as a result of the scheme, that improvement can always be quantified in economic terms. This is to say that, if the environmental benefits outweigh the costs of financing a scheme, then the scheme itself should not be seen as a loss for the port authority. On the contrary, considering that any improvement of air quality will inevitably benefit citizens, any potential loss of revenue for port authorities could be balanced with a compensation from local authorities – proportioned with the environmental benefits obtained – based on the consideration that, if a

[70] While differentiated port dues in Swedish ports have been analysed in the first phase of the Study, for more details on the fairway due system (which is outside the scope of this study), please see Kågeson P., Economic instruments for reducing emissions from sea transport, AIR POLLUTION AND CLIMATE SERIES NO. 11 / T&E REPORT 99/7, 1999. Please also see Ljungström T., The environmental differentiated fairway dues system, Swedish Maritime Administration, 2010.

measure implemented by the port benefits the whole community, then its costs should be shared accordingly.

#7 - EU and / or Port authorities

Establish a forum and a neutral platform to collect and exchange learning insights on environmental charging between ports.

A key objective of the study was to create a learning environment to support port managing bodies and their stakeholders in the decision-making with regard to the adoption of an incentive scheme, by means of simple, transparent and straightforward toolbox. However, the relative 'lock-in', once a certain scheme is chosen, as well as the complementarity between incentive systems potentially necessitate a coordinated effort by both current providers (ESI, Green Award, etc.), trade associations (IAPH, ESPO, others) and individual port managing bodies to adopt and expand the toolbox developed in the framework of this study, and feed it with data to facilitate decision-making, and to increase learning. The research undertaken in this study has shown that many port managing bodies, as well as incentive schemes themselves, are still in the learning phase, with several interesting insights generated at the individual port managing body level.

It would be useful if port authorities and stakeholders could meet periodically to discuss the state-of-play of environmental charging in the EU and exchange good practices. The forum could be promoted by a neutral organisation such as the EU, and could help keep the momentum going. Drawing on the experience of the ESI, such a forum could also be established in the framework of the IAPH. Representatives from outside the EU should also be invited, as quite often non-EU countries have entirely different approaches to environmental charging.

A neutral platform could be set up to collect learning insights, ensuring individual confidentiality of the insights provided, and paying attention to competitive aspects. Furthermore, as the learning process is still ongoing, frequent updates will be needed to keep both the inputs (new insights) and the outputs (in terms of recommendations) up to date. Among other things, a sector-wide collaboration based on the principle of 'ports freely exchanging knowledge and experience' would also provide a data base from which the actual environmental benefits of green charging could be assessed at both local and strategic scales.

The platform could be one of the tools to implement the principles on differentiated infrastructure charging laid out in COM(2009) 8 final, COM(2011)144 and COM(2013)295 final.

Since the platform might serve as a means to exchange, inter alia, confidential information, it is recommended that this initiative is promoted by port authorities directly, or via a sector association.

#8 - EU and / or port authorities

Develop a pilot project for the collection of information on actual emission production on board ships

During the study, it emerged that there are very few instances where the environmental benefits of the application of differentiated charging schemes can be identified on the basis of systematic, scheme-specific, scientific monitoring. This lack of evidence should not lead to concluding that differentiated charging is not effective *per se.* In fact, the obvious corollary to burning cleaner fuel, operating a 'greener' vessel and using OPS is an improvement, or at least enhanced protection of the environment in terms of quality and the standard of living of local communities.

Feedback from port sector stakeholders suggests that it may be difficult to monitor and quantify the environmental benefits of such schemes because of the difficulties of distinguishing the impact of specific emissions or discharges related to differentiated charging schemes from the sum total of aspects impinging on environmental quality in its entirety.

Nevertheless, albeit technically challenging, it should be possible to at least try to develop modelling techniques that make use of precise emission inventories and time series that includes monthly means of dispersion factors, in such a way as to allow estimating the overall impact of a specific charging scheme on certain significant environmental aspects. The models developed would then have to be tested against a set of observational data to verify their reliability.

However, one of the main challenges is that high resolution modelling requires highly detailed data on emissions from various sources. In Section 2 §2.2 of this report, several studies and projects are analysed, which aim to calculate detailed ship emissions even for single ships, as well as their spatial distribution within the port area at different times. Because it is costly to set up a system to collect emissions data at single ship level, and because there is no framework for the collection of such data, these exercises remain isolated initiatives.

For this reason, more data on actual emission production on board ship should be collected and made generally available through promotion of monitoring campaigns and reporting of monitored data. This would allow further improvement of the validity of emissions factors and improve verification of emission production models.

A pilot project could be conducted by a representative sample of ports and ship owners together with other relevant parties like NGOs or the European Maritime Safety Agency (EMSA). If successful, the model could be replicated on a wider scale. The availability of data on emission production would improve modelling exercises enormously, and, as a consequence, would also make it possible to measure the effects of any given environmental charging scheme on the areas surrounding a port. Moreover, the data on actual emissions collected in the framework of this exercise could be used to make a comparison with ships' environmental performance as certified by existing indexes and / or certification programmes. Amongst other things, the benchmarking exercise could contribute to fine-tuning indexes and certification programmes and enable them to better take into account actual ship-generated emission.

Such an exercise shares similarities with the MRV Regulation, according to which, from 2018, large ships using EU ports will be required to report their verified annual emissions and other relevant information. The pilot project may complement the objectives and effects of the MRV Regulation, which deals with CO_2 emissions, although, at the level of port area, there are also other emissions that affect the environment.

Moreover, the project would respond to one of the specific objectives of the LIFE programme for the priority area 'Environment and Resource Efficiency', i.e. "to improve the knowledge base for the development, implementation, assessment, monitoring and evaluation of Union environmental policy and legislation, and for the assessment and monitoring of the factors, pressures and responses that impact on the environment within and outside the Union". Similar projects on air quality monitoring – albeit not dealing with emissions on board ships – have been financed in the past[71].

The project would also respond to Horizon 2020's Priority III Societal challenges, which among its challenges includes 'Secure, clean and efficient energy' and 'Smart, green and integrated transport'.

#9 - EU

Further detail the concept of 'green ship' in the revision of the Port Reception Facilities Directive

The first recommendation from the REFIT Evaluation of the PRF Directive is to look at developing the 'green ship concept' in the context of waste reduction on board (Article 8(2)c). The Evaluation study recommends that *The PRF Directive needs to encourage the development of measures / innovative practices that reduce the amounts of waste produced on board. For this the current provisions for green ships should be further*

[71] A complete list is available at:
http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=home.getProjects&themeID=3&projectList

improved, by defining minimal criteria for a more uniform application of a discount on waste fees charged by port reception facilities.

The current formulation of Article 8(2)c[72] is very generic, and the leeway left to Member States for implementation may create problems when it comes to establish specific criteria. This may be one of the reasons why, as observed during the Study, only few ports seem to be implementing differentiated schemes that address waste. It is thus recommended that at least basic requirements are laid down in the new directive so to reduce the vagueness. It is not easy to give a precise definition of a 'green ship'. 'A green ship is a green ship'; hence the new Directive may accept that the qualifying criteria for respective ship indexes or certification schemes reduce environmental impact. Onus on index auditors and ship-owners to demonstrate benefits.

For instance, the Directive could attempt at defining the criteria to establish an EU-level register of the indexes and certification schemes considered reliable for the purposes of the PRF directive. To this purpose, it is worth mentioning that, as announced during the second panel discussion with stakeholders for this Study, the Green Award Foundation is about to revise its qualifying criteria for waste management on board.

It is important however that, besides addressing the use of the amount of waste generated on board, the Directive duly takes into account what happens to the same waste once it is discharged. Many stakeholders have lamented that it makes little sense to incentivise ship owners to reduce the amount of waste generated, or to segregate it according to MARPOL, if, once discharged, it is not known how that waste is treated.

#10 - EU and / or port authorities

Further analysis should be carried out to complete the mapping of incentives to reducing emissions and waste for ports

The focus of this study is on 'port infrastructure charges', defined as fees collected for the direct or direct benefit of the managing body of the port, and paid by the operators of waterborne vessels or cargo owners for the use of facilities and services that allow vessels entry and exit in and out of port. The study, thus, does not cover either port service charges, or the contractual conditions between port authorities and port service providers which could regulate port service charges. However, ships are not the sole source of emissions and waste in ports, nor are they necessarily the major polluters[73]. Therefore, it is advisable to map if there exist other economic incentives to reducing emissions also in and around ports. Despite the efforts made by ship owners to reduce the environmental footprint of the shipping industry, there are other players that carry out potentially polluting activities in the port area. While, on the one hand, it is true that, just like ship owners, these other players too are often completely or partially subject to further legislation or permitting (e.g. EURO standards for road transport, Energy Performance of Buildings, Ecodesign, etc.), on the other hand, albeit limitedly, they still remain sources of pollution.

Such an exersise would be in line with § 4.1. 'Improving the environmental performance' of the 'Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Strategic goals and recommendations for the EU's maritime transport policy until 2018' (COM(2009) 8 final). More specifically it would respond to the strategic objective of promoting a European Environmental Management System for Maritime Transport

[72] *Fees may be reduced if the ship's environmental management, design, equipment and operation are such that the master of the ship can demonstrate that it produces reduced quantities of ship-generated waste.*

[73] Nonetheless, it should be noted that at least according to a study by Merk, between 70% and 100% of in-port emissions may be attributed to shipping, 1/5 to trucks and locomotives and roughly 15% comes from equipment.
Merk, O., Shipping Emissions in Ports, International Transport Forum, Discussion Paper 2014-20. Retrieved from: http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DP201420.pdf

(EMS-MT), targeting the continuous improvement of the environmental performance of shipping; considering modulation of registration fees, port dues and other charges, with a view to rewarding efforts towards greener shipping'

Furthermore, the White Paper called 'Roadmap to a Single European Transport Area – Towards a competitive and resource efficient transport system' published by the Commission in March 2011 (COM(2011) 144) stipulates the restructuring of transport charges and taxes (Action 39 – Smart pricing and taxation). A key part of this wide strategy is to get transport prices right and promote a further recourse to the 'polluter pays' and 'user pays' principles in order to internalise the infrastructure and external costs.

Finally, the 2013 EC Communication on ports policy 'Ports: an engine for growth' recites that "Ports should consider whether to reward operators who anticipate or exceed the application of mandatory environmental standards and promote the use of door-to-door low-carbon and energy efficient logistics chains, e.g. short sea shipping. Although existing schemes introduced on a voluntary basis by a number of ports to raise their environmental image should continue to be supported, a more consistent application of such environmental variation of port infrastructure charges at a European or regional level would help to increase their effectiveness".

#11 - Port authorities and national authorities

When negotiating concessions or service contracts, consider introducing contractual provisions by which service providers must offer differentiated charging options to users.

As noted with recommendation #10 'ships are not the sole source of emissions and waste in ports, nor are they necessarily the major polluters.' While recommendation #10 deals with mapping existing incentives for terminal operators, it is recommended that, in conjunction with this exercise, port and / or national authorities also consider introducing specific contractual provisions and clauses in the concessions to service providers and terminal operators, by virtue of which they must reward users (for example, but not only, ships) that voluntarily decide to go beyond the environmental standards required by the law.

At the current level of knowledge, and without first completing the proposed mapping exercise, it may be difficult to outline potential incentives, especially because there is a multitude of services provided in ports, and each of them may need specific mechanisms. Nonetheless, the core principles should resemble those than inform differentiated infrastructure charging in ports; that is the system should preferably reward greener users rather than punishing those just in compliance, and a certain degree of standardisation should be sought within the industry, so that users can cumulate incentives across different ports, thus increasing their attractiveness.

#12 - Port authorities and / or national authorities, depending on the governance model

Make sure that existing certification schemes include mechanisms for inspections and/or audits.

The relative lack of standardised audits and inspections currently somewhat harms the perceived strength of the (successful) ESI system, through the lens of some stakeholders (as opposed to e.g. Green Award). Government support might need to be envisaged to support successful and widely adopted schemes to gain further credibility.

9 Conclusions

All transport activities generate benefits and costs to society. Users are normally charged a price, based on the principle that those who enjoy the benefits of an economic activity should also bear its costs.

However, transport activities also generate external costs that are not fully borne by users, such as pollution, noise, congestion, accidents and spills, etc. Transport providers and users make their decisions without taking into account "externalities", although these inevitably produce side effects on society as a whole. The policy intervention aimed at making side effects part of the decision-making process of transport users is called 'internalisation of external costs'. According to the welfare theory approach, internalisation of external costs through the use of market-based instruments may lead to a more efficient use of infrastructure, reduce negative side effects of transport activities and improve fairness between transport users[74].

Fair and efficient transport pricing is also advocated in a number of policy documents issued by the European Commission, notably the 2011 White Paper on Transport. In 2008, the European Commission released its first handbook with estimates of external costs in the transport sector (then updated in 2014[75]). The handbook, jointly prepared by several transport research institutes, summarises the state of the art best practices as regards the valuation of external costs. The Commission used this handbook to prepare a communication on a strategy to internalise the external costs for all modes of transport that was adopted in July 2008. Environmental charging is a step in the direction towards this policy.

According to our survey, there are 30 ports in the TEN-T core network that are currently applying one or more environmental charging schemes. It is believed that there may be an even larger number of ports not included in the TEN-T core network that are doing the same, although they fell outside the scope of this study. The results of our survey, inter alia, are consistent with an internal survey that ESPO is carrying out.

Apart from a few examples at national level (namely Spain and Sweden), in the EU itself, environmental charging is currently 'self-regulated' at the level of port authority. The 2013 EC Communication on ports policy 'Ports: an engine for growth' states that "Ports should consider whether to reward operators who anticipate or exceed the application of mandatory environmental standards and promote the use of door-to-door low-carbon and energy-efficient logistics chains, e.g. short sea shipping. Although existing schemes introduced on a voluntary basis by a number of ports to raise their environmental image should continue to be supported, a more consistent application of such environmental variation of port infrastructure charges at a European or regional level would help to increase their effectiveness".

As noted in this survey, however, self-regulation has spontaneously produced a certain degree of coordination among port authorities, as the vast majority of schemes identified revolve around a common set of core principles, and offer rebates on port dues that on average range from 0,5% to 20% to vessels that are certified under well acknowledged indexes and / or certification programmes. It may reasonably be assumed that the success of this practice is to be found in the fact that these initiatives are becoming increasingly recognised and popular in the shipping industry, and assign 'user-friendly' scores to ships that comply with certain environmental standards. It is thus much easier for port authorities to structure differentiated charging, based on well-established criteria certified by a third party. At the same time, it would also seem more convenient for ship owners to benefit from rebates based on well-known certifications with clear, qualifying criteria. This point is of special significance, as it has been argued that the 'transaction costs'[76] of differentiated port dues may be significant, in that ships must demonstrate that

[74] Ricardo-AEA, Update of the Handbook on External Costs of Transport, Report for the European Commission: DG MOVE, 2014.
[75] Idem.
[76] Transaction costs can be defined as the costs of participating in a market.

they qualify for a rebate and port authorities have to handle a more complex pricing structure[77]. In actuality, the port and shipping professionals interviewed for this study seem to believe that relying on third-party certifications and / or indexes is a win-win approach. Ports actually incur lower transaction costs than they otherwise would if they were to set up bespoke metrics to measure 'how much green' a green ship is; from the viewpoint of ship owners, on the other hand, a quick look at the websites of the most popular indexes and certifications reveals that the transaction costs are virtually non-existent. Even more to it, several ship owners apply for an environmental certification for a number of reasons, not necessarily connected to environmental charging, and so the (albeit negligible) transaction costs should be apportioned accordingly.

Moreover, the advantages of relying on existing indexes and certifications are corroborated by the fact that, when it comes to the uptake of environmental charging, no significant differences were observed during the study between large and small ports. If administrative and transaction costs had increased further to the implementation of an environmental charging scheme, then one would have expected to observe a higher uptake by larger ports, which, theoretically, have more options to take advantage of the practices. By contrast, there seems to be no difference between large and small ports, apart from the fact that the former set aside a larger budget for environmental charging as well.

The question as to whether the sector should continue to self-regulate environmental charging, or a more consistent application of it should be fostered at EU/national level is of special significance for the success of the practice. On the one hand, several port authorities firmly believe that any centralised coordination, especially if based on a top-down approach, would be detrimental to the sector, in that it might fail to acknowledge the inherent diversity of EU ports in terms of ownership, organisation, management, size, functions, and geographical location, and conflict with free competition. At the opposite end of the spectrum, some stakeholders consider that a more coordinated approach across the EU may make environmental charging more effective, since ship owners would benefit from the application of consistent standards, thus cumulating rebates across each port of call.

It is outside of the scope of this study to suggest overly-specific policy options, as in principle any approach to environmental charging may be equally valid, depending on context. Nevertheless, it should be noted that, under the current approach, several port authorities and stakeholders believe that environmental charging may be perceived to be rather weak as an incentive to persuade ship owners to 'go greener'. Among the main reasons reported is the fact that port dues are only a fraction of the total costs borne by ship owners, and rebates are thus insufficient to alter their behaviour and cover the costs of significant investments in clean technologies. The problem with this argument is that it holds true only as long as ports act individually and use different criteria for eligibility. Indeed, should a more consistent approach be pursued, ship owners might cumulate the incentives from environmental charging and spread the costs of qualification (i.e. investment in clean technology) over a larger number of ports.

Moreover, despite being relatively widespread, the belief that the incentives are too weak to alter ship owners' behaviour seems to rest on anecdotal evidence, rather than on thorough economic and financial analysis. In principle, no stakeholder objects that environmental charging is a 'good practice', but very few of them are actually monitoring the effects of the scheme they implement. According to a scenario developed in the Study, should all ports in the EU (plus Norway and Turkey) apply an environmental charging scheme based on certain common characteristics, an average 30% rebate on port dues for 'green ships' could result in incentives for the shipping sector of 1,4 billion euro over 5 years (provided that at least 30% of the fleet meets the eligibility criteria). This makes a good argument for a more coordinated approach, in that certain indexes or certain measures taken by the ship can provide entitlement for multiple rebates in different ports. The condition of whether these rebates can be cumulated or not is important as small rebates can be compounded to sizable incentives when cumulated, thus increasing the strength of environmental charging as an economic incentive.

[77] De Langen P., The Analyst: sense of green port dues, published on Port Economics on 7 October 2016. Available at: http://www.porteconomics.eu/2016/10/07/4010/

This becomes even more evident when it comes to climate change, as there is potential for environmental charging to become a market-based measure to reduce GHG emissions, but only if a concerted effort is taken at EU level. With the effective application of the MRV Regulation, it should be possible to establish an EU-level scheme that rewards ship owners who decide to go beyond current standards for CO_2 reduction. If, for instance, a 20% rebate were given to vessels that are 50% more efficient than the standards already set until 2025 at IMO level, the scheme would make it possible to reduce CO_2 emissions from voyages from /to EU ports by 3,97% in 2030 alone, and save up to 63,2 million tonnes of CO_2 from 2018 to 2030, assuming that 30% of the fleet is eligible. This reduction would build on top of an already existing set of reductions decided at IMO level and is likely to increase after 2030, reflecting the upward trend in the demand for maritime transport. Furthermore, the data collected in the framework of the MRV Regulation will allow linking the rebates to the level of efficiency of each ship, and to know with a sufficient degree of precision how much CO_2 is emitted (and how much is saved) on each journey. In contrast to schemes addressing air quality and / or waste, in the case of CO_2, the actual effect would be appreciable only if a sufficient critical mass of ports implementing the scheme is created at EU level.

When it comes to verifying whether incentives from environmental charging can contribute to making investments in greener technologies (e.g. installation of a scrubber or LNG solution, or investment in OPS) more profitable, it emerges that under certain circumstances they may shorten the payback period of the investment by one or more years. For this reason, it is believed that environmental charging may contribute to accelerating the deployment of alternative fuels such as LNG or OPS.

Another interesting finding of the Study is that in the short run environmental charging may not necessarily lead to altered behaviour of ship owners; however, the incentive becomes more effective when it comes to the development of new ships and the choice of fuel. Ship owners are perfectly aware of the increasingly stringent emissions regulations at the international level, as they have to take them into account to decide whether to renew their fleet or to invest in green technologies to comply. Ship owners inevitably incur costs as a result of environmental legislation; the possibility to reap even modest benefits from environmental charging should be seen as a reduction of these costs and / or as an incentive to take action before the target date for entry into force of new regulation (i.e. the above-mentioned early compliance). Hence, the real impact of a scheme should be considered in a long-term perspective, when its full potential is wielded. Inasmuch as the indexes and certifications that are used to determine eligibility for rebates are kept up to date with the latest development in environmental legislation (and they normally are, lest they may soon become obsolete), environmental charging is apt to be an incentive to encourage early compliance. Its significance may vary from modest to substantial, depending on whether a sufficient 'critical mass' of ports implement consistent criteria for eligibility.

Furthermore, environmental charging may also carry positive implications in terms of image (which could ultimately yield economic benefits) for both ports and ship owners, and could also be seen as one of the steps to reduce the overall environmental footprint of the industry; an effort whose costs would be partly compensated by the improvement of significant environmental aspects in port areas and the incentives from reduced port dues.

However, the significance of environmental charging cannot be reduced solely to economic considerations. In fact, its *raison d'être* lies in promoting the use of cleaner technology and reducing the footprint of the shipping sector, especially in the port area and its environs. Hence, its effectiveness as an incentive should also be assessed also under the environmental point of view.

In this case too, the overwhelming majority of EU ports do not actually monitor the impact of differentiated charging on significant environmental aspects such as, inter alia, air quality and waste. In the absence of any actual data, an estimation was specifically carried out as part of this Study. It emerged that a discount of only 20% on port dues in all EU ports for vessels certified with an ESI score of 30 points may lead up to a 4,34% reduction of current NO_x, SO_x and PM emissions in the EU, if only 14% of the EU fleet were eligible for the discount

Even more importantly, the study seeks to link environmental and economic considerations under the same framework. Environmental charging may be a strong economic incentive and may lead to a significant

reduction of pollutants emission in the port area. Yet, financing a scheme implies that port authorities may forego an important share of their revenues to attain certain environmental objectives, especially if the principle of 'revenue neutrality' is not respected. At the same time, it is proved beyond any reasonable doubt that pollution affects human health and causes death from a multitude of diseases. Damage from pollution thus has both social and economic costs which should be a concern for society as a whole, not simply for port authorities. The models developed in the study show that, if external environmental costs are factored in, savings from reduced emissions in the port area may outweigh the costs connected with the revenue foregone from reduced port dues.

If ports are not able or not willing to determine whether, or to what extent a green charging scheme yields benefits for the environment in terms of reduced pollution, then the paradox is that it becomes controversial to argue in favour of its implementation in the first place, as well as to justify the foregone revenue that a port authority may suffer from its application. This situation triggers a 'vicious circle' whereby EU ports are not monitoring the impact of environmental charging, therefore they do not possess sufficient data to be able to determine whether it is working, therefore they often tend to believe that its impact on the environment may be negligible and / or too difficult to measure. However, as shown in the study, if attempts were to be made, they might well reveal a different reality, or at least provide solid figures on which to ground an evidence-based opinion.

It may be considered that the current largest gap between policy and practice is the lack of science-based, quantified evidence required to formulate and encourage effective implementation based on proven efficacy of charging models and the benefits delivered to environmental quality. There is strong scope for collaboration between Port authorities, Municipalities and Shipping to monitor to mutual benefit. This would ease the concerns of Port Authorities who see the cost of set-up, staffing and operating such schemes as expensive, provide scope for the 'polluter pays' principle, and generally encourage a system approach to this trans-boundary, multi-parameter complex of science and technology-based challenges.

In addition, there is potentially even stronger scope for a more coordinated approach to environmental charging across the EU, as the application of common standards would inevitably maximise environmental and economic benefits, while reducing the workload and administrative burden connected to the implementation and management of the schemes.

Finally, the focus of this study is on 'port infrastructure charges', and thus does not cover either port service charges, or the contractual conditions between port authorities and port service providers which could regulate port service charges. However, ships are not the sole source of emissions and waste in ports, nor are they necessarily the major polluters[78]. Despite the efforts taken by ship owners to reducing the environmental footprint of the shipping industry, there are other players that carry out potentially polluting activities in the port area. While, on the one hand, it is true that, just like ship owners, these other players too are often completely or partially subject to further legislation or permitting (e.g. EURO standards for road transport, Energy Performance of Buildings, Ecodesign, etc.), on the other hand, albeit limitedly, they still remain sources of pollution. It is thus recommended that port and / or national authorities also consider introducing service charges or other financial incentives that reward port service providers based on their environmental performance. While this practice is worth being further investigated, it is clear that it has enormous potential to improve certain significant environmental aspects in the port area, as well as the quality of life of the people living nearby.

[78] Nonetheless, it should be noted that at least according to a study by Merk, between 70% and 100% of in-port emissions may be attributed to shipping, 1/5 to trucks and locomotives and roughly 15% comes from equipment.
Merk, O., Shipping Emissions in Ports, International Transport Forum, Discussion Paper 2014-20. Retrieved from: http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DP201420.pdf

Annex I

Overview of shipping emissions and waste

Shipping emissions – Greenhouse gases and air pollutants

Introduction

Air pollution is the contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere (Word Health Organisation, 2015).

Even though maritime shipping is considered to be the most carbon-efficient mode of transport in terms of carbon dioxide produced per cargo transported, the industry is responsible for the generation of massive quantities of emissions (OECD, 2010). Carbon dioxide is the major driver of shipping contribution to radiative forcing, with significant long-lasting impacts[79]. Geospatially, ship emissions are concentrated along the major trade routes, whilst more than 70% of the international shipping occurs within 400 km of land (Eyring et al., 2005).

The main types of emissions from shipping are Sulphur Dioxide (SO_2), Nitrogen Oxides (NO_x), Volatile Organic Compounds (VOC), Particulate Matter (PM) and Carbon Dioxide (CO_2). The quantity of gas emitted depends on the total fuel consumption (IMO, 2014), which is in turn affected from various parameters such as the shape of the hull of the ship, the loading conditions, the state of engine, etc (Miola et al., 2009). Main engines[80], auxiliary engines[81] and boilers are the primary emission sources. Auxiliary engines and boilers are used to produce power for other onboard functions such as lighting, ventilation etc., and thus they operate even when the ship is at berth.

Air pollutants are classified into primary and secondary. Primary pollutants are those emitted directly into the atmosphere, while secondary pollutants are formed in the air environment as the result of the chemical reaction of primary pollutants with other pollutants and atmospheric gases (Holman, 1999). The distinction among primary and secondary pollutants is directly connected with the selection of abatement method.

The aim of this section is to review the major air emissions produced from the operations of the international fleet, en route and at ports, as well its impacts in air and marine environment and human health.

Sulphur oxides (SO_x)

SO_x is gaseous, colourless non-flammable gas but with intense irritating odour at very high concentrations. Oxides of sulphur form during the combustion process, from the interaction of the sulphur in the fuel with oxygen. In humid conditions, SO_x is dissolved in the air and converted into sulphureous acid, whilst it is oxidised and converted to sulphuric acid in dry conditions, which together with the nitric acid is the main constituent of acid rain. The amount of emissions depends on the sulphur contained in the fuel (Kontovas and Psaraftis, 2009). The sulphur content of maritime fuels can vary from 0,3% to more than 5%, with the average content ranging from 2,4%-2,7% (Eyring et al., 2007), whereas chemical conversions in the atmosphere change the properties of the emissions, affecting their life time, transport distance and disposition rate (Svensson, 2011). Based on an IMO Study, international shipping generated 9,2 thousand tonnes of SO_x in 2011. The annual average estimates of SO_x (as SO_2) were 10,6 million tonnes, which correspond to 13% generated from anthropogenic sources and 12% of global SO_x.

[79] LowCarbon Shipping, 2014

[80] Main engines' emissions depend on the characteristics of the engine, load factor and year of build. Activity specifics (berth, anchoring, manoeuvring), speed, weather, loading conditions are also parameters affecting the mass of emissions.

[81] Alike for main engines, type, operations and built year affect the amount of emissions generated from auxiliary engines.

Sulphur dioxide (SO_2) is one of the main atmospheric pollutants, generated from the operations of the international fleet mostly due to fact that the industry uses dirtier fuels. Indicative of that is that marine fuels are on average 2.700 times dirtier that the ones used in road transport (AirClim,2011).

Table 78 - SO_x emissions estimates (thousand tonnes as SO_2)

Marine sector	Fuel Type	2007	2008	2009	2010	2011
International marine bunkers	HFO	8.268	8.220	8.404	9.158	9.199
	MDO	69	60	66	74	78
	LNG	0	0	0	0	0
International total		*8.337*	*8.280*	*8.470*	*9.232*	*9.277*
Domestic navigation	HFO	945	659	775	732	657
	MDO	60	63	62	68	72
	LNG	0	0	0	0	0
Domestic total		*1.005*	*723*	*837*	*800*	*792*
Fishing	HFO	52	51	51	41	41
	MDO	14	13	13	14	13
	LNG	0	0	0	0	0
Fishing total		*66*	*64*	*64*	*55*	*55*
Total		**9.408**	**9.066**	**9.371**	**10.087**	**10.061**

HFO: heavy fuel oil; MDO: Marine diesel oil; LNG: liquid natural gas

Source: IMO, 2014

Impacts: Maritime transport is a major contributor to emissions of sulphur oxides. It is estimated that by 2020 the contribution of shipping to sulphur oxide emissions will exceed the corresponding terrestrial means. Oxides SO_x can be transported over long distances and create acid rain away from the location of the original emission. This deposition of acidic gases can occur either by dry deposition (gases or particles adsorbed by land surfaces, materials or water surfaces) or wet deposition (pollutants are dissolved in clouds, fog, rain or snow (Svensson, 2011). SO_x can result in poor visibility, and can have significant effects on human health. The intensity of aerosol formation and its permanence depend on meteorological conditions and catalytic impurities in the air[82]. Some of the impacts to human health are breathing difficulty, airways inflammation, heart failure and circulatory collapse. Long-term exposure to sulphur dioxide can cause respiratory problems, asthma and chronic bronchitis. People with cardiovascular, chronic lung diseases, young children and elderly are vulnerable to such conditions.

Limits: Under the umbrella of the IMO, it was decided that the sulphur content limit in bunker fuels should be gradually reduced over the following years, with the greater reductions required for the specific gas control areas emissions (Emission Control Areas, ECA). SO_x emissions from marine diesel engines are regulated under the International Convention for the Prevention of Pollution from Ships, MARPOL: MARPOL 73/78, Annex VI, Regulation 14, SO_x. The sulphur content of bunker fuels is reduced progressively from 2010 to 2020. The initial 4,5% m/m (until 2011) was gradually reduced to 3,5% from the 1st of January 2012 followed by 0,5% from the 1st of January 2020. However, an extension until 2025 is envisaged, based

[82] http://www.mma.gob.cl/retc_ingles/1316/w3-article-51518.html

on the availability of required fuels. In SECAs[83], the sulphur limit from 1,0% in effect from the 1st of July 2010 is reduced to 0,1% from the 1st of January 2015. The Revised Annex VI applies to all ships of 400 GT and above, though some exceptions are specified in the Annex, e.g., for the purpose of securing the safety of a ship or saving life at sea.

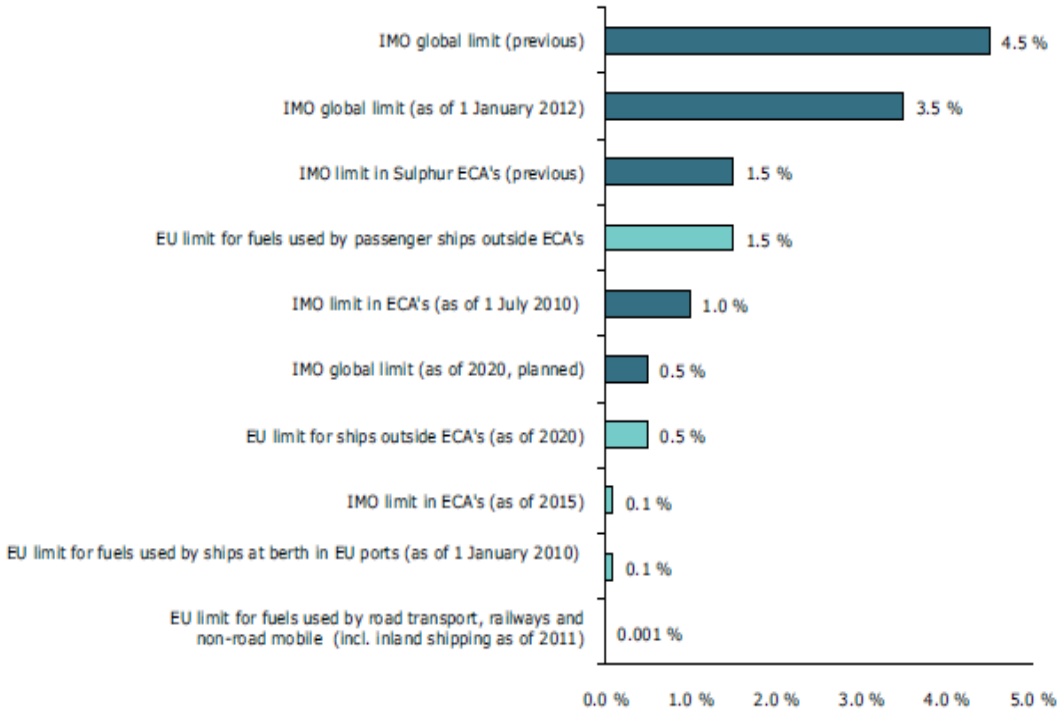
The European legislation is aligned with the requirements of the IMO, through Directive 2012/33/EU. Directive 2012/33/EU[84] is the main legislative act on the reduction of sulphur dioxide emissions from the use of all liquid fuels used by ships and modifies Directive 1999/32/EC as regards the sulphur content of marine fuels. The main additional requirements compared to MARPOL are:

- a 0,1% sulphur limit on fuel by at berth in EU/EEA ports;
- a 1,5% sulphur limit for marine diesel oil and heavy fuel oil used by passenger vessels on regular services between EU/EEA ports, unless ECA requirements apply;
- a 0,1% sulphur limit on marine gas oils used or sold in the EU;

In October 2016, the IMO's Marine Environment Protection Committee (MEPC) reached an agreement in favour of maintaining the deadline of 2020 for introducing a global cap of 0.5% sulphur content in marine fuels. ESPO congratulated IMO on its decision, because, by setting 2020 as deadline for the global 0.5% sulphur cap, the IMO timing is being aligned with the EU timing as envisaged in the current Sulphur Directive. This will mean equal rules for EU and its neighbouring countries.

Based on the European Environment Agency's data (2013), Figure 1 illustrates the evolution of relevant regulatory limits.

Figure 14 – Evolution of regulatory limits (sulphur)



Source: EEA, 2013

[83] SECA areas include the Baltic Sea, the North Sea, the North America ECA and US Caribbean ECA.
[84] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32012L0033&from=EN

Oxides of Nitrogen (NO_x)

Nitrogen oxides (NO_x) are gaseous products generated from fuel combustion in the main and auxiliary engines. The formation NO_x occurs from the oxidation of molecular nitrogen in the combustion air or the oxidation of organic nitrogen in the fuel (Hans Otto, 2012). The oxides are very toxic particularly when they react with other compounds in the atmosphere. The amounts of nitrogen oxides produced in ship engines depend on the combustion temperature (as temperature increases, produced amounts increase too), on the stay time of the fuel in the cylinder and the low-quality mixing of fuel and air in the combustion chamber[85]. Ship's age is also referred as a determinant factor (EEA, 2013).

International shipping is estimated to produce 5,6 million tonnes of NO_x annually, representing 15% of total global NO_x generated from anthropogenic sources (IMO,2014).

Table 79 - NOx emissions (Top-down approach) (thousands tones as NO_2)

Marine sector	Fuel Type	2007	2008	2009	2010	2011
International marine bunkers	HFO	16.191	16.461	15.429	16.638	16.545
	MDO	2.269	1.981	2.173	2.460	2.583
	LNG	0	0	0	0	0
International total		*18.460*	*18.442*	*17.601*	*19.098*	*19.127*
Domestic navigation	HFO	1.851	1.321	1.423	1.330	1.181
	MDO	1.981	2.085	2.059	2.242	2.391
	LNG	0	0	0	0	1
Domestic total		*3.832*	*3.406*	*3.482*	*3.573*	*3.572*
Fishing	HFO	102	102	93	74	74
	MDO	471	428	436	454	445
	LNG	0	0	0	0	0
Fishing total		*574*	*530*	*530*	*528*	*520*
Total		**22.865**	**22.378**	**21.613**	**23.199**	**23.219**

Source: IMO, 2014

Impacts: Evidence of the impact of increased NO_x emissions due to international shipping is highlighted by Richter et al., (2004), who note the concentrations of NO_2 along the major international shipping routes. More recently (2014), the Clean North Sea Shipping Final Report came to similar conclusions, noting that the areas of the North Sea where the highest emissions of pollutants in general occur are those where the majority of the big ships with high energy demand sail. By superimposing AIS and emissions data, the study demonstrates that the big vessels do not contribute significantly to emissions in North Sea as a whole, while their contribution is remarkable along densely populated coasts, where the major international shipping routes lead along. At local and regional level, shipping impacts human health through the generation and transport of ground-level ozone. Ozone is not emitted directly into the atmosphere but is the result of the reaction of nitrogen oxides with volatile organic compounds in the presence of heat and sunlight (secondary pollutant) (IMO, 2000). NO_x and sulphur dioxide react with other substances and form acid rain. NO_x are contributing to acidification and eutrophication, thus affecting natural ecosystems, water quality deterioration and threatening biodiversity. Major health impacts on human beings include effects on breathing and the respiratory system, damage to lung tissue, and premature death.

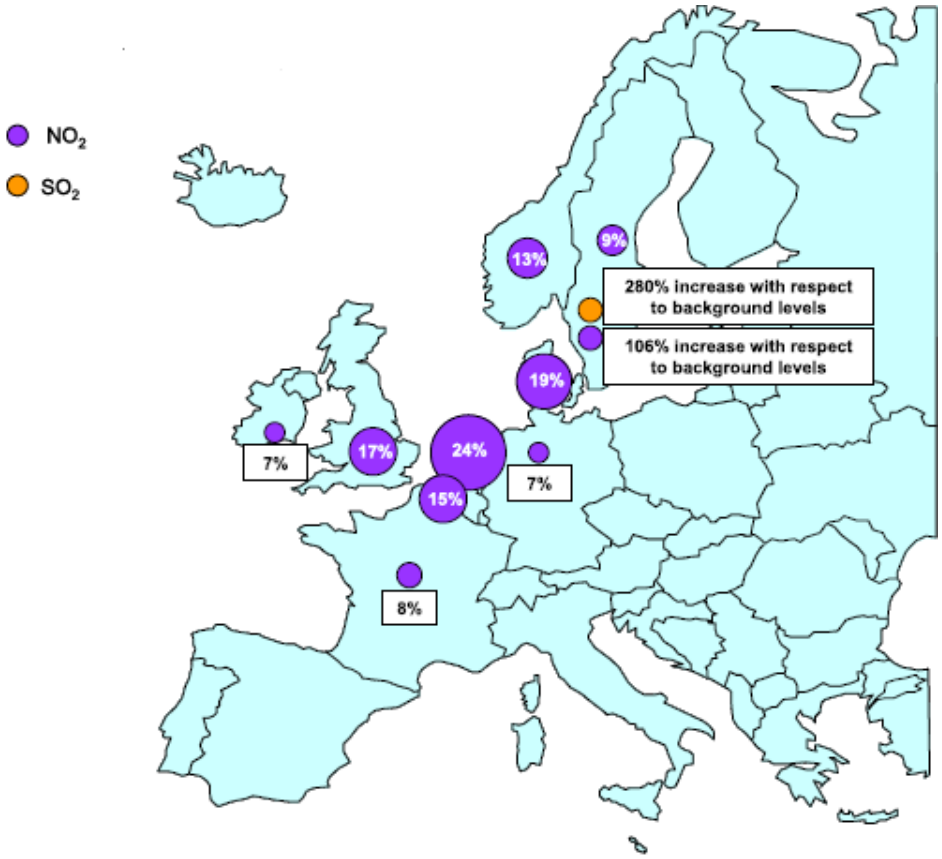
In coastal countries of the North Sea, Nitrogen oxide emissions from shipping is estimated to be responsible for 7-24% of country average NO_x concentration in 2030 (Hammingh et al., 2012 cited in Viana, 2014).

[85] http://ec.europa.eu/environment/enveco/taxation/ship_emissions/pdf/app6final.pdf

Based on the same source the Netherlands and Denmark are expected to be the countries recording the highest concentrations with 24% and 19% respectively.

Figure 15 presents the contribution from shipping emissions to air quality across Europe.

Figure 15 – Distribution of ship-based emissions in Europe



Source: Viana, 2014

Limits: Control of NO_x emissions produced from global fleet is required by the new regulations of MARPOL Annex VI (Regulation 13, on Nitrogen Oxides) regulating the maximum shipping nitrogen oxide emission limits. The NO_x control requirements apply to all installed marine diesel engines of over 130 kW output power, regardless of the tonnage of the ship. The different Tiers of control depend on the age of the ship, the engine's rated speed and year of manufacture. The limits described in Tier I and Tier II of IMO Standards (see tableTable 80 below) have general application, while those under Tier III apply to ships operating in Emission Control Areas (ECA). The limits of Tier I refer to machines manufactured between 2000-2011 and the limits of Tier II refer to machines constructed after 1/1/2011. As regards Tier III, NO_x standards after 1 January 2016 also apply to ship operating in the North American ECA and the United States Caribbean Sea ECA.

Table 80 – IMO Standards (NO_x emissions)

Tier	Ship construction date on or after	Total weighted cycle emission limit (g/kWh) n = engine's rated speed (rpm)		
		n < 130	n = 130 - 1999	n ≥ 2000
I	1 January 2000	17,0	$45 \cdot n^{(-0.2)}$ e.g., 720 rpm – 12,1	9,8
II	1 January 2011	14,4	$44 \cdot n^{(-0.23)}$ e.g., 720 rpm – 9,7	7,7
III	1 January 2016*	3,4	$9 \cdot n^{(-0.2)}$ e.g., 720 rpm – 2,4	2,0

Source: IMO, 2014

Corresponding NECA (Nitrogen Emission Control Areas) areas are not determined, and, as highlighted from the EEA, (2013) present regulations can only have a limited impact in regulating NO_x.

At EU level, there is no binding legislation for the reduction of ship-based NO_x emissions[86]. IMO MARPOL and EU regulations provide alternative equivalents in order to achieve air emissions' reduction and as such allow the use of Exhaust Gas Cleaning Systems (EGCS), called scrubbers[87]. The logic is to achieve the same SO_x limits as when using fuel with a sulphur content of less than 0,1%. In this context, IMO has issued EGCS requirement details for the testing, survey, certification and verification of scrubbers so as to ensure that emissions' levels are met.

During the 70th Marine Environment Protection Committee, the IMO has designated the North Sea and the Baltic Sea as NO_x Emission Control Area (NECA) starting from January 1, 2021 onwards. The NECA regulation will apply to all vessels built after 2021, and will require to reduce NO_x emissions by 80% compared to the present emission level. According to recent estimates by European Monitoring and Evaluation Programme (EMEP), consisting of deposition modelling based on available emission scenarios (Jonson et al 2015), the annual reduction in total Nitrogen deposition to the Baltic Sea area will be 22,000 tons as a combined effect of the Baltic and North Seas NECAs and compared to a non-NECA scenario[88].

Particulate Matter (PM)

Particulate matter is the term used to describe the mixture of solid particles and liquid droplets found in the air, including 'inhalable coarse particles' with diameters larger than 2,5 micrometers and smaller than 10 micrometers and 'fine particles' with diameters of 2,5 micrometers and smaller (EPA, 2015)[89]. Microparticles consist of powder material, coal and other solid released into the atmosphere from the

[86] http://www.emsa.europa.eu

[87] It is estimated that the establishment of scrubber system can reduce sulphur emissions by more than 90%, as well PM emissions by 60-90% (NABU, 2015).

[88] Jonson J. E., Jalkanen J. P., Johansson L., Gauss M., and Denier van der Gon, H. A. C., Model calculations of the effects of present and future emissions of air pollutants from shipping in the Baltic Sea and the North Sea, Atmospheric Chemistry and Phisics, 2015.

[89] http://www.epa.gov/pm/basic.html

normal operation of ships or work in ports, shipyards and repair areas. Particulate matters are either directly emitted from fuel combustion (primary particles) and transferred through wind, or are indirectly formed (secondary particles) when pollutants emitted to air turn into particulate matters[90].

Ship exhaust contains particulate matter resulting from the incomplete combustion of carbon, with smoke produced to be considered an indication of the combustion quality (Hans Otto, 2012). However, the amount emitted is directly correlated to the type of fuels used. Specifically, it has been estimated that the emission factors for engines burning distillate fuel are five times lower (0,3g/KW-hr) than engines burning HFO (1,3 g/KW-h) (Sax and Alexis, 2007). This is grounded by the fact that marine distillate fuels have a sulphur content of approximately 0,25% compared to HFO which content is ~2,5%. Nevertheless, Diesch et al. (2013) note that, besides fuel quality, engine type, exhaust system (temperature and pressure) and operational conditions can also play a role.

Also SO_x and NO_x emissions produce particulate matter through chemical reactions caused when interacting with water vapor and light. Shipping is argued to contribute to increasing particle number concentrations, dominated by ultrafine particles (Reche et al., 2011).

PM emissions from shipping in 2011 were estimated at 1,4 thousand tonnes.

Table 81 - PM emissions estimates (thousand tonnes)

Marine sector	Fuel Type	2007	2008	2009	2010	2011
International marine bunkers	HFO	1.191	1.198	1.183	1.276	1.283
	MDO	27	23	25	29	30
	NG	0	0	0	0	0
International total		*1.217*	*1.221*	*1.208*	*1.304*	*1.313*
Domestic navigation	HFO	136	96	109	102	92
	MDO	23	24	24	26	28
	NG	0	0	0	0	0
Domestic total		*159*	*121*	*133*	*128*	*120*
Fishing	HFO	8	7	7	6	6
	MDO	6	5	5	5	5
	NG	0	0	0	0	0
Fishing total		*13*	*12*	*12*	*11*	*11*
Total		**1.390**	**1.354**	**1.354**	**1.444**	**1.443**

Source: IMO, 2014

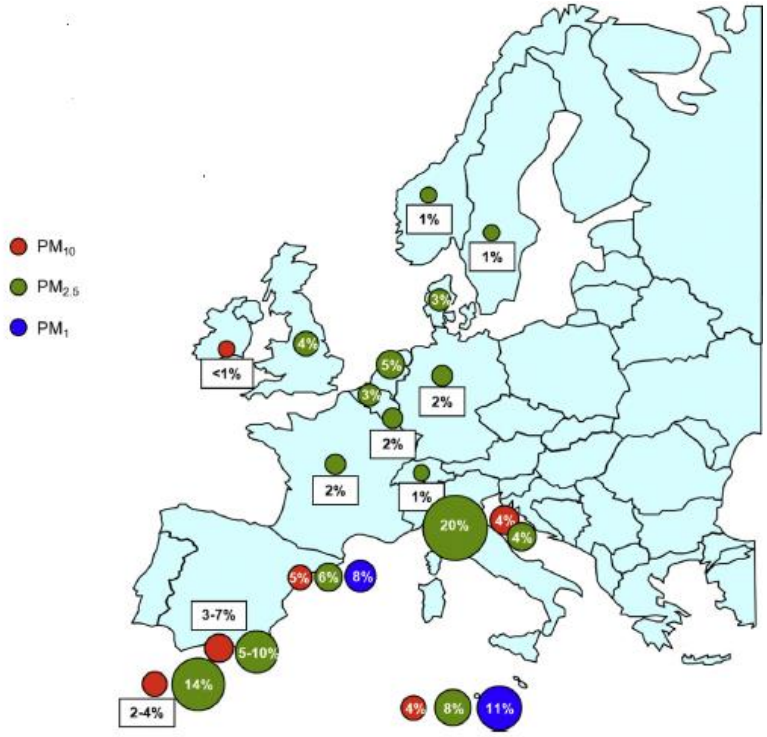
Impacts: the impact of PM_x concentrations from ship emissions is estimated either through dispersion and reception models or chemical tracer models, whilst the impact of shipping emissions on PM presents significant variations across European coastal regions (Viana et al., 2014). Based on the review of Viana et al. (2014), as far as the impact of shipping on air quality in coastal areas is concerned, the following results are summarised, indicating the significance of PM to the quality of regional air environment:

[90] http://www.greenfacts.org/en/particulate-matter-pm/level-2/01-presentation.htm#0

- In Gothenburg, the exposure to transient particles (smaller than 0.1 µm in diameter) in the inner part of the harbour increased by a factor of 3 in number concentration when a ship plume was recorded;
- In Cork (Ireland) the fresh ship plumes were not found to contribute significantly to primary $PM_{2.5}$ e $_{0.1}$ concentrations
- In Copenhagen, ships were estimated to contribute significantly to PM concentration in the areas near the port, with a contribution to the annual PM_{10} mean of 0.08e0.15 µg/m^3.
- For countries near the North Sea the contribution of $PM_{2.5}$ depends on the proximity of the country to the major shipping routes, with the $PM_{2.5}$ percentage varying from 5% (Netherlands and the UK) until 1% (Sweden and Norway).
- In the Mediterranean region, it was found that shipping emissions contributed with 2% and 4% of mean annual PM_{10} levels and 14% of mean annual $PM_{2.5}$ levels.
- Across Europe, shipping emissions' contribution to ambient PM levels was 1-7% of PM_{10}, 1-14% of $PM_{2.5}$.

Authors concluded that air quality degradation due to PM is higher in the Mediterranean compared with the North and Baltic Sea, a fact partially attributed to the establishment of SECA areas and the standards for lower SO_2 emissions in the region.

Figure 16 – PM emissions in Europe



Source: Viana et al, 2014

It is argued that there is a correlation between fine particulate and increased incidence of illness[91]. Exposure to conditions of high particle concentration can increase the sensitivity of respiratory bacterial or viral diseases. Depending on their size, particles can enter the respiratory system, causing damage to lungs,

[91] http://www.epa.gov/captrade/documents/power.pdf

asthma, pulmonary chronic and allergic bronchitis, and even carcinogenic and premature death. Vascular inflammation and atherosclerosis are also referred as impacts of $PM_{2.5}$ (Arden et al., 2002). Long term exposure is also linked with coronary incidents, and, as concluded by ESCAPE project (2014)[92], an increase of human exposure to 5 μg/m^3 can increase the risk of heart attacks by 13%. Particles are responsible for 3% of deaths from cardiopulmonary disease, about 5% deaths from cancer of the trachea, bronchus, and lung, and about 1% of deaths from acute respiratory infections in children under 5 years, worldwide (Aaron et al., 2005). Corbett et al., (2007) in their work about ship emissions and mortality concluded that the PM emissions generated from the shipping activity are responsible for 60 thousand cardiopulmonary and lung cancers deaths annually, with the majority of them observed in the coasts of Europe, and Asia.

Limits: Particulate Matter emissions from ships are in general controlled by the limits on the sulphur content of marine fuel oils (Annex VI Regulation 14, on Sulphur Oxides).

At EU level, Directive 2012/33/EU[93] establishes sulphur limits and incorporates the legal provisions of MARPOL Annex VI.

VOCs (Volatile Organic Compounds, VOCs) and NMVOCs (Non Methane Volatile Organic Compounds)

Volatile organic compounds (VOCs) are a mixture of hydrocarbons, mainly methane, propane, butane and other gases that are formed by the evaporation of crude oil and its products. VOCs are classified into non-methane and methane (CH_4) (Komar et al., 2010)

Based on Rudd and Hill (2001), the rate of VOC emissions is a function of multiple parameters including: composition and temperature of loaded cargo, operational parameters such as loading rate, turbulence in the vapor space, sea conditions (for offshore loading), time since unloading of previous cargo and ship's design and motion. There is a large number of gaseous compounds which can be considered volatile. VOCs are produced during loading, unloading, ballasting and transport. However, the most significant source is the loading process[94]. This is due to the displacement of vapor existing in the empty tank prior to loading, and from the evaporation from the cargo during loading (Rudd and Hill, 2011). The emissions resulting from ship loading corresponds to 0,8% of all emissions of VOCs in the EU (Komar et al., 2010).

Respectively, NMVOCs are compounds generated by the amount of hydrocarbons passing unburnt through the engine. Emitted amounts are affected by the type of the engine, the type of the fuel and the use of post-combustion emissions (Jun et al.,2001). Non-Methane Volatile Organic Compounds (NMVOC) when come in reaction NO_x and particulate contribute to ground-level ozone. The table below illustrates the amount of NMVOC produced from total shipping.

[92] http://ec.europa.eu/environment/integration/research/newsalert/pdf/370na4_en.pdf
[93] Amending Directive 2005/33/ EC
[94] As regards VOC emissions produced during ballasting, these are believed to be limited as regulated by MARPOL and segregated ballast tanks dedicated to ballast water are required (Rudd and Nicolas, 2001).

Table 82 – NMVOC estimates (thousand tonnes)

Marine sector	Fuel Type	2007	2008	2009	2010	2011
International marine bunkers	HFO	536,2	545,2	511,0	551,0	547,9
	MDO	80,1	69,9	76,7	86,9	91,2
	NG	0,0	0,0	0,0	0,0	0,0
International total		*616,3*	*615,1*	*587,7*	*637,9*	*639,1*
Domestic navigation	HFO	61,3	43,7	47,1	44,0	39,1
	MDO	69,9	73,6	72,7	79,2	84,4
	NG	0,1	0,2	0,2	0,2	0,2
Domestic total		*131,3*	*117,5*	*120,0*	*123,4*	*123,7*
Fishing	HFO	3,4	3,4	3,1	2,5	2.5
	MDO	16,6	15,1	15,4	16,0	15,7
	NG	0,1	01	0,1	0,1	0,2
Fishing total		*20,1*	*18,5*	*18,6*	*18,5*	*18,3*
Total		**767,8**	**751,1**	**726,2**	**779,8**	**781,1**

Source: IMO,2014

Impacts: Non-Methane Volatile Organic Compounds have a significant effect on air quality. NMVOC is contributing to the formation of ozone, through the chemical reactions involving nitrogen oxides and sunlight. Ozone affects human health especially when this reaches high concentration levels. Prolonged exposure may cause various problems such as cardiac, digestive, kidney and nervous disorder. Additionally, there are NMVOCs with carcinogenic or mutagenic properties[95]. Moreover, ground level ozone can damage plants, crops, etc. and is a greenhouse gas that contribute to global warming.

Limits: Volatile Organic Compounds are regulated by MARPOL Annex VI, Regulation 15. The regulation applies only to tankers and, under certain conditions, to gas carriers, and includes two major measures. The first one concerns the control of VOC emissions in certain ports and terminals through a vapour emission control system (VECS). The second requires that all tankers carrying crude oil have an approved and effectively implemented ship specific VOC Management Plan.

Directive 94/63/EC[96] is the corresponding legislation at EU level, and includes measures to control the emissions of volatile organic compounds coming from the storage of gasoline and its subsequent distribution to service stations. However, the Directive makes no reference to the loading/unloading of ships[97]

Refrigerant Emissions

Refrigerant emissions are gas exhaust generated by ships' air conditioning and refrigeration systems. A refrigerant is a fluid that absorbs heat at a low temperature and pressure, with a change of state, and rejects heat at a higher temperature and pressure. The amount of refrigerant required primarily depends on the number of cabins and machinery, and not on the size of the vessel (Schwarz and Rhiemeier, 2007).

[95] CITEPA, http://www.citepa.org/en/air-and-climate/pollutants-and-ghg/aep/vocs
[96] Directive was amended by Directive 2010/75/EU
[97] http://ec.europa.eu/environment/archives/air/pdf/vocloading.pdf

Passenger ships are generally equipped with larger systems, since it is needed to air-condition common spaces and cabins.

Moreover, refrigerants are also found in the cooling systems of reefer containers used for maintaining the temperature constant during the transport process of perishable goods, (chilled or frozen). It has been estimated that there are 1,7 million refrigerant containers carrying 6 kg of refrigerant. Sea waves are claimed to be responsible for the higher volumes of emissions produced from ships compared to land-based systems (DG ENV, 2007), while the composition of the global fleet affects the total volumes exhausted (IMO, 2014).

Refrigerants from global shipping is estimated to 8.412 tonnes, corresponding to 15 million tonnes in CO_2. Compared with CO_2 emissions in 2011, refrigerant emissions constituted 1,9% of the GHG emissions from shipping, whilst these percentages reach 2,2% when reefer TEUs are included (IMO, 2014).

The table below illustrates the annual emissions of refrigerants from the global fleet and the shares of various refrigerants.

Table 83 - Annual emissions of refrigerants from the global fleet

Year	Refrigerant emissions, tons, reefer TEUs excluded	Low bound, tons	High bound, tons	%, R22	%, R134A	%, R404
2007	8.185	5.926	10.444	80%	17%	4%
2008	8.349	6.045	10.654	77%	19%	4%
2009	8.484	6.144	10.825	75%	21%	4%
2010	8.709	6.307	11.110	73%	23%	4%
2011	8.235	5.967	10.503	71%	24%	4%
2012	8.412	5.967	10.726	70%	26%	4%

Source: IMO, 2014

Impacts: The emission of ozone-depleting substances (ODSs), such as chlorofluorocarbons (CFCs), halons, and hydrochlorofluorocarbons (HCFCs) into the atmosphere can contribute to global warming, and thus halocarbons are considered strong GHGs due to their molecules' ability to absorb infrared radiation. Global warming is responsible for multiple effects such as sea-level rise, changes in precipitation patterns, extreme meteorological events etc. (UNEP DTIE, 2010).

Limits: In the past, refrigerants were exclusively fluorinated compounds (Faber et al, 2008). On a global scale, some refrigerants are being phased out by the Montreal Protocol, and others by MARPOL Annex VI. Before 2002, the common refrigerants were Hydro-Chlorofuorocarbons (HCFCs, R-22), which, due to their effect on ozone depletion and their contribution to global warming, are regulated by the Montreal Protocol, European legislation and MARPOL Annex VI, Regulation 12-Ozone Depleting Substances. Since 2002, chlorine-free HydroFluoroCarbons (HFCs) have been replacing HCFCs as refrigerants in newly built ships.

More specifically, MARPOL Annex VI, which entered into force on 1 July 2010, prohibits installations which contain ozone-depleting substances on all ships constructed on or after 19 May 2005. Respectively, for the ships constructed on or after 1 January 2020, installations containing HCFCs are prohibited on ships.

Carbon Dioxide (CO2)

Carbon dioxide (CO_2) is produced from all combustion processes in which complete, or nearly complete combustion of a hydrocarbon fuel takes place. The amount of the emissions produced depends on the hydrocarbon composition of the fuel. To that extent, CO_2 emission is a function of fuel consumption, which consequently is determined by the engine power required, its efficiency, as well as the elemental composition of the fuel being burnt (Hans Otto, 2010). Number of ships, average annual consumption and adoption of slow steaming practices are some key drivers affecting the amount of emissions (IMO, 2014).

The table below quotes the CO_2 emissions generated from total shipping activity compared with the corresponding global amounts.

Table 84 - CO_2 emissions of shipping

Year	Global CO_2	Total shipping CO_2	Percentage of global	International shipping CO_2	Percentage of global
2007	31.409	1.100	3,5%	885	2,8%
2008	32.204	1.135	3,5%	921	2,9%
2009	32.047	978	3,1%	855	2,7%
2010	33.612	915	2,7%	771	2,3%
2011	34.723	1.022	2,9%	850	2,4%
2012	35.640	949	2,7%	796	2,2%
Average	**33.273**	**1.016**	**3,1%**	**846**	**2,6%**

Source: IMO, 2014

International shipping CO_2 emissions in 2012 were estimated at 796 million accounting for 2,2% of global CO_2 emissions, while for a six-year period (2007-2012) the average contribution of the industry was 3,1% (IMO, 2014). Based on the findings of the Third IMO GHG Study from 2007 and onward, CO_2 presents a slight decreasing trend (from 3,5% in 2007 to 2,7% in 2012) attributed to the wide adoption of slow steaming[98] practices across the sector. In this regard, it is worth mentioning the case of containers ships, which are considered to be among the major polluters of the shipping industry (Kontovas and Psaraftis, 2011)[99], and recorded a decrease in their speed ranging from 60-70% (IMO,2014). However, it is commented that the slow steaming practice, despite affecting fuel consumption, is not proportionally improving efficiency, because for the same transport work more ships or more days at sea are required. Future predictions suggest that seaborne transport will experience a positive growth rate, and, in IMO study's alternative scenarios, CO_2 emissions are projected to increase by 50% to 250% by 2050.

The major contributors to global CO_2 emissions from shipping are container ships followed by tankers and bulk carriers. As regards container ships, Psaraftis and Kontovas (2009) noted that in 2007 containers generated 20% of international emissions, whilst representing 4% of the global fleet. It is stressed that reefer containers are also responsible for refrigerant emissions. According to IMO's data, total refrigerant emissions accounted for 1,9% of GHG emissions, whilst this percentage increases to 2,2% when including reefer TEUs.

The table below illustrates the contribution of different types of ships to CO_2 emissions:

[98] Since the beginning of the global financial crisis, the industry adopted a new economic model to correspond to high oil prices, low revenues and increased regulations on emissions and efficiency (Sustainable Shipping, 2014).

Table 85 - Ship type contribution to CO_2 emissions

Ship type	Global shipping	Voyage to EU ports	Intra- EU
Container	33,3	24,3	18,4
Tanker	20,8	16,5	15,1
General cargo	7	10,7	12,9
Bulk carrier	15,1	10,6	5,9
Reefer	2	2,5	1,4
Ro-Ro	5,1	6,8	8
Passenger	10,7	22	29,6
Fishing	1,1	1,4	2
Rest	4,9	5,2	6,7
Total	**100**	**100**	**100**

Source: Faber et al. (2009)

However, at EU level, containers and passenger ships are the most significant sources of CO_2 emissions, representing 24% and 22% respectively of the total generated exhaust in the EU. Based on a study of Policy Research Corporation (2009), the emissions from cruise ships calling European ports are presented in the table below.

Table 86 - Emissions from cruise tourism in EU ports in 2009

Emissions (tonnes)	No_x		SO_2		CO_2		PM	
	Absolute	%	Absolute	%	Absolute	%	Absolute	%
At sea	156.521	89%	96.288	99%	6.091.920	85%	15.006	87%
In Ports	20.296	11%	677	1%	1.076.411	15%	2.277	13%
Totals	**176.817**	**100%**	**96.965**	**100%**	**7.168.331**	**100%**	**17.283**	**100%**

Source: Policy Research Corporation, 2009

Impacts[100]: Carbon Dioxide emissions have a significant impact on climate change and ocean acidification. CO_2 is among the major GHGs which absorb energy, preventing the loss of heat to space and thus contributing to global warming, and has a long lifetime in the atmosphere (Eyring et al., 2007).

As carbon dioxide concentrations increase and climate warms, a considerable amount of CO_2 is absorbed by the oceans. This process results in significant changes to the sea system, altering its chemistry, which becomes more acidic. New conditions jeopardise the viability of the various sea organisms. Moreover, the increase of temperature results in the melt of sea ice, increasing sea levels and consequently disrupting the marine ecosystem and ocean circulation.

[100] Harrould-Kolieb (2008)

Apart from the degradation and alternation of the marine ecosystem, humans are also affected due to the changes in the morphology of shores, weather changes and alteration to production methods.

When it comes to human health, CO_2 has a multitude of effects, including physiologic (e.g., ventilatory stimulation), toxic (e.g., cardiac arrhythmias and seizures), anaesthetic (significantly depressed CNS activity), and lethal ones (severe acidosis and anoxia) (Rice, 2004).

Limits/Regulations: As referred in the EEA's study, due to its international dimension, shipping is the only industry with emission reduction targets. However, IMO regulations are not establishing direct reduction limits. On the other hand, the main tools used for this objective are the Energy Efficiency Design Index (EEDI), the Energy Efficiency Operational Indicator (EEOI) and the Ship Energy Efficiency Management Plan (SEEMP). EEDI is an index quantifying the amount of carbon dioxide that a ship emits in relation to the goods transported. Respectively, the objective of SEEMP is to establish a mechanism, both for the company and the ship, in order to improve ships' operational efficiency.

In 2011, the Commission's White Paper on transport set the quantitative targets of the EU regarding CO_2 emissions. Based on that, CO_2 emissions from shipping should be reduced in the EU by 40% (50% if feasible) from 2005 levels by 2050. In 2013, the EU published its Strategy[101], which includes CO_2 reduction policies.

The Strategy consists of three subsequent steps:

- Monitoring, reporting and verification of CO_2 emissions from large ships using EU ports;
- Greenhouse gas reduction targets for the maritime transport sector;
- Additional measures, including Market Based Measures, in the medium to long term.

The Monitoring, Reporting and Verification (MRV) system is the suggested instrument for the monitoring of ship-based emissions to and from the EU ports, which is proposed to apply to shipping activities from 1 January 2018. This system concerns all ships exceeding 5.000 GT irrespectively of their flag, port of registry or home port, and comes as a response to the lack of reliable information on fuels consumption. The implementation of the MRV is expected to contribute to the existing policies e.g. EEDI and can lead to the reduction of greenhouse gas emissions up to 2%-compared to the business as usual scenario, while aggregated net cost can be reduced up to €1,2 billion by 2030.Specifically, the operational components of the propose MRC system would include:

- Focus on CO_2 as predominant GHG emitted by ships and on other climate relevant information such as efficiency information to address market barriers for the uptake of cost-efficient mitigation measures and to align MRV with IMO discussion on efficiency standards for existing ships;
- Calculate annual CO_2 emissions based on fuel consumption and fuel type and energy efficiency using available data from log books, noon reports and bunker delivery notes;
- Use existing structures and bodies of the maritime sector, in particular recognised organisations to verify emission reports and to issue documents for compliance;
- Exclude small emitters (ships below 5.000 GT) which represent about 40% of the fleet, but only 10% of the total emissions.

As regards the MRV geographical coverage, it is suggested to include all intra-EU voyages, incoming voyages-last non-EU voyage, first EU port of call- and outgoing voyages meaning voyages from an EU port to the next non-EU port of call.

In December 2015, 195 countries agreed, by consensus, on the Paris Agreement to reduce emissions as part of the method for reducing greenhouse gas[102]. In the 12-page document, the members agreed to

[101] COM (2013)479 final.
Access from: http://ec.europa.eu/clima/policies/transport/shipping/docs/com_2013_479_en.pdf
[102] http://unfccc.int/paris_agreement/items/9485.php

reduce their carbon output “as soon as possible” and to do their best to keep global warming “to well below 2 degrees C”.

Each country that ratifies the agreement will be required to set a target for emission reduction or limitation, called a “nationally determined contribution” (NDC), but the amount will be voluntary. There will be neither a mechanism to force a country to set a target by a specific date nor enforcement measures if a set target is not met. There will be only a “name and shame” system. The threshold for entry into force of the Paris Agreement was achieved on 5 October 2016, and the agreement entered into force on 4 November 2016. One of the problems of the Paris Agreement, however, is that it does not include provisions on air and maritime transport.

In view of that, the Marine Environment Protection Committee (MEPC) of the IMO agreed that IMO should determine a possible fair share contribution for the international shipping sector, which if developed, should take into account the circumstances that are relevant to the international shipping sector, including the importance of international trade in supporting the sustainable development of national economies. In October 2016, the MEPC formally adopted a mandatory data collection system for fuel consumption of ships. The MEPC also agreed that an initial but comprehensive IMO strategy on reduction of GHG emissions from ships should be adopted in 2018.At the same time, the MEPC noted that shipping is already, by far, the most energy efficient form of commercial transport. Any increase in shipping activity due to a shift from other less efficient transport modes will in fact contribute to an overall reduction in the world’s total CO_2 emissions. On the other hand, an unrealistic contribution to reduce the sector’s absolute CO_2 emissions could lead to a shift to less energy-efficient transport modes. This would clearly be counterproductive with respect to reducing the world's total CO_2 inventory[103].

MEPC’s decision to adopt a strategy on reduction of GHG emissions from shipping only in 2018 was the result of discussion and compromise. The EU enter the debate and in December 2016, the Environment Committee (ENVI) of the European Parliament adopted a report on the revision of the EU Emissions Trading System (ETS)[104], which puts pressure on the IMO to have a system comparable to ETS operating for global shipping as from 2021. If that is not the case, then shipping will be included in the European ETS as from 2023. Part of the revenues generated from ETS will be channelled through a Maritime Climate Fund to improve energy efficiency and invest in innovative technologies for ports and short sea shipping.

Emissions per sea basin

In 2005, the emissions from international shipping in European seas were estimated at 2,8 million tonnes of NO_x, 1,7 million tonnes of SO_2 and 195 thousand tonnes of fine particles ($PM_{2.5}$) (Camplin et al. ,2013). Based on specific scenario projections, shipping emissions are expected to decrease by 13% as regards NO_x emissions, and by 80% when it comes to SO_x emissions, due to the current legislative framework. Moreover, the study of Camplin et al. (2013) estimated a reduction by 35% for $PM_{2.5}$ emissions as the result of fuel quality improvement until 2020. As expected, this decrease originated from the SECA regions. However, future trade trends and the corresponding increase of fuel consumption lead to an increase ranging from 40-50% until 2020. Table 10 illustrates the NO_x emissions in kt per sea basin.

[103] http://www.worldshipping.org/public-statements/regulatory-comments/MEPC_70-7-8_-_Development_of_a_road_map_to_determine_IMO_contribution_Aug_2016.pdf

[104] ENVI(2016)1215_1. Documents available at http://www.emeeting.europarl.europa.eu/committees/agenda/201612/ENVI/ENVI(2016)1215_1/sitt-3968209

Table 87 – NO_x emissions (kt) from international shipping by sea region (2005: baseline scenario)

Measures applied	Current legislation			
Sea Regions	**2005**	**2020**	**2030**	**2050**
Baltic Sea	220	183	202	250
Bay of Biscay	474	425	488	633
Black Sea	47	36	44	54
Celtic Sea	22	18	20	23
Mediterranean Sea	1.294	1.116	1.255	1.587
North Sea (incl. English Channel)	518	449	503	627
Rest of NE Atlantic	246	220	250	319
Total	**2821**	**2447**	**2762**	**3493**

Source: Camplin et al. (2013)

The Mediterranean is considered to be the sea region with the highest amount of exhaust emitted from international shipping. According to 2005 data, the Mediterranean recorded 1.294 kt of NO_x emissions, representing almost 46% of the total NO_x emitted in Europe[105], followed by North Sea (18,4%). Until 2020 NO_x emissions is expected to be reduced in all sea regions, with the Black Sea recording the highest reduction values (30%). However, after 2020, NO_x emissions are expected to increase with an average rate of 12% until 2030, and 19,5% until 2050. The allocation pattern of SO_x emissions is similar to that of NO_x. However, the 2020 projections estimate an average reduction of corresponding emissions up to 83,6% for all sea regions, whilst, as mentioned above, the pattern will change in 2050, when an average increase of 32% is expected. It is stressed though that, compared with 2005, total SO_x emissions are estimated to record a decrease of 73%.

Table 88 - SO_x emissions (kt) from international shipping by sea region (2005: baseline scenario)

Measures applied	Current legislation			
Sea Regions	**2005**	**2020**	**2030**	**2050**
Baltic Sea	130	6	7	9
Bay of Biscay	282	65	78	103
Black Sea	27	6	8	10
Celtic Sea	14	2	2	3
Mediterranean Se	764	167	198	254
North Sea (incl. English Channel)	309	15	17	22
Rest of NE Atlantic	143	33	39	51
Total	**1669**	**294**	**349**	**452**

Source: Camplin et al. (2013)

[105] Baltic Sea, Bay of Biscay, Black Sea, Celtic Sea, Mediterranean Sea, North Sea (+ English Channel Rest of NE Atlantic (within EMEP grid) Rest of NE Atlantic (TNO grid outside EMEP).

As regards $PM_{2.5}$ emissions, until 2020 a decreasing trend (36% in average) is expected, whereas in 2050 emissions volumes are expected to record values similar to 2005 in the Bay of Biscay, Black Sea, Black Sea and North-East Atlantic, while for the Baltic and the North Sea a slight decrease is forecast.

Table 89 - $PM_{2.5}$ emissions (kt) from international shipping by sea region (2005: baseline scenario)

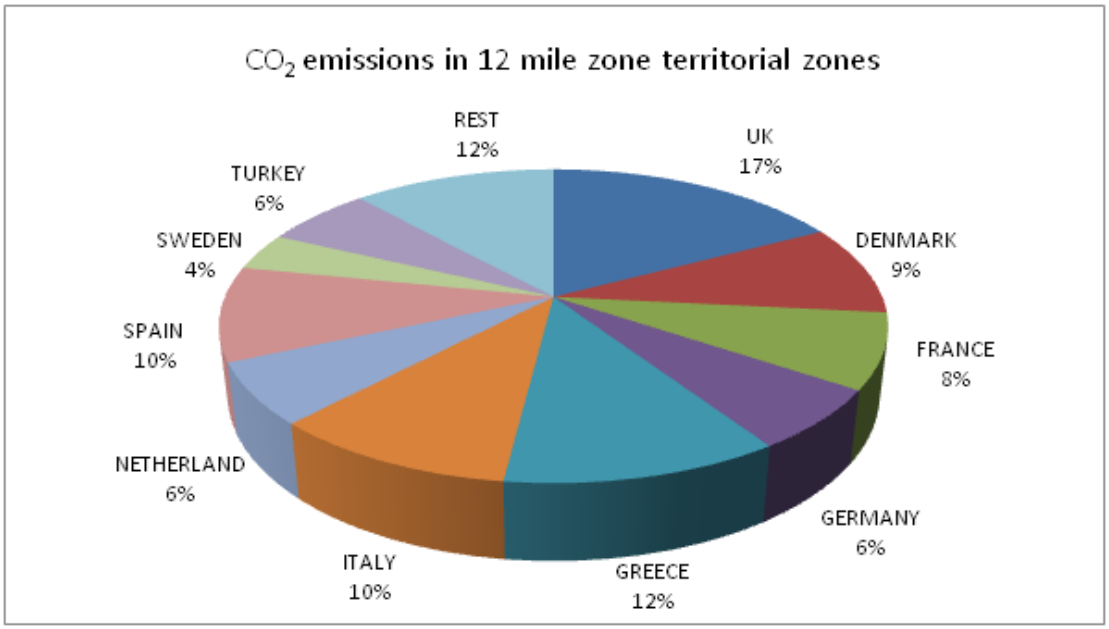
Measures applied	Current legislation			
Sea Regions	**2005**	**2020**	**2030**	**2050**
Baltic Sea	14,2	8,7	10,1	12,8
Bay of Biscay	34	22,8	27,3	36
Black Sea	2,9	1,9	2,2	2,8
Celtic Sea	1,5	0,9	1,1	1,3
Mediterranean Sea	87,4	57	67,3	86,3
North Sea (incl. English Channel)	36,5	22,5	26,4	33,5
Rest of NE Atlantic	17,5	11,7	11,7	18
Total	**193,9**	**125,5**	**146,1**	**190,7**

Source: Camplin et al. (2013)

At country level, based on the study of Cofala et al. (2007) on the spatial distribution of CO_2 emissions within 12-mile zones for the year 2000, 78% of the emissions generated from vessels >500grt are recorded in nine countries.

Based on Cofala et al. (2007), the highest CO_2 concentrations at EU level were recorded in the UK (5.999,4 kt), corresponding to 17% of total CO_2 emissions followed by Greece (3.942,5 kt), Italy (3.516 kt) and Spain (3.393,6 kt). Despite the earlier data, there is consistency among the different inventories as to the sea regions which concentrate the largest amounts of ship-based emissions.

Figure 17 – CO_2 emissions



Source: own elaboration based on Cofala et al., 2007

A more recent analysis for the year 2005, based on the Mediterranean shipping activity, concluded that more than 80% of CO_2 emissions are produced at sea, while the rest during berth and manoeuvring.

In the North Sea, the busiest area is the English Channel, which, as consequence, is concentrating the highest nitrogen oxide emissions together with the coasts of Belgium and the Netherlands (Hammingh et al., 2012).

Emissions in ports

In-port emissions constitute a small proportion of the overall emissions produced from shipping (Dalsoren, 2009). It has been estimated that 70% of the exhaust emitted occur within a distance of 400 km from land (Eyring et al.,2005), and therefore the adverse impact of ship emissions on the urban environment may be significant. Moreover, ships' berthing makes ports a point of concentration of ship exhausts, with significant contribution to air quality degradation (Tzannatos, 2010). Adverse impact of ships emissions is not only found in the major ports with significant traffic, but also in the smaller ones (Viana et al., 2009). However, the total impact depends on the type of the port and its size, as well as on the characteristics of the city (e.g. degree of industrialisation) (Merk, 2014). In this regard, the monitoring of emissions from port-related operations is crucial, although the process is complex on account of the lack of reliable data, mostly due to the range of the different operations occurring. The number of studies relevant to in-port emissions is limited (Merk, 2014). In his review, Merk (2014) identifies thirteen relevant studies (from 2001-2011) of port emission inventories, the majority of which concerns US ports.

Emissions from ships occur during manoeuvring, at anchor and during loading and unloading operations. Based on ship type, main engines may operate also at berth. Oil tankers use the main engine for operational reasons, discharge and loading pumps. This is also the case for passenger ships which are berthed at a port for a limited time. Based on Corbett and Fischbeck (1997, cited in Viana, 2014), it was estimated that ship manoeuvring contributes to about 6% of NO_x and 10% of SO_2 of total shipping emissions in US ports.

Whall et al. (2007) concluded that in the Mediterranean ship manoeuvring contributed by 1,1% (or 16 Kt) to total NO_x emissions from shipping and by 1,2% (or 10 Kt) to total SO_2. The corresponding percentages at berth were 12,8% (185 Kt) and 11% respectively. The highest percentage is estimated for VOC (18,5%), portraying the potential impact of ships' emissions. In the same study, it was also estimated that 25% of the main emissions types are produced within the 12-mile zone, indicating that coastal areas in general and port areas specifically are also affected by sea-based emission (Hammingh et al., 2012). In the North Sea, it is estimated that the emissions generated within 12 miles from the shore correspond to 32% of the total emissions produced, while 89% is produced within 50 nautical miles (Hammingh et al., 2012). Respectively, the amount of NO_x emissions in ports is representing 10% of total generated emissions. Merk's (2014) port-based emissions studies concluded that between 70% and 100% of in-port emissions may be attributed to shipping, 1/5 to trucks and locomotives and roughly 15% comes from equipment[106]. Based on the same study, in 2011 shipping emissions in ports[107] accounted for 18 million tonnes of CO_2, 0,4 million tonnes of NO_x emissions, 0,2 million of SO_x emissions and 0,03 million tonnes of PM_{10} emissions, representing 2% of the total shipping emissions. Focusing on European ports, the study highlighted that emissions are much lower compared to ports in Asia. Specifically, based on his estimation the allocation of the various emissions is: SO_x (5% of world total), PM_{10} (7%), $PM_{2,5}$ (8%)and CO_2 (19%).

[106] However, as noted by Joseph et al. (2009 cited in Merk, 2014) the allocation of emissions to the different in port sources is differentiated between developed and developing countries due to the less strict regulations for vehicles.
[107] Please note that the study estimates emissions from ocean-going vessels only in maritime ports.

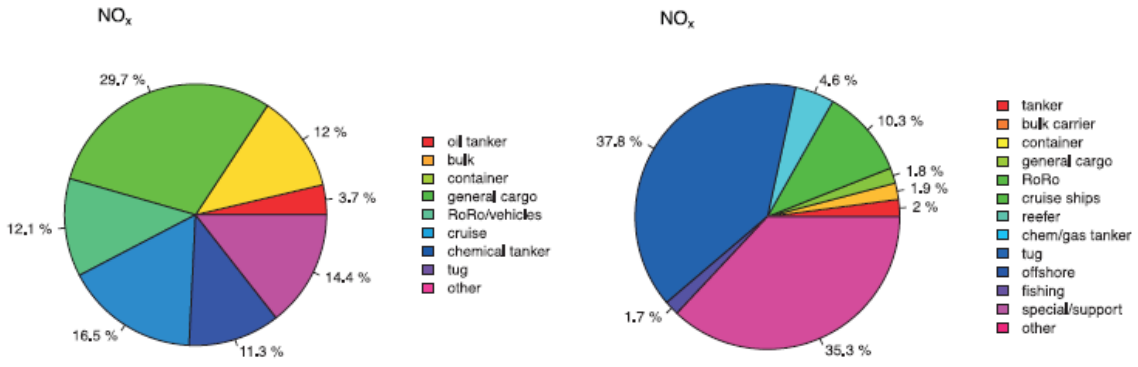
Table 90 - Estimated shipping emissions in international ports (mln tones)

Emission type	Quantity
CO_2	18,3
NO_x	0,4
SO_x	0,2
PM_{10}	0,03
$PM_{2,5}$	0,03
CO	0,03
CH_4	0,002

Source: Merk, 2014

Containers and tankers are the major contributors to in-port emissions (85%). It was highlighted that container ships have short stays in ports (27% of port time), but produce a higher mass of emissions. The opposite applies for bulk carriers, i.e. long stay times with comparatively lower emissions. In the case of North Sea ports, it was observed that, the contribution of each ship type to the overall amount of emissions generated depends on the major ship traffic (Clean North Sea Shipping, 2014). Based on the findings of the Clean North Sea Shipping study (2014), in the case of Hamburg, container ships are responsible for a large part of emissions; nevertheless, their share on total emissions is lower than other types of ships combined, such as bulk and Ro-Ro, even though these make fewer calls. The average quantity of emissions per call is thus lower than other types of ship. On the other hand, in the port of Bergen, cruise ships were responsible for the majority of the generated emissions. The figure below illustrates the allocation of NO_x emissions per ship type, in the case of Bergen and Hamburg respectively.

Figure 18 – NO_x al location in the port of Bergen and Hamburg



Source: Clean North Sea Shipping, 2014

In Barcelona, 79% of the total NO_x emissions came from ship activities while cargo handling contributed only by 2%. (APICE, 2013).

Table Hry of air quality EU and international legislation

<table>
<tr><th>Pollutant</th><th>IMO</th><th>EU</th></tr>
<tr>
<td>Sulphur Oxides (SO_x)</td>
<td>
MARPOL 73/78, Annex VI, Regulation 14

The sulphur content of bunker fuels is reduced progressively from 2010 to 2020. The initial 4.5% m/m (until 2011) was gradually reduced to 3.5% from the 1st of January 2012 followed by 0.5% from the 1st of January 2020
<table>
<tr><td>Outside an ECA established to limit SOx and particulate matter emissions</td><td>Inside an ECA established to limit SOx and particulate matter emissions</td></tr>
<tr><td>4.50% m/m prior to 1 January 2012</td><td>1.50% m/m prior to 1 July 2010</td></tr>
<tr><td>3.50% m/m on and after 1 January 2012</td><td>1.00% m/m on and after 1 July 2010</td></tr>
<tr><td>0.50% m/m on and after 1 January 2020*</td><td>0.10% m/m on and after 1 January 2015</td></tr>
</table>
</td>
<td>
Directive 2012/33/EU: Alignment with IMO requirements

Additional requirements:

a 0.1% sulphur limit on furl by at berth EU/EEA ports
a 1.5% sulphur limit for marine diesel oil and heavy fuel oil used by passenger vessels on regular services between EU/EEA ports, unless ECA requirements apply
a 0.1% sulphur limit on marine gas oils used or sold in the EU

</td>
</tr>
</table>

<table>
<tr><th>Pollutant</th><th>IMO</th><th>EU</th></tr>
<tr>
<td>Nitrogen Oxides
(NO_x)</td>
<td>
MARPOL 73/78 Annex VI, Regulation 13
The NOx control requirements apply to all installed marine diesel engines of over 130 kW output power, regardless of the tonnage of the ship
<table>
<tr><th rowspan="2">Tier</th><th rowspan="2">Ship construction date on or after</th><th colspan="3">Total weighted cycle emission limit (g/kWh)
n = engine's rated speed (rpm)</th></tr>
<tr><th>n < 130</th><th>n = 130 - 1999</th><th>n ≥ 2000</th></tr>
<tr><td>I</td><td>1 January 2000</td><td>17.0</td><td>$45 \cdot n^{(-0.2)}$
e.g., 720 rpm – 12.1</td><td>9.8</td></tr>
<tr><td>II</td><td>1 January 2011</td><td>14.4</td><td>$44 \cdot n^{(-0.23)}$
e.g., 720 rpm – 9.7</td><td>7.7</td></tr>
<tr><td>III</td><td>1 January 2016*</td><td>3.4</td><td>$9 \cdot n^{(-0.2)}$
e.g., 720 rpm – 2.4</td><td>2.0</td></tr>
</table>
</td>
<td>EU Air Quality Directive (2008/50/EU) sets limit values for i.a. NO_2 and PM (based on concentrations in ambient air).

No certain measures for the control of NO_x emissions from ships</td>
</tr>
<tr>
<td>Particulate Matter (PM)</td>
<td>Particulate Matter emissions from ships are controlled by the limits on the sulphur content of marine fuel oils (Annex VI, Regulation 14, on Sulphur Oxides)</td>
<td>Directive 2012/33/EU establishes sulphur limits and incorporates the legal provisions of MARPOL Annex VI.
Directive 2008/50/EC sets standards and target dates reducing concentrations of fine particles</td>
</tr>
<tr>
<td>Volatile Organic Compounds
(VOC)</td>
<td>MARPOL Annex VI, Regulation 15
For tankers: control of VOC emissions in certain ports and terminals through a vapour emission control system (VECS).
All tankers carrying crude oil have an approved and effectively implemented ship specific VOC Management Plan.</td>
<td>Directive 94/63/EC includes measures for the control the emissions of volatile organic compounds coming from the storage of gasoline and its subsequent distribution to service stations.
The Directive makes no reference to the loading/unloading of ships</td>
</tr>
</table>

Pollutant	IMO	EU
Refrigerants Emissions	**MARPOL Annex VI, Regulation 12-Ozone Depleting Substances** Prohibits installations which contain ozone-depleting substances on all ships constructed on or after 19.05.2005. Respectively, for the ships constructed on or after 01.01.2020, installations containing HCFCs are prohibited on ships	
CO_2	IMO regulations are not establishing direct reduction limits. Main tools used for this objective are the Energy Efficiency Design Index (EEDI), the Energy Efficiency Operational Indicator (EEOI) and the Ship Energy Efficiency Management Plan (SEEMP).	The Monitoring, Reporting and Verification (MRV) system is the suggested instrument for the monitoring of ship-based emissions to and from the EU ports, which is proposed to apply to shipping activities from 1 January 2018. This system concerns all ships exceeding 5,000 GT irrespectively of their flag, port of registry or home port, and comes as a response to the lack of reliable information on fuels consumption.

Overview of waste

N.B.: At EU level, EU Directive 2000/59/EC of the European Parliament and of the Council on port reception facilities for ship generated waste and cargo residues aims at the prevention of pollution by ships, by reducing discharges of ship-generated waste and cargo residues into the sea, based on the 'polluter pays' principle. The Directive covers all waste, including sewage, and residues other than cargo residues, which are generated during the service of a ship and fall under the scope of Annexes I, IV and V to Marpol 73/78, and cargo-associated waste as defined in the Guidelines for the implementation of Annex V to Marpol 73/78. It is mentioned at the beginning of this section, since it equally applies to all paragraphs below.

The Directive focuses on the operations of ships in EU ports and covers all ships calling at EU ports. Specifically, the Directive aligns with the relevant requirements of the MARPOL Convention, and intends to improve pollution prevention while ensuring smooth operation of maritime traffic. The provision of adequate reception facilities is at the core issue of the Directive, according to which ports should have adequate reception facilities that correspond to the needs of the fleet. Moreover, an appropriate waste reception and handling plan must be developed and implemented, and approved by the Member States. Member States remain free to adjust facilities and waste reception in a manner that suits their specificities. The directive also requires that ships deliver all their wastes before leaving an EU port, except when the ship can prove that has adequate storage capacity (see Art. 7(2)).

The directive also takes into consideration the costs of port reception facilities (including the treatment and disposal of waste) which must be covered by the ships, and highlights the need for ports to establish cost recovery systems that encourage the onshore delivery of wastes, ensuring that fees are fair, non-discriminatory and transparent.

The Directive states that the waste fee system must not provide any incentive to discharge ship waste into the sea and that a 'significant' part of the waste fee shall be paid by all ships calling at ports, irrespective of waste delivery. According to a Commission declaration annexed to the Directive, 'significant' means at least 30%[108].

The determination of a standard fee based on certain criteria such as shio type and size is suggested. Moreover, Art. 8(c) envisages lower tariffs for ships that produce reduced quantities of waste, based on their management system, design, equipment and operation.

Based on an EMSA's study[109] (2012), Article 8 of the Directive is interpreted and applied in various ways across EU ports, as a result of the nature of the legislation, which leaves to MSs the flexibility to adopt measures based on ports' special conditions. In this context, the study concluded that most ports perceived that fee charging consists of two parts: an indirect or fixed fee, corresponding to the suggested minimum of 30% of the total cost for ship-waste handling, and a direct fee covering the actual delivery and treatment activity. However, it is commented that ports do not dispose the appropriate information to correlate the fee with the total cost of waste handling, due to the fact that most operations are conducted by external partners. Nevertheless, the practices applied by the ports can be classified as follows:

(a) 100% indirect fee (either with no volume limitations or with volume limitations) to cover the waste handling cost, meaning that regardless if the ship delivers wastes or not to the port, the corresponding fee will be collected.

(b) Collection of the indirect fee as a deposit, which can then be reclaimed by the ships, when waste delivery occurs in the port or in another EU port.

[108] http://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=URISERV:l24199&from=EN

[109] http://emsa.europa.eu/index.php?option=com_flexicontent&view=item&cid=2&id=1607&Itemid=62

(c) "Sanctions" or "penalty" fee, meaning an ex-post payment based on ship's size in the case of no delivery of waste.

(d) d) Administrative fee, based on ship's size and type which does not include any waste delivery costs.

Waste oils and related mixtures

Oil residues (Sludge)

Sludge is defined in MARPOL Annex I[110] (subparagraph 3.1) as the residual waste oil products generated during the normal operations of a ship, such as those resulting from the purification of fuel or lubricating oil for main or auxiliary machinery, separated waste oil from oil filtering equipment, waste oil collected in drip trays, and waste hydraulic and lubricating oils.

Generally speaking, vessels burn low quality heavy fuel oil, requiring special treatment before being used in the engines. To prevent damage to engine components, purification of the fuel is required in order to remove the amount of water as well as the heavy molecules that fuel contains (EMEC, 2010).

Additionally, sludge is generated from other onboard processes like sedimentation of solids in sedimentation tanks, tank dewatering processes, leaks or cleaning cycles in backflush filters and separators for treating fuel oil and lube oil[111].

Sludge is heavier than bilge water, and the volumes produced vary significantly; an average ship can produce from few litres up to several tonnes. This depends on fuel's quality, the condition of the equipment used to store, transfer and heat it and its compatibility with previous shipboard fuels. Approximately 1,5-2% of the heavy fuel oil burned ends up as sludge (EMSA,2008).

Impacts: In 2003, it was estimated that the global fleet generated 500 million gallons of sludge, of which 65 million are illegally dumped (Criag Welch, 2003). In the case of the North Sea, discharges of operational oil waste were estimated at 400 cases a year (OSPAR Commission, 2010).

The table below illustrates the volumes of oily waste produced by the European fleet.

[110] http://www.imo.org/blast/blastDataHelper.asp?data_id=26472

[111] http://www.westfalia-separator.com/applications/marine/sludges-containing-oil-and-water.html

Table 91 - Liquid waste of EU fleet(>100gt)

EU Fleet	Oily waste	Liquid waste
Impact Type	Oil sludge from centrifuges (to reception facilities or bunt on board)	
Sources	EMAS ship	DSA (Ro)
Unit of Measure	Tonnes/y	-
Tanker (oil, chem., LG, others)	159.944	
Bulk carrier	98.306	
General and specialised cargo	95.607	
Container & Reefer	177.043	
Ro-pax and Ro-Ro cargo	79.014	184.685
Total cargo and cargo/pax ships	603.915	184.685
Cruise and passenger ships	33.850	28.622
Grand Total *Total cargo and cargo/pax + cruise and passenger*	**637.765**	**213.307**

Source: Maffii et al. (2007)

Sludge can cause severe damage to the marine environment and sea animals (mammals, fish, shellfish, etc.). Depending on water stratification, sludge is separated into three phases: a surface slick, a low salinity surface plume and a primary plume, while decomposition can take about 12 weeks (Costello and Read, 1994). Disposal of sludge can lead to changes to the size of the populations as well the diversity of marine organisms. Shellfish contamination too may be considered as another adverse impact.

Legal limits: Sludge containing oil or petroleum waste must be disposed of in a safe manner in compliance with MARPOL regulations. Sludge tanks on board are used as a preliminary storage for sludge waste. Based on Regulation 12 of MARPOL, all ships of 400 GT and above must have adequate tanks order to store oil residues. The size of sludge depends on the type of the machinery and the length of the voyage.

Oil residues discharges are prohibited within special areas, while outside special areas discharges are permitted under certain conditions. The table below illustrates discharge conditions based on MARPOL's requirement.

Table 92 - Oil discharge requirements

OIL TANKER OF ALL SIZES Oil discharge from cargo tank areas, including pump-room	
Within special areas	DISCHARGES PROHIBITED Except clean or segregated ballast
Outside special areas	DISCHARGES PROHIBITED Excepct clean or segregated ballast, or except when: - Tanker is more than 50 nautical miles from the nearest land, and - Tanker is proceeding en route, and - Instantaneous rate of oil discharge does not exceed 30 litres per NM, and - Total quantity of oil discharged does not exceed: -for existing tankers 1/150.00 -for new tankers 1/30.000 of cargo which was last carried and - Tankers has in operation an oil discharge monitoring and control system and slop tank arrangement as per Regulation 15
OIL TANKERS OF ALL SIZES and OTHER SHIPS>400 GRT Oil discharge from machinery spaces	
Within special areas	OIL DISGARGES PROHIBITED, except when: - Ship is proceeding en route and, - Oil in the effluent without dilution does not exceed 15 part per million, and - Ship has in operation oil filtering equipment complying with Regulation 16(5), with an automatic 15 parts-per-million stopping device, and - Bilge water does not originate from cargo pump-room bilges and is not mixed with cargo oil residue
Outside special areas	OIL DISGARGES PROHIBITED, except when ship is proceeding en route, and - Oil in the effluent without dilution does not exceed 15 parts per million and - Ship has in operation oil discharge monitoring and control system oil water separating or filtering equipment or other installation as required by Regulation 16 and - Bilge water does not originate from cargo pump-room bilges and is not mixed with cargo oil residue

SHIPS< 400 GRT OTHER THAN OIL TAKERS Oil discharges from machinery spaces	
Within special areas	OIL DISCHARGES PROHIBITED Except when oil in effluent dilution does not exceed 15 parts per million
Outside special areas	OIL DISCHARGES PROHIBITED except when, at the judgment of the Flag State, all of the following conditions are satisfied as far as practicable and reasonable: ship is proceeding en route, and - oil in the effluent without dilution does not exceed 15 parts per million, and - ship has in operation oil discharge monitoring and control system, oily water separating or filtering equipment, or other installation as required by Regulation 16.

Source: OSPAR Commission, 2010

Bilge water (Oily residues)

Bilge water is water contaminated by oil fluids, lubricants, cleaning fluids and other waste resulting from various on board sources such as engine, piping, and other mechanical and operational sources (e.g leakage or maintenance work in machinery spaces) (EPA, 2008).

Based on MARPOL, oil residue (sludge) includes:

1. Separated sludge, i.e. sludge resulting from purification of fuel and lubricating oil;
2. Drain and leakage oil, i.e. oil resulting from drainages and leakages in machinery spaces; and
3. Exhausted oils, i.e. exhausted lubricating oil, hydraulic oil or other hydrocarbon-based liquids which are not suitable for use in machinery due to deterioration and contamination.

Bilge water on ships is usually treated in two ways: either stored onboard in holding tanks which are discharged in port reception facilities, or it is treated on board with an oil separator, for separating oil from water. The amount of bilge water generated depends on various factors, such as the size of the ship, engine room design, preventative maintenance, and the age of the components (EPA, 2008). The synthesis of oil bilge has changed over the last few years, due to the usage of different oils and fuels (EMEC 2010). As noted by EMEC, the substances that can be found in bilge water are: leaked condensed and coolant water, oil from various sources, all kind of fuels, dirt and paint particles and corrosion and protection agents. Bilge oil discharge represents 45% (252.000 tons/per annum) of total oil discharges.

Impacts: The impacts of oil bilge water vary depending upon several factors, such as the different types of fuel oils, the rate of release and the toxicity of its compounds (EPA,2008) As indicated in the report of the EPA, fuel type affects the physical and biological impacts of an oil spill. Specifically, lighter petroleum products, even if evaporate fast, are highly toxic, while heavier oils are less toxic, but do not evaporate, and can thus sink, causing seabed contamination. Unregulated discharges can have multiple impacts on the shore, whilst the contamination of marine resources can poison marine life, disrupt reproduction, and ultimately can impact the survival rate of certain species.

Cruise ships can be considered as significant bilge water producers. According to the figures provided by the Department of Environmental Conservation for the year 2000, operating vessels produced from 1.300 to 5.300 gallons of bilge every 24 hours.

Table 93 - Bilge water from cruise ship

TShip Tonnage (Gross Tons)	Passenger and Crew Capacity	Bilge Water Production (max.gallons/day)
22.000	1.100	1.000
46.000-48.000	1.500-2.160	3.000
50.700-55.400	1.850-2.380	5.000
76.000-78.000	8.700-3.200	2.640

Source: ADEC, 2000 (cited in EPA, 2008)

Limits: Initially, Annex I of MARPOL regulated oily waste, and then incorporated guidance for an integrated bilge water treatment system, in an effort to reduce the generation of oily bilge water. This includes certain regulations and unified interpretation for the storage, handling and disposal of oily residues and engine-room oily bilge water. The IMO specifies that bilge water may be discharged into the sea, only if its residual oil content is below 15 ppm[112], and while en route. The table below summarises under which conditions a ship can discharge bilge water.

Table 94 - Bilge water discharge requirements

All vessels ≥ 400 gross tons All waters	Machinery space bilges	• Proceeding en route; and • Oil content less than 15 parts per million; and • Oil discharge monitoring and control system and oil filtering equipment to be operating In some circumstances, oil or oily mixtures, may be retained onboard for discharge to port reception facilities – see MARPOL Annex I, Regulation 14. Note: 15ppm discharges can be anywhere at sea (not within port limits). Vessel must not be stationary when undertaking discharge.
All vessels <400 gross tons All waters	Machinery space bilges	• Oil and all oily mixtures retain onboard for on shore disposal OR • Proceeding en route; and • Has in operation equipment of a design approved by the administration that ensures oil content less than 15 parts per million. Note: 15ppm discharges can be anywhere at sea (not within port limits). Vessel must not be stationary when undertaking discharge.

[112] In the United States and in the Baltic and North Seas, disposal of separated bilge water is only permitted at least 12 nautical miles from shore.

Ballast Water

Ballast is defined as any material used to balance/weight an object, therefore ballast water is the water carried by ships in order to ensure stability[113] and manoeuvrability. International shipping transfers from 3 to 5 million tonnes of ballast water per year, while the same volumes can be transferred between regions every year (http://goballast.imo.ogr). In normal conditions, a ship may require several tonnes of ballast water, ranging from 30-40% of a vessels' DWT. The exact volume required, as well as its distribution, depend on the size and the design of the ship. Ballast needs are classified into: ballast for cargo replacement, for vessel control and for loading and unloading operations.

Treatment of ballast water can be done on board through specialised equipment in the installed ballast system. This solution can be efficient, especially for ships having large ballast loading needs, when they can combine their related processes with normal ballast - deballasting procedures (loading - unloading ballast). Delivery of ballast to specialised reception facilities that are provided to certain ports and terminals is another solution. Despite sufficient expertise in similar treatment systems on land facilities, introducing suitable systems for ships ballast water treatment with wide application is a process that presents many challenges, due to the special conditions of the ship (Dobroski et al, 2009). This is attributed to the wide range of different operating conditions of the vessel, but also to the difficulty to process and retain large quantities of ballast. The introduction of ballast treatment systems is hindered by the fact that these systems are often unfit to ships' design and operational characteristics (ship's type, cargo, area of activity and port of call, Ventikos and Xatzinikolaou, 2011).

Impacts: The transfer of alien aquatic organisms, pathogens and microbes through the ballast can have serious negative environmental, economic and social impacts. Typically, ballast water is loaded from port areas, and then discharged into the next port over long distances. Species and other microorganisms taken from the initial port, if they manage to survive within ballast tanks, are then disposed to another marine environment, facing two potential survival scenarios: a) either they do not survive due to the change of natural conditions (salinity, temperature etc) or b) adapt to the new environment and may grow quickly. In this case, these species are called "invaders"[114]. More than 7.000 different species are estimated to be transferred in ships' ballast. Alien invasive species are one of the main environmental problems of the growth of trade, and the second most important reason of biodiversity loss (JRC, 2009). It is estimated that the average discharge of ballast water is about 250.000 tonnes yearly per ship, while 24% of the global discharge volumes is generated by the EU fleet (Maffii et al. 2007).

Oily mixtures

Based on MARPOL, oily mixtures should be intended as a mixture with any oil content. Oil mixtures are produced during the normal operation of the engine room machinery and devices. In addition, as far as tanker vessels are concerned, oil waste can also be generated during the cleaning procedures of the cargo tanks. It is estimated that this last category can account from 0,5% to 10% of the transported cargo (Treichel and Wiewiora, 2007). Residues from tank washing should be stored in ships' tanks and delivered to shore-based facilities.

Impacts: The effects from oil spills depend upon various factors such as the quantity and type of oil spilled, weather conditions and the ecological characteristics at regional level.

Oil spills can affect the marine environment in various ways: (i) physical smothering of organisms affecting critical functions such as respiration, feeding and thermoregulation, (ii) toxicity through the absorption into organs, tissues and cell, and (iii) ecological changes, such as replacement of local organisms with others

[113] http://globallast.imo.org
[114] NORTH SEA BALLAST WATER http://www.northseaballast.eu/northseaballast/2145/5/0/82

having different functions that can alter the dynamics of the ecosystem[115]. Oil spills impact can be immediate, causing the death of birds and marine mammals, and can generate toxic stress on subsurface organism (OSPAR Commission, 2010). More in detail, oil spills can poison marine species, or can prevent them from breathing. Shellfish may also be affected, as they filter water to feed[116]. Although oil is dissolved in water, lowering the toxicity level, it still can affect the organism of animals and lead to biodegradation.

Legal limits: MARPOL Regulation 15 of Annex I regulates the operational discharges of oil or oily mixtures from any ship. According to the Regulation, any discharge from ships of 400 GT and above is prohibited, unless certain conditions are satisfied. Specifically, these includes:

1. The ship is proceeding *en route*; or
2. The oily mixture is processed through an oil-filtering equipment meeting the requirements of Regulation 14 (the oil content of the effluent without dilution does not exceed 15 parts per million);
3. The oily mixture does not originate from cargo pump-room bilges; on oil tankers the oily mixture, in case of oil tankers, is not mixed with oil cargo residues.

As regards discharge in special areas, the aforementioned conditions are also applied, while any discharge in the Antarctic is prohibited. For ships under 400 gross tonnes, oil and oil mixtures must either be retained on board or discharged into sea.

Sewage

In Annex IV of MARPOL 73/78, 4 types of sewage are classified:

1. Drainage and other waste from any form of toilets, urinals, and WC scuppers;
2. Drainage from medical premises;
3. Drainage from spaces containing living animals;
4. Other waste waters when mixed with the drainages;

However, in this report, sewage will be treated as a single item, considering that relevant information is not available for allowing an in-depth analysis of each of the four items listed in MARPOL. However, sewage produced on board can be distinguished in black water and grey water. Black water is mainly liquid waste generated from accommodation or medical areas (rest homes, pharmacies, etc.) via sinks, bathtubs and sewage pipes. Grey water consists of waste water not coming from toilets and includes water from kitchen, showers, sinks and laundry etc. It can also include water from treatment facilities. The quantities produced vary widely, depending on the type of ship, the duration of the trip, the frequency of use and the type of the installed wastewater management system. The use of scrubbers to reduce air emissions is also referred to as a source of marine environment's pollution.

[115] The International Tanker Owners Pollution Federation Limited: http://www.itopf.com/knowledge-resources/documents-guides/environmental-effects/

[116] http://www.unc.edu/~bbuck/dumpinglink.htm

Table 95 - Wastewater volumes from EU fleet

World fleet	Marine Pollution				
Impact Type	Black wastewater	Grey wastewater	BOD from black water	BOD from grey water	Ballast water
Unit of measure	Mtonnes/y	Mtonnes/y	tonnes/y	tonnes/y	Mtonnes/y
Tanker	0,39	6,59	73	1.318	980
Bulk carrier	0,24	4,08	45	816	730
General and specialised cargo	0,45	7,47	83	1.494	270
Container &Reefer	0,2	3,33	37	665	569
Ro-pax & Ro-Ro cargo	5,12	30,68	256	6.135	246
Total cargo and cargo/pax ships	6	52	494	10.428	2.796
Cruise and passenger ships	0,79	4,75	40	951	54
Grand Total *Total cargo and cargo/pax + cruise and passenger*	**7**	**57**	**533**	**11.379**	**2.850**

Source: Maffii et al., 2007

In 2006, 250 million tonnes of black and grey waters were discharged by the international fleet, with ¼ of the volumes generated by the fleet of the EU (Maffii et al., 2007).

According to Klein (2005)[117], a cruise passenger produces approximately 48 gallons of accommodation wastewater, 24 gallons of galley and waste treatment plant wastewater, 20 gallons of wastewater from laundry and 5 gallons of raw sewage. The average wastewater production per day per person is estimated at 97 gallons.

As noted by the WWF (2010)[118], more than half of the cruise ships visiting the Baltic Sea do not deliver their waste water in the corresponding facilities, and discharge it into the sea. Based on same estimation, the 350 cruise ships that visited the Baltic Sea generated 113 tonnes of nitrogen and 38 tonnes of phosphorus, two components that contribute to the eutrophication of the sea.

Impacts: Sewage disposal can generate adverse impacts to the marine environment. Illegal disposal of sewage can have an observable visual pollution, while pathogens (bacteria, viruses and protozoa), solids (including organic matters) and nutrients (nitrogen and phosphorus) can enter the marine environment, leading to poor water quality (OSPAR Commision, 2010). Nutrients may contribute to eutrophication, which is the excessive growth of marine plant life. Algal population is increased, blocking sunlight, causing lack of oxygen in the water and affecting the growth of seagrass, which is a vital component for the survival and reproduction of fish and other marine organisms. The alteration of oxygen conditions can ultimately lead to the death of sea animals and other species. Moreover, algal blooms are considered toxic and have the potential of affecting or even killing marine mammals. (CEP-UNEP,2015)[119]. Wash water from scrubbers further contributes to acidification, eutrophication and the accumulation of hazardous hydrocarbons and heavy metals leading to the deterioration of water quality (NABU, 2015).

[117] Cruise Ship Squeeze: The new pirates of the seven seas
[118] http://wwf.panda.org/?195090/Cruise-ships-still-dump-their-sewage-in-the-Baltic-Sea
[119] http://www.cep.unep.org/publications-and-resources/marine-and-coastal-issues-links/wastewater-sewage-and-sanitation

Human health can also be impacted from the increase of algal population and its exposure to toxins. Due to the fact that pathogenic bacteria can survive in sea conditions from few days to several weeks – also in fish and shellfish – they are deemed to be responsible for various diseases and illnesses such as diarrhoea, cholera, and dysentery (CEP-UNEP,2015).

Legal limits: Annex IV of MARPOL 73/78 envisages certain requirements for sewage discharge limits. These depend on the processing method adopted, and on its distance from the nearest land. Regulation 11 provides that discharge of sewage from ships – other than passenger ships in all areas and discharge of sewage from passenger ships outside special areas – is prohibited, except when:

a. the ship is discharging comminuted and disinfected sewage at a distance of more than 4 nautical miles (nm) from land, or in the case of sewage which is not comminuted and disinfected at a distance of more than 12 nm from land, and when the ship is en route and proceeding at not less than 4 knots; or

b. the ship has in operation an approved sewage treatment plant and the effluent shall not produce visible floating solids nor cause discoloration of the surrounding water.

Moreover, Regulation 11, Article 3 states that from 1 January 2016 for new passenger ships, and from 1 January 2018 for existing passenger ships, the discharge of sewage within a special area shall be prohibited except when the ship has an approved sewage treatment plant in operation, and the effluent shall not produce visible floating solids nor cause discoloration of the surrounding water.

Additionally, Annex 9 of MEPC 184/59[120] sets various criteria for the discharge of wash water from exhaust gas scrubbers, as follows:

- pH of no less than 6.51
- concentration of PAH (phenanthrene equivalents) max. 50 µg/L
- turbidity not more than 25 FNU or 25 NTU above inlet turbidity
- nitrates not higher than that associated with 12 % NO_x removal or 60 mg/L for wash water discharge rate of 45 tons/MWh, whichever is greater.

Garbage

Garbage includes all types of food waste, domestic waste and operational waste, all plastics, cargo residues, cooking oil, fishing gear, and animal carcasses generated during the normal operation of the ship (MEPC 62, Annex 13)[121].

In 2006, it was estimated that the global fleet produced 10.5 million m^3 of which 30% was generated by the EU fleet (Maffii et al., 2007)[122].

[120] http://www.imo.org/blast/blastDataHelper.asp?data_id=26469&filename=184(59).pdf
[121] http://www.imo.org/blast/blastDataHelper.asp?data_id=30760&filename=201(62).pdf
[122] http://www.trt.it/english/Schede-progetti/European-parliament/External%20Costs%20of%20Maritime%20Transport.pdf

Table 96 - Solid waste of the EU fleet by category

World fleet	Solid Waste produced on board (Marpol Annex V categories, in m3)							Solid waste disposal	
Impact Type	Total ship generated solid waste (before disposal)	Cat.1 Plastics	Cat.2 Floating packaging and covering materials	Cat.3 Paper, rags, glass, metals, bottles and other similar residues	Cat.4 Triturated paper, rags, glass, metals, bottles etc	Cat.5 Food waste	Cat.6 Other waste (ashes, etc)	Total waste discharged overboard or incinerated	Total solid waste reception facilities
Unit of measure	m^3/y	m^3/y	m^3/y	m^3/y	m^3/y	m^3/y	m^3/y	m^3/y	m^3/y
Tanker	166.085	18.857	14.774	8.864	56.141	39.889	27.560	124.745	41.340
Bulk carrier	102.769	11.668	9.142	5.485	34.738	24.682	17.053	77.189	25.580
General and specialised cargo	188.262	21.375	16.747	10.048	63.637	45.216	31.240	141.402	46.860
Container &Reefer	83.806	9.515	7.455	4.473	28.328	20.128	13.907	62.946	20.860
Ro-pax & Ro-Ro cargo	2.241.011	336.969	10.328	158.404	1.003.225	712.818	19.267	988.679	1.252.332
Total cargo and cargo/pax ships	2.781.933	398.383	58.445	187.274	1.186.070	842.734	109.027	1.394.961	1.386.972
Cruise and passenger ships	360.335	52.223	6.147	24.549	155.478	110.471	11.467	144.691	215.644
Grand Total Total cargo and cargo/pax + cruise and passenger	**3.142.268**	**450.606**	**64.592**	**211.823**	**1.341.548**	**953.205**	**120.493**	**1.539.652**	**1.602.616**

Source: Maffii et. al, 2007

Based on Maffii et al. (2007), 27% of waste production is delivered in port reception facilities. In a study conducted in the Port Louis Harbor during 2009-2010, it resulted that approximately 5.010 tonnes of waste were generated by the ships and the industries in the port area. Plastics and paper waste represented 60% and 30% respectively of the 480 tonnes of ship-generated waste (Mohee et al., 2012). Moreover, the International Chamber of Shipping estimated that between 1,4 and 2,5 kg of wet garbage and 0,5-1,5 kg of dry garbage are produced per day on a ship of medium size[123]. Cruise ships are a significant source of waste that can add considerable pressures to the environment. It is estimated that an average cruise ship generates 1 kg of solid waste plus two bottles and two cans, per passenger per day (Butt, 2007). The waste amounts depend on the size of the ship, occupancy rate, the duration of the itinerary, etc. The waste volume delivered at ports varies considerably, and this makes the port waste planning difficult to manage in terms of demand[124]. In Stockholm, out of the 240 cruise ships that visited the port, only 115 of them delivered waste, but in small volumes[125].

Impacts: Garbage disposal at sea can have harmful effects on the marine environment. Apart from visual pollution, due to the garbage and mostly plastic floating at the surface of the sea, there is a potential danger due to the accumulation of plastic debris on the sea floor (Derraik, 2002). The most widely recognised problems include entanglement, ingestion, suffocation and general debilitation (Murray, 2009). Based on the study of Blight and Burger (1997), plastic particles were found in the stomach of multiple seabird species. Plastic particles affect the fitness of seabirds, and consequently their ability to migrate and reproduce (Derraik, 2002). This can also be the case fish, which, upon ingesting plastic debris, reduce food taking, can be injured internally and ultimately can die. Marine debris affects 267 different species including 86% of all sea turtle species, 44% of all seabird species, and 43% of all marine mammal species (Laist, 1997). Marine mammals are also threatened by entanglement, that may lead to the decline of their populations in various areas (Derraik, 2002). Plastic debris can be considered responsible for alien species invasion into the marine ecosystem (Grassle et al., 1991), which can lead to the extinction of several species and the degradation of the marine environment.

Limits: The International Convention for the prevention of pollution from ships (MARPOL Annex V, Regulation 3) prohibits the general discharge of garbage into the sea. However, the Annex (Regulation 4) allows the discharge of certain types of garbage which have received certain on board treatment while specifying the permitted distance from coasts. The table below presents a simplified overview of discharge provision of the revised MARPOL Annex V.

[123] http://www.ukmarinesac.org.uk/activities/ports/ph6_2_2.htm
[124] http://www.sustainablecruise.eu/wp-content/uploads/D-4.1.1-Preliminary-Report.pdf
[125] http://wwf.panda.org/?195090/Cruise-ships-still-dump-their-sewage-in-the-Baltic-Sea

Table 97 - Overview of discharge provision of the revised MARPOL Annex V

Type of garbage	Ships outside special areas	Ships within special areas	Offshore platforms and all ships within 500 m of such platforms
Food waste comminuted or ground	Discharge permitted ≥3 nm from the nearest land and *en route*	Discharge permitted ≥12 nm from the nearest land and *en route*	Discharge permitted ≥12 nm from the nearest land
Food waste not comminuted or ground	Discharge permitted ≥12 nm from the nearest land and *en route*	Discharge prohibited	Discharge prohibited
Cargo residues[1] not contained in wash water	Discharge permitted ≥12 nm from the nearest land and *en route*	Discharge prohibited	Discharge prohibited
Cargo residues[1] contained in wash water		Discharge only permitted in specific circumstances[2] and ≥12 nm from the nearest land and *en route*	Discharge prohibited
Cleaning agents and additives[1] contained in cargo hold wash water	Discharge permitted	Discharge only permitted in specific circumstances[2] and ≥12 nm from the nearest land and *en route*	Discharge prohibited
Cleaning agents and additives[1] contained in deck and external surfaces wash water		Discharge permitted	Discharge prohibited
Carcasses of animals carried on board as cargo and which died during the voyage	Discharge permitted as far from the nearest land as possible and *en route*	Discharge prohibited	Discharge prohibited
All other garbage including plastics, domestic wastes, cooking oil, incinerator ashes, operational wastes and fishing gear	Discharge prohibited	Discharge prohibited	Discharge prohibited
Mixed garbage	When garbage is mixed with or contaminated by other substances prohibited from discharge or having different discharge requirements, the more stringent requirements shall apply		

Source: IMO, 2012

As mentioned in the section on waste, EU Directive 2000/59 is the European legislative instrument that regulates the delivery of all waste in port reception facilities, in order to prevent marine pollution and minimise the environmental risks deriving from waste discharges in the marine environment.

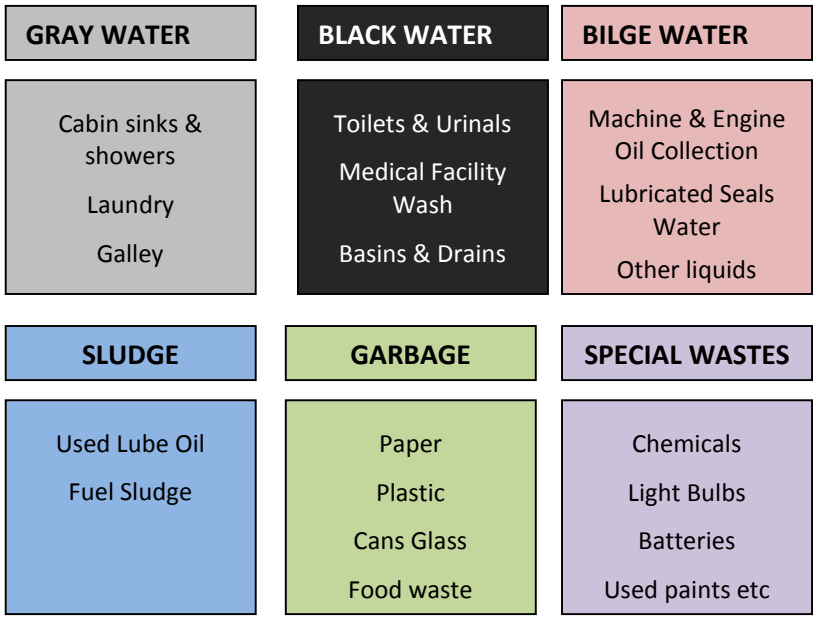
Table 98 - Amount of waste per average ship and total amount of waste in European waters

Type of waste	Amount per ship	Measurement unit	Total amount per year in EU waters	Measurement unit
Bilge water	15 000	Liter/day/ship	48383	m^3
Sewage	70 000	Liter/day/ship	2 241 787	m^3
Greywater	550 000	Liter/day/ship	17 614 044	m^3
Solid water	2.5	Kg/day/passenger	104 727	Tonne
Hazardous waste	60	Kg/day/ship	1 922	Tonne
Ballast water	1 000	Tonne/ship/release	16 927 000	Tonne

Source: Policy Research Corporation, 2009

The figure below summarises the main waste streams in ports. Sewage, bilge water and sludge flows are also shown.

Figure 19 - Waste Streams (from cruise ships)



Adapted from http://oceancouncil.org/

Noise at ports

Ports are areas where multiple activities take place, with different types of noise being produced, affecting the quality of the acoustic climate in the surrounding environment. It is indicative that European ports have recognised the management of noise emissions among their top environmental priorities (ESPO, 2012)[126]. The noises produced vary from port to port depending on the type of the port and the range of different

[126] Noise pollution was prioritised fifth priority in 2004 and first in 2009. http://esci-ksp.org/wp/wp-content/uploads/2014/04/espo_green-guide_october-2012_final.pdf

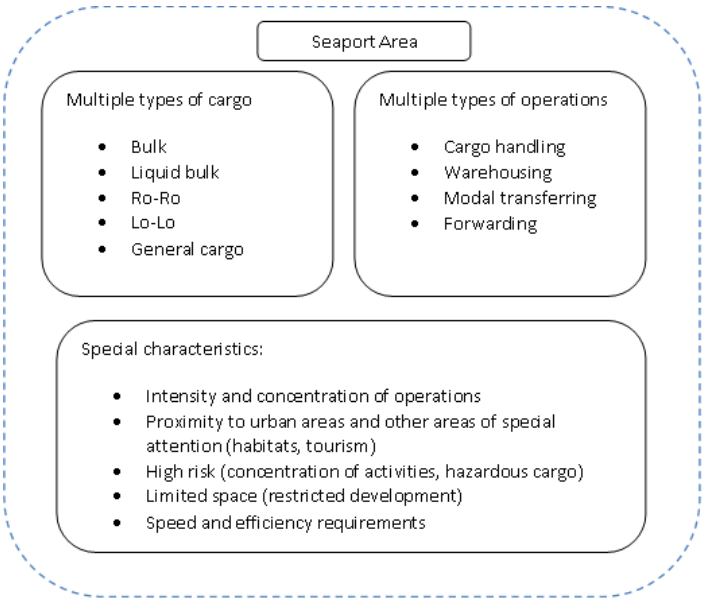
activities conducted (Mustonen, 2013). In this regard, the significance of the impact generated depends on the location of the port, and more specifically on proximity of to the city. In most cases, ports are located close to urban areas and may also include areas of environmental significance (NoMEPorts, 2005). Even if the boundaries of a port area can be well defined, the area exposed to noise pollution generated by port related activities exceeds the geographical limits of a port.

Generally speaking, the sound generated depends on the type of the noise source, distance from the source to the receiver and the nature of the working environment (WHO)[127]. Respectively, noises sourcing from ships depend upon ship's type, operations, location within port area (Badino et al., 2012), and even ship's deadweight (Witte, 2010). Even though it is argued that passenger ports produce less noise than cargo ports, the fact that these are located closer to city areas make them a significant source of disturbance. Moreover, it is stressed that port operations take place in open spaces, and thus noise pollution is not limited to the port zone, making its abatement more difficult (Holma et al., 2013).

Moreover, other factors affecting noise emissions are: propagation through air (air-borne noise), propagation through solids (structure-borne noise), diffraction at the machinery boundaries, reflection from the floor, wall, ceiling and machinery surface, absorption on the surfaces, etc. (WHO). Environmental conditions that may affect the levels of noises are humidity, wind direction and speed (Tang-Hung and Khoo, 2013).

The figure below illustrates the complexity of the port system and the range of activities that may contribute to noise emissions.

Figure 20 - Port noise sources



Source: NoMEPorts, 2005

Noise generated by ships

While there is a multitude of noise sources in port areas, for the purpose of this Study, only noise generated by ships will be taken into consideration. The noise generated by a ship can be distinguished into direct and indirect as follows (Rizzuto et al., 2010):

[127] World Health Organisation, Occupational exposure to noise: evaluation, prevention and control. Access from: http://www.who.int/occupational_health/publications/occupnoise/en/
Access from: http://www.who.int/occupational_health/publications/noise5.pdf

- **Direct ship noise**: is the noise produced from vessels' engines when a) the ship is sailing along the coast and b) when the ship is berthed or at anchor;
- **Indirect ship noise**: is the noise generated due to vessels' handling and may include loading/unloading, shipbuilding operations and road and rail traffic from/to the port area.

According to Lloyd's Register ODS (2010), the main sources of ships' noise at port is classified into three main categories: diesel generator engine exhaust, ventilation inlets/outlets and secondary noises resources such as pumps, refrigerated containers etc.

Diesel generator exhaust is identified as the main source of noise at port. This is due to its position at the top of funnel and therefore the generated noise can be transmitted to large distances without being prevented or absorbed by surrounding landscape. The spectrum of noise level depends on various parameters including piping system layout, type, performance of the silence and its location.

Ventilation is another significant source of noise. Based on vessels' types, ventilation system includes engine room, cargo, AC-systems, galley etc. The sound power level of the fan depends on the volume flow and the fan's total pressure[128]. Produced noise will increase if the fan is not operating at the designed maximum efficiency. It is stressed that if no noise reducing measures are implemented in the ventilation system, the sound power will be comparable to the sound power of the fan.

Secondary noise sources include all other on board sources which contribute to sound pollution and includes hydraulic pumps, loading/unloading of cargo, winches, reefer etc.

The table below illustrates the main sources of noise produced by type of vessel. Some of the on-board sources are common to all vessels types, while others depend on the ship's category.

[128] Fans are used to move a large volume of air for ventilation, by bringing in fresh air from the outside, blowing out dust, vapour or oil mist from an industrial environment, and for a drying or cooling operation, etc. Industrial fans are usually low-speed, low-static-pressure and have a large volume flow rate.

Table 99 - Noises produced by ship type

Ship	Noise sources
Bulk ships	- The exhaust from the auxiliary engines. - The ventilation of the machine room.
Tankers	- Pumps when pumping oil from ship to shore. - Exhaust noise. - Ventilation noise of machine housing.
Container ship	- The exhaust from the auxiliary engines. - The ventilation of the machine room. - The reefers (cooled containers).
General cargo ship	- The exhaust from the auxiliary engines - The ventilation of the machine room.
Ro-Ro ship	- The exhaust from the auxiliary engines. - The ventilation of the machine room. - The ventilation of the cargo decks.

Own elaboration based on Witte (2010)

In container ships, reefers (temperature control system) can be a significant noise source[129]. Despite the fact that the sound level generated by reefers is lower compared to the aforementioned two categories, however the number of reefers placed on board will increase respectively noise level.

Impacts: generally speaking, excessive noise levels can have multiple effects on human health, reducing performance and causing changes in social behaviour (WHO, 2015). The World Health Organisation in the Guidelines for Community Noise[130] has documented seven categories of adverse health impacts from noise exposure:

- Hearing impairment concerns an increase in hearing thresholds, occurring at higher frequency ranges (3,000-6,000 Hz)[131].
- Speech intelligibility results in personal handicaps and behavioural changes.
- Sleep disturbance can cause increased blood pressure, heart rate, respiratory changes, cardiac arrhythmia etc. As suggested the equivalent sound level should not exceed 30dB for a good night sleep.
- Physiological functions, such as hypertension and ischaemic heart disease.
- Mental illness, such as neurosis.
- Performance, such as reading, attention, solving and memorising problems etc
- Social and behavioural effects as well as annoyance.

[129] The sound power of the reefers is approximately 90 dB(A)
[130] http://whqlibdoc.who.int/hq/1999/a68672.pdf
[131] In a worldwide scale hearing impairment is the major irreversible occupation hazard with 120 million people facing hearing difficulties.

Based on an OECD study on ports, the number of people exposed to port-based noises range from 240 to 900 residents per port. The impacts generated vary on a daily basis, and, as reported by the same study, noise exposure during night hours exceeding 50 dB can have multiple harmful effects to human health. In the case of the Port of Long Beach, the average peak noise levels reached 70.3 dB at early morning hours 8 a.m. and again at 1 p.m and 2 p.m. (Hung Khoo and Nguyen, 2011) indicating excess of WHO relative limits. Alike in the case of Dublin, it was estimated that the night-time handling activity exceeded the limit of 40dB increasing the possibility of greater disturbance to residents' sleep patterns (Murphy and King, 2014).

In the case of the port of Livorno it was estimated that daytime limit value was 60dB, while the number of people exposed were about 300 inhabitants, while for the night-time people exposed was estimated in about 900 inhabitants (Morretta et al, 2008).

Legal limits: At EU level, environmental noise is regulated by the Environmental Noise Directive (END) issued in 2002 (2002/49/EC)[132]. The Directive aims at introducing a common framework for the avoidance, prevention or reduction of the harmful effects of environmental noise on a prioritised base. The monitoring of the environmental noise is among the main actions foreseen in the Directive, through the creation of strategic noise maps. The Directive is not establishing any limit values neither describe any measures or activities to be integrated in the action plans. Even if the Directive addresses noise maps for roads, railways, airports and other agglomeration, however no specific reference is made for ports. On the other hand, the Equipment Noise Directive (2005/88/EC)[133] regulates noise emissions from certain types of cargo handling. IMO, specifies in resolution A.468(XII), Code noise levels on board ships and operating conditions on port (paragraph 3.4.2-paragraph 3.4.4).

[132] http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002L0049&from=EN

[133] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2005:344:0044:0046:EN:PDF

Annex II
Port profiles

Port of Algeciras

Country	Spain
Geographic setting	Coastal Port
Geographic location	Mediterranean Sea
Ownership/governance	State
Owner of the land	State
Terminals operated by	Private company
Port specialisation	Container: 3 > 5 mln TEUs / year Liquid bulk: 15 < 25 mln tonnes/ year Dry bulk: < 5 mln tonnes/ year RoRo: < 5 mln tonnes/ year Other cargo: <5 mln/ year Passengers (non cruise): 3 < 7 mln/ year
Environmental charging scheme based on	No index / certification
Scheme description	A discount of 50% on port dues (vessel rate) to liquid natural gas-driven ships on high seas or use of liquid natural gas / electricity at berth. A discount of 5% (bonus coefficient as it's called officially) on port dues (vessel rate) to encourage better environmental practice, as per art. 245.1 of Royal Legislative Decree 2011/2. The discount is applied when a vessel demonstrates compliance with certain conditions of respect for the environment, improving those required by international standards and conventions, and when the shipping company or the shipowner has signed an agreement with Puertos del Estado on good environmental practices associated with operations and permanence of ships in the port. This agreement shall provide for a set of technical and operational instructions, based on the "Guidelines of good environmental practices" approved by Puertos del Estado, whose operational compliance can be verified through an environmental management system. Ships' compliance to these rules and international conventions must be certified by accredited certification bodies belonging to the International Accreditation Forum. The compliance with the agreement signed will be verified by the Port Authority. The vessel rate (T1) is calculated as follows: T1= GT / 100 x Hours x Basic amount (B;S) x Weighting x Utilisation Rate x Discounts x Bonus.
Authority in charge of the scheme	Port managing body. Approval from another level of government or an independent regulator is needed. The port authority may decide whether to apply the discount or the bonus, but the functioning of the scheme (including its coefficients) are determined by a state law. In addition, in order to benefit from the bonus to encourage better environmental practice, vessels need to sign an agreement with a state agency, Puertos del Estado.
Incentives for short-sea shipping	A discount of 20% is applied to the 'Cargo rate' to 'Goods and transportation elements in maritime access or departure in regular short-distance maritime service vessels'. A discount of 20% is applied to the 'Cargo rate' to 'Goods and transportation elements in maritime access or departure in regular short-distance roro maritime service vessels'. The 'Cargo rate' (T3) is calculated as follows: T3=(Equipment element x Basic amount (M) x Weighting x Equipment rate x Discounts x Bonus
Incentives for terminal operators or other stakeholders	-
Port certified with	ISO 140001 certification

Port of Amsterdam

*Data not yet validated by the port

Country	Netherlands
Geographic setting	River/Seagoing Canal port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	Liquid bulk: 25 < 50 mln tonnes/ year Dry bulk: 25 < 50 mln tonnes/ year
Environmental charging scheme based on	Environmental Ship Index
Scheme description	A discount on port dues is applied to ships with an ESI total score of at least 20 points. An extra discount is applied to ships with a score higher than 31 points. The discount is not a fixed percentage and depends on the gross tonnage of the ship, as follows: GT Class Reward 0 – 3000 € 200 3001 – 10000 € 500 10001 – 30000 € 900 30001 – 50001 € 1200 50001 – up € 1400 the calculating formula of the height of the incentive is: - ESI-score≥ 20 points: score/100 multiplied by “GT-class reward” - ESI-score≥ 31 points: add 1/4 of the “GT-class reward”
Environmental charging scheme based on	Green Award
Scheme description	A discount of 6% on port dues applied to Crude oil/Product Tankers that are certified with Green Award A discount of 5%, 10% or 15% on port dues for inland barges according to their Green Award level (Bronze, Silver, Gold) A discount of 10% on port dues for inland barges with certificates issued before the 17th of June 2014
Authority in charge of the scheme	
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	
Port certified with	

Port of Antwerp

*Data not yet validated by the port

Country	Belgium
Geographic setting	River/Seagoing Canal port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	Container: > 5 mln TEUs / year Liquid bulk: 50 < 100 mln tonnes/ year
Environmental charging scheme based on	ESI
Scheme description	Discount of 10% on port dues applied on vessels with an ESI score of at least 31 points. The discount is given on a quarterly basis, with retroactive effect. The discount is calculated on the net invoiced tonnage dues (including all discounts). In order to get a discount, a ship must be registered and be published on the public part of the ESI-website
Environmental charging scheme based on	Other
Scheme description	- Discount of 20% on port dues for vessels that use LNG as a power source, 15% for vessels that use closed loop scrubber system in 2015; respectively 15% and 10% discount in 2016 and respectively 10% and 5% in 2017. - Increase of 35% on port dues for tankers that do not have separated ballast tanks or are single walled tankers.* - Discount of 50% on waste contribution for vessels running on engines exclusively powered by an environmentally friendly energy source (marine diesel, gas oil or LNG)*
Authority in charge of the scheme	Port managing body. There is autonomy in tariff setting.
Incentives for short-sea shipping	-
Incentives for terminal operators or other stakeholders	Twice a substantive sustainability report has been produced by Port of Antwerp, for which the elaboration includes intensive stakeholder consultation and also the report in itself is a means for stakeholders to monitor their progress.
Port certified with	No certification

* Although there is an incentive related to the contribution for waste, the direct effect on garbage and sewage is absent as the incentive is based on the use of power of the ship (marine diesel, gas oil, LNG). Thus the incentive can urge an increase in use of environmentally friendly power sources, although it does not directly incentive actions on garbage and sewage.

Port of Bilbao

*Data not yet validated by the port

Country	Spain
Geographic setting	Estuary port
Geographic location	South Atlantic Sea
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	Containers:0,5 < 1 mln TEUs/year Liquid bulk: 15 < 25 mln tonnes/ year Dry bulk: < 5 mln tonnes/ year Other cargo: 5 < 15 mln tonnes/ year
Environmental charging scheme based on	No index / certification
Scheme description	A discount of 5% (bonus coefficient, as it's called officially) on port dues (vessel rate) to encourage better environmental practice, as per art. 245.1 of Royal Legislative Decree 2011/2. The discount is applied when a vessel demonstrates compliance with certain conditions of respect for the environment, improving those required by international standards and conventions, and when the shipping company or the shipowner has signed an agreement with Puertos del Estado on good environmental practices associated with operations and permanence of ships in the port. This agreement shall provide for a set of technical and operational instructions, based on the "Guidelines of good environmental practices" approved by Puertos del Estado, whose operational compliance can be verified through an environmental management system. Ships' compliance to these rules and international conventions must be certified by accredited certification bodies belonging to the International Accreditation Forum. The compliance with the agreement signed will be verified by the Port Authority.
Authority in charge of the scheme	Port managing body. Approval from another level of government or an independent regulator is needed. The port authority may decide whether to apply the discount or the bonus, but the functioning of the scheme (including its coefficients) are determined by a state law. In addition, in order to benefit from the bonus to encourage better environmental practice, vessels need to sign an agreement with a state agency, Puertos del Estado.
Incentives for short-sea shipping	Short sea shipping vessels have a cheaper basic rate than other vessels
Incentives for terminal operators or other stakeholders	
Port certified with	ISO 140001 certification

Port of Bremen

*Data not yet validated by the port

Country	Germany
Geographic setting	River/Seagoing Canal port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	Passenger (non cruise): Passenger (cruise): < 1mln/ year Container: > 5 mln TEUs / year Liquid bulk: Dry bulk: 5 < 15 mln tonnes/ year RoRo: 50 < 100 mln tonnes/ year Other cargo:
Environmental charging scheme based on	Environmental Ship Index
Scheme description	A discount of 5% on port dues is applied to ships with an ESI score between 30 and 40; A discount of 10% on port dues is applied to ships with an ESI score 41 or more. Only 25 ships with the best ESI score will receive the discount.
Authority in charge of the scheme	Local administration
Incentives for short-sea shipping	logistics center fruit terminals and cold store
Incentives for terminal operators or other stakeholders	electricity consumption at the workshops and offices has been minimised; a photovoltaic system on the roof of the central workshop in Bremerhaven generates green power, modern LED technology helps to reduce the current consumption of lock signalling systems. Moreover, the company cars are gradually being replaced by electric vehicles and low-consumption models
Port certified with	Port Environmental Review System (PERS)

Port of Cartagena

*Data not yet validated by the port

Country	Spain
Geographic setting	Coastal Port
Geographic location	Mediterranean Sea
Ownership/governance	State
Owner of the land	State
Terminals operated by	Private company
Port specialisation	Container: < 0,25 mln TEUs / year Liquid bulk: 15 < 25 mln tonnes/ year RoRo: < 5 mln tonnes/ year Other cargo: <5 mln/ year Passengers (cruise): < 1 mln/ year
Environmental charging scheme based on	No index / certification
Scheme description	A discount of 50% on port dues (vessel rate) to liquid natural gas-driven ships on high seas or use of liquid natural gas / electricity at berth.
Authority in charge of the scheme	Port managing body. Approval from another level of government or an independent regulator is needed. The port authority may decide whether to apply the discount or the bonus, but the functioning of the scheme (including its coefficients) are determined by a state law. In addition, in order to benefit from the bonus to encourage better environmental practice, vessels need to sign an agreement with a state agency, Puertos del Estado.
Incentives for short-sea shipping	-
Incentives for terminal operators or other stakeholders	-
Port certified with	ISO 140001 certification Eco-Management and Audit Scheme (EMAS)

Port of Civitavecchia

*Data not yet validated by the port

Country	Italy
Geographic setting	Coastal port
Geographic location	Mediterranean Sea
Ownership/governance	State
Owner of the land	State
Terminals operated by	Private company
Port specialisation	Passengers (cruise): 1 mln < 3 mln/ year Passengers (non cruise): 1 mln < 3 mln/ year
Environmental charging scheme based on	Environmental Ship Index
Scheme description	Discount on the waste collection fee, depending on the ESI score achieved by a ship: ESI score 0,1 up to 10 = 6% discount ESI score 10,1 up to 20 = 8% discount ESI score 20,1 up to 30 = 11% discount ESI score > 30 = 15% discount
Authority in charge of the scheme	Port managing body.
Incentives for short-sea shipping	Discount of 5% (technically the ship tonnage which is part of the formula to calculate the tariff is reduced by 15%) on 'dock dues' (part of Maritime Dues of the Ghent Port Company) if a bulk vessel has a valid shortsea Green Award certificate
Incentives for terminal operators or other stakeholders	In the strategic plan 23 objectives are identified of which a large amount clearly focus on an environmental or sustainability approach. These are, amongst others: - Stimulation of biomass cluster; - Concession policy that stimulates sustainability for concessionaires, next to economic and spatial aspects; - Modal Split objective: 35% road, 50% inland waterway and 15% rail. - Strategic Spatial Masterplan that focuses on a 25% more efficient use of land in the old part of the port. - Stimulate the 'liveability' for the surrounding villages (stakeholder management). - Striving to improve energy efficiency of Energy consumption economic activities inside the port area with 20% by 2020. The port also produces biannually an environmental report to increase transparency and provide clear communication on environmental policy and associated results of Ghent Port Company.
Port certified with	Port Environmental Review System (PERS)

Port of Ghent

*Data not yet validated by the port

Country	Belgium
Geographic setting	River/Seagoing Canal port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	Other
Owner of the land	Other
Terminals operated by	Private company
Port specialisation	Liquid bulk: 5 < 15 mln tonnes/ year Dry bulk: 25 < 50 mln tonnes/ year RoRo: < 5 mln tonnes/ year
Environmental charging scheme based on	Green Award
Scheme description	Discount of 15% (technically the ship tonnage which is part of the formula to calculate the tariff is reduced by 15%) on 'dock dues' (part of Maritime Dues of the Ghent Port Company) if a bulk vessel has a valid bulk Green Award certificate.
Environmental charging scheme based on	Environmental Ship Index
Scheme description	Discount of 5% (technically the ship tonnage which is part of the formula to calculate the tariff is reduced by 5%) on 'dock dues' (part of Maritime Dues of the Ghent Port Company) if the vessel has an ESI sore of at least 20 The discount increases to 10% if the vessel has an ESI score of at least 30, as registered by the World Ports Climate Initiative. The reduction based on ESI score cannot be combined with a Green Award based reduction.
Environmental charging scheme based on	Other
Scheme description	Discount of 50% on 'environmental dues' (calculated per stay per vessel regardless of vessel type) for vessels that sail on an environmentally friendly fuel (marine diesel, gas oil, LNG, other) + need for permission from OVAM*. (environmental dues = fixed amount of 75 EUR + variable amount of 0,005 EUR per GT of the vessel, and the maximum dues are 400 EUR)
Authority in charge of the scheme	Port managing body. Approval from another level of government or an independent regulator is needed
Incentives for short-sea shipping	Discount of 5% (technically the ship tonnage which is part of the formula to calculate the tariff is reduced by 15%) on 'dock dues' (part of Maritime Dues of the Ghent Port Company) if a bulk vessel has a valid shortsea Green Award certificate
Incentives for terminal operators or other stakeholders	In the strategic plan 23 objectives are identified of which a large amount clearly focus on an environmental or sustainability approach. These are, amongst others: - Stimulation of biomass cluster; - Concession policy that stimulates sustainability for concessionaires, next to economic and spatial aspects; - Modal Split objective: 35% road, 50% inland waterway and 15% rail. - Strategic Spatial Masterplan that focuses on a 25% more efficient use of land in the old part of the port. - Stimulate the 'liveability' for the surrounding villages (stakeholder management). - Striving to improve energy efficiency of Energy consumption economic activities inside the port area with 20% by 2020. The port also produces biannually an environmental report to increase transparency and provide clear communication on environmental policy and associated results of Ghent Port Company.
Port certified with	Port Environmental Review System (PERS)

* Environmental dues can be reduced if the vessel sails on environmentally friendly fuel. This can directly influence sewage.

Port of Gibraltar

*Data not yet validated by the port

Country	UK
Geographic setting	Coastal Port
Geographic location	Mediterranean Sea
Ownership/governance	State
Owner of the land	State
Terminals operated by	Private company
Port specialisation	Passengers (cruise): < 1 mln/ year
Environmental charging scheme based on	Green Award
Scheme description	Discount of 5% on port dues applied to all ships with a valid Green Award certificate.
Authority in charge of the scheme	Port managing body.
Incentives for short-sea shipping	-
Incentives for terminal operators or other stakeholders	-
Port certified with	No certification

Port of Gothenburg

*Data not yet validated by the port

Country	Sweden
Geographic setting	Coastal port
Geographic location	North Sea
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	Passenger (non cruise): 1 < 3 mln/ year Passenger (cruise): < 1 mln/ year Containers: 0,5 < 1 mln TEUs/ year Liquid bulk:15 < 25 mln tonnes/ year RoRo: < 5 mln tonnes/ year
Environmental charging scheme based on	Environmental Ship Index
Scheme description	Discount of 10% on port dues applied to ships with an ESI score of at least 30
Environmental charging scheme based on	Clean Shipping Index
Scheme description	Discount of 10% on port dues applied to ships that achieve green standard according to the CSI
Environmental charging scheme based on	No index / certification
Scheme description	Discount of 20% on port dues applied to ships that switch to LNG as a fuel. The discount will be applied until December 2018.
Authority in charge of the scheme	Local administration
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	
Port certified with	ISO 140001

Port of Hamburg

*Data not yet validated by the port

Country	Germany
Geographic setting	River/Seagoing Canal port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	Passenger (cruise): < 1mln/ year Container: > 5 mln TEUs / year Liquid bulk: 5 < 15 mln tonnes/ year Dry bulk: 25 < 50 mln tonnes/ year RoRo: < 5 mln tonnes/ year
Environmental charging scheme based on	Green Award
Scheme description	Discount of 3% on port dues applied to crude oil, product and chemical tanker and LNG carriers of any size that hold a valid Green Award certificate.
Environmental charging scheme based on	Environmental Ship Index
Scheme description	Discount of 15% on the gross tonnage portion of port dues applied to ships that are exclusively powered by LNG i.e. with and ESI-SO_x score = 100). However, the discount cannot exceed EUR 2 000 and is limited in time until December 2018 Discount on the gross tonnage portion of port dues applied to ships with the following overall ESI scores: ESI score 20 up to < 25 = 0.5% discount, maximally € 250 ESI score 25 up to < 35 = 1%discount, maximally € 500 ESI score 35 up to < 50 = 5%discount, maximally € 1,000 ESI score ≥ 50 = 10% discount, maximally € 1,500
Environmental charging scheme based on	Blue Angel
Scheme description	Discount of 2% on the gross tonnage portion of port dues applied to ships that hold a valid RAL-UZ 110 (Blue Angel) certificate
Environmental charging scheme based on	No index / certification
Scheme description	Discount of 15% on the gross tonnage portion of port dues applied to ships that use shore power while berthing in the port. The overall discount cannot exceed EUR 2 000.
Authority in charge of the scheme	Local administration
Incentives for short-sea shipping	'Short distance traffic' is priced lower that the other traffic in terms of price in € per tonne Handled, price in € / loaded TEU, and price in € / GT. Port dues vary based on the type and size of ships, and it's impossible to report them here. For more details, please see http://www.hamburg-port-authority.de/de/Documents/AGB%202015_ENG%20annex%20price%20list.pdf
Incentives for terminal operators or other stakeholders	Transshipment discounts in container transport
Port certified with	ISO 140001 certification

Port of Huelva

*Data not yet validated by the port

Country	Spain
Geographic setting	Estuary port
Geographic location	South Atlantic Sea
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	
Environmental charging scheme based on	No index / certification
Scheme description	Discount of 20% on port dues applied to ships with a certificate issued by the Maritime Administration stating that reduced amounts of waste are generated due to the ship's environmental management.
Authority in charge of the scheme	Port authority. Approval from another level of government or an independent regulator is needed
Incentives for short-sea shipping	Short-sea shipping vessels have a cheaper basic rate than other vessels The vessel rate (T1) is calculated as follows: T1= GT / 100 x Hours x Basic amount (B;S) x Cofficient (depending on the type of ship). The 'basic amount' is: 1,20 for short-sea shipping 1,43 for all other transport Short-sea shipping vessels will thus pay lower fees.
Incentives for terminal operators or other stakeholders	
Port certified with	ISO 140001 certification

Port of Klaipeda

Data not yet validated by the port

Country	Lithuania
Geographic setting	Coastal port
Geographic location	Baltic Sea
Ownership/governance	State
Owner of the land	State
Terminals operated by	Private Company
Port specialisation	Container: 0,25 < 0,5 mln TEUs / year Liquid bulk: 5 < 15 mln tonnes/ year Dry bulk: 15 < 25 mln tonnes/ year RoRo: < 5 mln tonnes/ year Other cargo: 5 < 15 mln tonnes/ year Passenger (non cruise): < 1 mln/ year Passenger (cruise): < 1 mln/ year
Environmental charging scheme based on	Green Award
Scheme description	Discount of 20% on sanitary dues applied to ships equipped with waste treatment system complying with Green Award and other modern waste treatment systems intended for minimisation of waste formation and waste re-sing and separation.
Authority in charge of the scheme	Port authority. Approval from another level of government or an independent regulator is needed
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	The new waste management plan enforces rules regarding the procedure of waste disposal and treatment
Port certified with	ISO 140001 certification

Port of Kotka

*Data not yet validated by the port

Country	Finland
Geographic setting	Coastal port
Geographic location	Baltic Sea
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	Passenger (non cruise): Passenger (cruise): Container: 0,5 < 1 mln TEUs / year Liquid bulk: < 5 mln tonnes/ year Dry bulk: < 5 mln tonnes/ year RoRo: < 5 mln tonnes/ year Other cargo: < 5 mln tonnes/ year
Environmental charging scheme based on	No index / certification
Scheme description	Port of HaminaKotka Ltd may give a reduction to the waste management charge for vessels which use equipment, methods or fuel grades which have significantly decreasing impacts on the amount of waste.
Authority in charge of the scheme	Local administration. There is autonomy in tariff setting.
Incentives for short-sea shipping	-
Incentives for terminal operators or other stakeholders	The Ecoport project aims to pay attention to the environment in all operations of the port. This is based on the life cycle approach, which means that all stages from design and construction all the way to commissioning and decommissioning are taken into account in the operations. The goal is to arrange the port's own operations so that other stakeholders, too, can work in a sustainable manner. Ecoport provides an opportunity to utilise the experiences and knowhow possessed by the port of its own development projects, and in this way to manage growth based on the relevant needs by means of swift response
Port certified with	ISO 140001 certification

Port of Las Palmas

*Data not yet validated by the port

Country	Spain
Geographic setting	Coastal port
Geographic location	South Atlantic Sea
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	Container: 1 < 2 mln TEUs / year Anca Sfetcovici <anca.sfetcovici@eurofish.dk> Other cargo: 5 < 15 mln/ year Passengers (cruise): 1 < 3 mln/ year Passengers (non cruise): 1 < 3 mln/ year
Environmental charging scheme based on	No index / certification
Scheme description	Discount of 20% on the waste management charge applied to ships are certified with an Environmental Management System Discount of 5% (bonus coefficient as it's called officially) on port dues (vessel rate) to encourage better environmental practice, as per art. 245.1 of Royal Legislative Decree 2011/2. The discount is applied when a vessel demonstrates compliance with certain conditions of respect for the environment, improving those required by international standards and conventions, and when the shipping company or the shipowner has signed an agreement with Puertos del Estado on good environmental practices associated with operations and permanence of ships in the port. This agreement shall provide for a set of technical and operational instructions, based on the "Guidelines of good environmental practices" approved by Puertos del Estado, whose operational compliance can be verified through an environmental management system. Ships' compliance to these rules and international conventions must be certified by accredited certification bodies belonging to the International Accreditation Forum. The compliance with the agreement signed will be verified by the Port Authority. The vessel rate (T1) is calculated as follows: T1= GT / 100 x Hours x Basic amount (B;S) x Weighting x Utilisation Rate x Discounts x Bonus.
Authority in charge of the scheme	Port authority. Approval from another level of government or an independent regulator is needed
Incentives for short-sea shipping	Short-sea shipping vessels have a cheaper basic rate than other vessels The vessel rate (T1) is calculated as follows: T1= GT / 100 x Hours x Basic amount (B;S) x Cofficient (depending on the type of ship). The 'basic amount' is: 1,20 for short-sea shipping 1,43 for all other transport Short-sea shipping vessels will thus pay lower fees.
Incentives for terminal operators or other stakeholders	
Port certified with	ISO 140001 certification

Port of Le Havre

*Data not yet validated by the port

Country	France
Geographic setting	Estuary port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	Liquid bulk: 25 < 50 mln tonnes/ year
Environmental charging scheme based on	Environmental Ship Index
Scheme description	A discount of 10% on port dues is applied to the 10 cleanest container or Ro-Ro ships ships with an ESI score of 31 or more.
Authority in charge of the scheme	
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	
Port certified with	

Port of Lisbon

*Data not yet validated by the port

Country	Portugal
Geographic setting	Estuary port
Geographic location	South Atlantic Sea
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	Liquid bulk: < 5 mln tonnes/ year Dry bulk: < 5 mln tonnes/ year
Environmental charging scheme based on	Green Award
Scheme description	A discount of 5% on port dues is applied to Crude Oil/Product Tankers that hold a valid Green Award certificate
Authority in charge of the scheme	
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	
Port certified with	ISO 140001 certification

Port of Marseille Fos

*Data not yet validated by the port

Country	France
Geographic setting	Coastal port
Geographic location	Mediterranean Sea
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	Liquid bulk: 25 < 50 mln tonnes/ year
Environmental charging scheme based on	No index / certification
Scheme description	Discount of 20% on port dues applied to ships whose maritime fuel used to produce electrical energy during the call at the port has zero sulphur content.
Authority in charge of the scheme	
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	
Port certified with	

Port of Moerdijk

*Data not yet validated by the port

Country	Netherlands
Geographic setting	Estuary port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	Liquid bulk: < 5 mln tonnes/ year Dry bulk: < 5 mln tonnes/ year
Environmental charging scheme based on	Green Award
Scheme description	Discount of 6% on port dues applied to Crude oil/Product Tankers that hold a valid Green Award certificate. Discount of 15% on port dues applied to inland barges that hold a valid Green Award certificate.
Authority in charge of the scheme	
Incentives for short-sea shipping	Vessels with a CCR4 certificate will be granted a discount of 30% on the port dues
Incentives for terminal operators or other stakeholders	
Port certified with	Port Environmental Review System (PERS)

Port of Riga

*Data not yet validated by the port

Country	Latvia
Geographic setting	River/Seagoing Canal port
Geographic location	Baltic Sea
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	Passenger (non cruise): < 1 mln/ year Passenger (cruise): < 1mln/ year Container: 0,25 < 0,5 mln TEUs/ year Liquid bulk: 5 < 15 mln tonnes/ year Dry bulk: 15 < 25 mln tonnes/ year RoRo: < 5 mln tonnes/ year
Environmental charging scheme based on	Green Award
Scheme description	10% discount on port dues applied to oil tankers that hold a valid Green Award certificate.
Authority in charge of the scheme	
Incentives for short-sea shipping	Short-sea ships are exempted from port dues.
Incentives for terminal operators or other stakeholders	Carrying out constant improvements of the Port Authority service provisions technologies with lower consumption of resources and more careful attitude towards the environment; Ensuring compliance with the environment protection requirements provided for in laws and regulations and other mandatory documents in activities carried out by all structural units of the Port Authority; Facilitating introduction of environmentally friendly raw materials and technologies in the Free Port of Riga;
Port certified with	ISO 140001 certification

Port of Rostock

*Data not yet validated by the port

Country	Germany
Geographic setting	River/Seagoing Canal port
Geographic location	Baltic Sea
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Municipality
Port specialisation	Passenger (non cruise): 1 < 3mln/ year Passenger (cruise): < 1mln/ year Liquid bulk: < 5 mln tonnes/ year Dry bulk: 5 < 15 mln tonnes/ year RoRo: < 5 mln tonnes/ year Other cargo: < 5 mln tonnes/ year
Environmental charging scheme based on	Environmental Ship Index
Scheme description	Discount on port dues applied to ships with the following overall ESI scores: ESI score ≥20 = 3% discount; ESI score ≥15 = 2% discount; ESI score ≥10 = 1% discount.
Authority in charge of the scheme	
Incentives for short-sea shipping	Connectivity with major seaports High quality intermodal connectivity
Incentives for terminal operators or other stakeholders	
Port certified with	ISO 140001 certification

Port of Rotterdam

*Data not yet validated by the port

Country	Netherlands
Geographic setting	River/Seagoing Canal port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	Containers > 5 mln TEUs/ year Liquid bulk: 50 < 100 mln tonnes/ year Dry bulk: 50 < 100 mln tonnes/ year
Environmental charging scheme based on	Green Award
Scheme description	Discount of 6% on port dues applied to Crude oil/Product Tankers and LNG carriers that hold a valid Green Award certificate. Discount of 15% on port dues applied to inland barges that hold a valid Green Award certificate.
Environmental charging scheme based on	Environmental Ship Index
Scheme description	Discount of 10% on the gross tonnage portion of port dues applied to ships which score 31 points or more on the Environmental Ship Index At the end of each quarter Port of Rotterdam Authority will determine which vessels are eligible for the ESI-discount. Two conditions will be applicable: 1. at the actual time of arrival (ATA) the vessel must have an ESI score of 31 points or more and 2. the ship called at the port of Rotterdam in the quarter concerned. The discount applies to each call in the quarter concerned, with a maximum of 20 calls per single ship per quarter; The discount will be doubled if the ship also has an individual ESI-NOx score of 31.0 or more.
Authority in charge of the scheme	
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	
Port certified with	

Port of Stockholm

*Data not yet validated by the port

Country	Sweden
Geographic setting	Coastal port
Geographic location	Baltic Sea
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	
Environmental charging scheme based on	Other
Scheme description	A funding contribution of SEK 1 million will be offered to every vessel that carries out restructuring work to enable the vessel to connect to electricity at the quayside. This applies for the quays where Ports of Stockholm offers quayside electricity connection capabilities. The port fee for LNG vessels will be discounted by 5 öre per unit of gross tonnage. For a vessel of the size of Viking Grace, calling at Stockholm daily, this amounts to a rebate of around SEK 1 million annually. For a vessel calling at Stockholm every second day the rebate will be around SEK 500 thousand annually. The discount for reduced emission of nitrous oxide will follow the seven-level scale applied by the Swedish Maritime Administration. For a normal-sized vessel operating daily calls this will mean a discount of between SEK 3 million to SEK 4 million annually, depending on the amount of nitrous oxide emissions.
Authority in charge of the scheme	
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	
Port certified with	ISO 140001

Port of Tallinn

*Data not yet validated by the port

Country	Estonia
Geographic setting	Coastal port
Geographic location	Baltic Sea
Ownership/governance	State
Owner of the land	Port authority
Terminals operated by	Private company
Port specialisation	Passenger (non cruise): > 7 mln/ year Passenger (cruise): < 1mln/ year Liquid bulk: 15 < 25 mln tonnes/ year Dry bulk: < 5 mln tonnes/ year RoRo: < 5 mln tonnes/ year
Environmental charging scheme based on	No index / certification
Scheme description	A discount of 9,38% on the waste fee is applied to cruise ships that collect garbage separately by types, in case at least one type of recyclable garbage (excluding mixed domestic waste) listed in MARPOL Annex V (garbage) is discharged. Lowered rate does not apply if a ship does not collect garbage listed in MARPOL Annex V separately by types or does not discharge any garbage at a port (including garbage listed in MARPOL Annex V). Lowered rate is always applied in Saaremaa harbour
Authority in charge of the scheme	Port authority. There is autonomy in tariff setting
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	Development of software application Mairis for prompt information and notification system in order to prevent exceeding the permitted limits outdoor air pollutants in Muuga harbor. Development of outdoor air monitoring in the western part of Muuga harbor. in cooperation with oil operators deveplment of an environmental management system etc.
Port certified with	ISO 140001 certification

Port of Tenerife

*Data not yet validated by the port

Country	Spain
Geographic setting	Coastal port
Geographic location	South Atlantic Sea
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	
Environmental charging scheme based on	No index / certification
Scheme description	Discount of 5% (bonus coefficient as it's called officially) on port dues (vessel rate) to encourage better environmental practice, as per art. 245.1 of Royal Legislative Decree 2011/2. The discount is applied when a vessel demonstrates compliance with certain conditions of respect for the environment, improving those required by international standards and conventions, and when the shipping company or the ship owner has signed an agreement with Puertos del Estado on good environmental practices associated with operations and permanence of ships in the port. This agreement shall provide for a set of technical and operational instructions, based on the "Guidelines of good environmental practices" approved by Puertos del Estado, whose operational compliance can be verified through an environmental management system. Ships' compliance to these rules and international conventions must be certified by accredited certification bodies belonging to the International Accreditation Forum. The compliance with the agreement signed will be verified by the Port Authority.
Authority in charge of the scheme	Port authority. Approval from another level of government or an independent regulator is needed
Incentives for short-sea shipping	Short-sea shipping vessels have a cheaper basic rate than other vessels The vessel rate (T1) is calculated as follows: T1= GT / 100 x Hours x Basic amount (B;S) x Cofficient (depending on the type of ship). The 'basic amount' is: 1,20 for short-sea shipping 1,43 for all other transport Short-sea shipping vessels will thus pay lower fees.
Incentives for terminal operators or other stakeholders	
Port certified with	ISO 140001 certification

Port of Valencia

*Data not yet validated by the port

Country	Spain
Geographic setting	Coastal Port
Geographic location	Mediterranean Sea
Ownership/governance	State
Owner of the land	State
Terminals operated by	Private company
Port specialisation	Container: 3 < 5 mln TEUs / year Liquid bulk: < 5 mln tonnes/ year Dry bulk:< 5 mln tonnes/ year RoRo: < 5 mln tonnes/ year Other cargo: 5 < 15 mln/ year Passengers (cruise): < 1 mln/ year Passengers (non cruise): < 1 mln/ year
Environmental charging scheme based on	No index / certification
Scheme description	A discount of 50% on port dues (vessel rate) to liquid natural gas-driven ships on high seas or use of liquid natural gas / electricity at berth. In addition, a discount of 5% (bonus coefficient as it's called officially) on port dues (vessel rate) to encourage better environmental practice, as per art. 245.1 of Royal Legislative Decree 2011/2. The discount is applied when a vessel demonstrates compliance with certain conditions of respect for the environment, improving those required by international standards and conventions, and when the shipping company or the shipowner has signed an agreement with Puertos del Estado on good environmental practices associated with operations and permanence of ships in the port. This agreement shall provide for a set of technical and operational instructions, based on the "Guidelines of good environmental practices" approved by Puertos del Estado, whose operational compliance can be verified through an environmental management system. Ships' compliance to these rules and international conventions must be certified by accredited certification bodies belonging to the International Accreditation Forum. The compliance with the agreement signed will be verified by the Port Authority.
Authority in charge of the scheme	Port managing body. Approval from another level of government or an independent regulator is needed. The port authority may decide whether to apply the discount or the bonus, but the functioning of the scheme (including its coefficients) are determined by a state law. In addition, in order to benefit from the bonus to encourage better environmental practice, vessels need to sign an agreement with a state agency, Puertos del Estado.
Incentives for short-sea shipping	Short-sea shipping vessels have a cheaper basic rate than other vessels The vessel rate (T1) is calculated as follows: T1= GT / 100 x Hours x Basic amount (B;S) x Cofficient (depending on the type of ship). The 'basic amount' is: 1,20 for short-sea shipping 1,43 for all other transport Short-sea shipping vessels will thus pay lower fees.
Incentives for terminal operators or other stakeholders	When a terminal or cargo handling operator (i) has signed an agreement on good environmental practices with the Port Authority. The agreement must be based on Puertos del Estado's guidelines on good environmental practices;

	(ii) is registered in the EMAS or has an environmental management system based on UNEEN-ISO-14001 and certified by a certifying body; they will receive a 15% bonus discount on their land lease charge, or a 20% bonus in the case of handling of solid and liquid bulk
Port certified with	ISO 140001 certification Eco-Management and Audit Scheme (EMAS)

Port of Ventspils

*Data not yet validated by the port

Country	Latvia
Geographic setting	Coastal port
Geographic location	Baltic Sea
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	Passenger (non cruise): < 1 mln/ year Liquid bulk:15 < 25 mln tonnes/ year Dry bulk: 5 < 15 mln tonnes/ year RoRo: < 5 mln tonnes/ year
Environmental charging scheme based on	No index / certification
Scheme description	Discount of 50% on the sanitary fee applied to vessels is equipped with a certified incinerator.
Authority in charge of the scheme	Local administration
Incentives for short-sea shipping	Coasters shall pay charges in the amount of 50% of the basic rate
Incentives for terminal operators or other stakeholders	
Port certified with	No certification

Port of Wilhelmshaven

*Data not yet validated by the port

Country	Germany
Geographic setting	River/Seagoing Canal port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	State
Owner of the land	State
Terminals operated by	Private company
Port specialisation	Container: 2 < 3 mln TEUs / year Liquid bulk: 15 < 20 mln tonnes/ year Dry bulk:< 5 mln tonnes/ year RoRo: < 5 mln tonnes/ year
Environmental charging scheme based on	Environmental Ship Index
Scheme description	Discount of on port dues applied to seagoing vessels with an ESI score of 20 points or more (after deduction of other possible rebates under the port´s price list, but no more) as follows ESI score 20.0 up to 30.0 = 2.5% discount ESI score 30.1 up to 50.0 = 5% discount ESI score > 50.1 = 10% discount A maximum of 10 ships' calls per owner/operator can be accepted.
Authority in charge of the scheme	
Incentives for terminal operators or other stakeholders	
Port certified with	ISO 140001 certification

Ports of Zeebrugge

*Data not yet validated by the port

Country	Belgium
Geographic setting	Coastal port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	
Owner of the land	
Terminals operated by	Private company
Port specialisation	Containers: 2 < 3 mln TEU/ year RoRo: 5 < 15 mln tonnes/ year
Environmental charging scheme based on	Environmental Ship Index
Scheme description	Discount of 10% on port dues applied to ships with an ESI score of at least 30 points. In any case, the discount cannot exceed EUR 750 per call.
Authority in charge of the scheme	
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	The port attempts to be a clean port. Wind farms and shore power are present in the port. Currently, the management of the port is looking into the CO_2 footprint of the port (and how to decrease it). The most important stakeholders of the port are its employees, the inhabitants of surrounding areas, shareholders, governmental institutions, interest groups, environmental pressure groups, educational institutions, other Flemish ports and the tourism industry. The port attempts to have a continuous dialogue with these stakeholders. The project "Leefbare Haven Zeebrugge" municipalities of Bruges and Knokke- Heist, the European Union, the Vlaamse Landmaatschappijh and the province of West-Flandres, the port authority aims to improve the environmental quality for residents, workers and tourists.
Port certified with	

Ports of Zeeland

*Data not yet validated by the port

Country	Netherlands
Geographic setting	Estuary port
Geographic location	Hamburg-Le Havre port range
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	Liquid bulk: 5 < 15 mln tonnes/ year Dry bulk: 5 < 15 mln tonnes/ year Other cargo: 5 < 15 mln tonnes/ year
Environmental charging scheme based on	Green Award
Scheme description	Discount of 6% on port dues applied to Crude oil/Product Tankers and LNG carriers that hold a valid Green Award certificate.
Environmental charging scheme based on	Environmental Ship Index
Scheme description	Vessels which score 25 points or more on the ESI will receive a discount on their port dues. To calculate the exact percentage of the discount, the following formula must be used: Discount (in %) = (score*score)/1000
Authority in charge of the scheme	
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	
Port certified with	

Port of Bergen

*Data not yet validated by the port

Country	Norway
Geographic setting	Coastal port
Geographic location	North Sea
Ownership/governance	
Owner of the land	
Terminals operated by	
Port specialisation	
Environmental charging scheme based on	No index / certification
Scheme description	Discount of 5% on port dues applied to ships using LNG as fuel.
Authority in charge of the scheme	
Incentives for short-sea shipping	
Incentives for terminal operators or other stakeholders	
Port certified with	

Port of Long Beach

*Data not yet validated by the port

Country	United States
Geographic setting	Coastal port
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	Container: >5 mln TEUs / year
Environmental charging scheme based on	No index / certification
Scheme description	The Green Ship Incentive Program is a voluntary clean-air initiative targeting the reduction of smog-causing nitrogen oxides (NO_x). It rewards qualifying vessel operators for deploying today's greenest ships to the Port of Long Beach and accelerating the use of tomorrow's greenest ships Participants must register to receive incentives, but they are not required to submit reports, because eligibility and payments are determined based on data the Port already receives. Vessels with main engines meeting 2011 Tier 2 standards established by IMO will be eligible for an incentive of $2.500 per ship call. For still cleaner vessels meeting 2016 Tier 3 standards, the incentive will increase to $6.000 per ship call. Tier 2 engines reduce NO_x emissions by 15 percent, and with Tier 3 engines, emissions will drop dramatically by 80 percent. By 2023, to meet Clean Air Action Plan (CAAP) goals, the Port aims to have 50 percent of all its ship calls be from Tier 2 vessels and 40 percent from Tier 3, which will reduce NO_x emissions from ships by 2,700 tons a year. The Green Flag Incentive Program began in January 2006 aiming at reducing air pollution to the Port of Long Beach, by providing financial incentives to the ships that voluntarily reduce navigation speed within 40 nautical miles of the harbor. The core philosophy of the initiative is that by reducing ships' speeds the ships use less fuel, which in turn prevents more than 1,000 tons of air pollutants and 45,000 tons of greenhouse gases from being emitted each year. Since this is a voluntary scheme, its effectiveness highly depends upon shipping industry's cooperation The initiative includes dockage rates discounts for vessel operators who reduce their speed during arriving or departing from the port. Specifically, vessel operators who agree to slow down to 12 knots or less within 20 or 40 miles from harbor's entrance are eligible for receiving the discount for calls made in the following calendar year. Participants that achieve at least 90% compliance in a year can earn the: •"Green Plus Rate" meaning a 25% discount to dockage rate if slow steam from 40nm or •"Standard "Green Flag Rate" meaning 15% discount if reduce ship's speed from 20 nm. Based on port's inventory, the implementation of the initiative resulted to a reduction of 50% for nitrogen oxides, 80% for sulfur oxides and 23% of greenhouse gases since 2005. In 2013, 98% of vessels reduced their speeds within 20 nautical miles and 89% within 40 nautical miles. During this year, the Port awarded $2.8 million in dockage savings to the vessels that met the 90% compliance with the requirements in 2012. Vessel Dockage Waiver Program In conjunction with the Port's Green Flag Program and the state's "At-Berth Regulation," the Vessel Dockage Waiver Program rewards complying vessel operators with "free parking." From July 2014 through June 2016, the Port will waive its dockage fees for vessels that both slow down 40 miles out from the harbor and plug into shore power, or use an equivalent emissions-reduction technology, at berth.

	To be eligible, vessels must be subject to the California Air Resources Board shore power rules as defined in CARB's web page at www.arb.ca.gov/ports/shorepower/shorepower.htm. Vessel operators must submit to the Port of Long Beach, on a quarterly basis, the "Visit Information" form as described in CARB's web page at www.arb.ca.gov/ports/shorepower/forms/forms.htm#raf as evidence of compliance with the CARB shore power requirements. Vessel operators must comply with the Green Flag Vessel Speed Reduction Program at the 40-nautical-mile range transiting in and out of the Port of Long Beach.
Authority in charge of the scheme	Port managing body. Approval from another level of government or an independent regulator is needed
Incentives for short-sea shipping	-
Incentives for terminal operators or other stakeholders	Greenhouse Gas Emission Reduction Mitigation Grant Program Project Type: Facility improvements and electric fleets Eligible Source Categories: Terminal facilities This program funds facility and fleet improvements that reduce or avoid greenhouse gas emissions. Eligible projects include energy-efficiency improvements, renewable energy, electric fleet vehicles, and landscaping projects.
Port certified with	Leadership in Energy and Environmental Design (LEED)

Port of Los Angeles

*Data not yet validated by the port

Country	United States
Geographic setting	Coastal port
Ownership/governance	Municipality
Owner of the land	Municipality
Terminals operated by	Private company
Port specialisation	Container: >5 mln TEUs / year Liquid bulk: 5 < 15 mln tonnes/ year Dry bulk: < 5 mln tonnes/ year
Environmental charging scheme based on	Environmental Ship Index
Scheme description	A Vessel Operator may apply for three different types of incentive grants (described under subsections a, b and c immediately below) for enrolled ocean going vessels (OGV) making Vessel Visits at the Port of Los Angeles: a. **ESI Score** Each ocean-going vessel that has the following ESI Scores is eligible for an incentive grant per Vessel Visit as follows: 1.ESI Score of 25-29 points is eligible for $250 per Vessel Visit; or 2.ESI Score of 30-34 points is eligible for $750 per Vessel Visit; or 3.ESI Score of 35-39 points is eligible for $1,000 per Vessel Visit; or 4.ESI Score of 40 points or more is eligible for $1,250 per Vessel Visit. b. **OGV5 -IMO Tier II or Tier III Standards** Each OGV that has a verified IMO Tier II or Tier III Main Engine is eligible for an incentive grant as follows: 1.Each vessel with a Main Engine that meets IMO Tier II standard for NO_x is eligible for an incentive grant of $750 per Vessel Visit; or 2.Each OGV with a Main Engine that meets IMO Tier III standard for NO_x is eligible for an incentive grant of $3,250 per Vessel Visit. **c. OGV6 – TAP Demonstration** The ESI Incentive program would provide an incentive for vessels that are demonstrating an emission technology reducing NO_x and/or Diesel Particulate Matter under the San Pedro Bay Ports Technology Advancement Program (TAP) (CAAP OGV6 Measure), under the terms and conditions of a TAP technology demonstration agreement approved by the Los Angeles Board of Harbor Commissioners. Vessel Operators may participate in any or all of the three types of incentive grants in combination for any Vessel Visit. The Port will rely on the ESI Scores issued by the ESI Administrator, and may adjust the incentives in the event of any adjustment to ESI Scores. The Port reserves the right in its sole discretion at any time to close the ESI Incentive Program to new applicants. Vessel Operators interested in participating in any of the three incentives under this ESI Incentive Program must be a registered participant in the IAPH/WPCI ESI program, and should request an ESI Score for their Ocean Going Vessels by registering on the IAPH/WPCI ESI website. To be eligible to receive ESI Incentive Program grants, Vessel Operators must enroll with the Port by submitting an enrollment application to the Executive Director.

Environmental charging scheme based on	No index / certification
Scheme description	Voluntary VSR Dockage Grant Application Criteria and Disbursement (1) Tier 1 incentive (20nm): Any Vessel Operator demonstrating that 90% or more of all of its Vessel Trips at a Weighted Average Speed of 12 knots or less in a zone that extends 20 nm from Point Fermin during any calendar year, commencing with calendar year 2008, is eligible to receive a Voluntary VSR Program Dockage Grant upon written notice from the Executive Director or his/her designee of the Port that the Vessel Operator has qualified to receive this grant. The annual grant will be equivalent to 15% of the first day of dockage per Vessel Visit as published in Tariff No. 4, Section 4, Dockage, for all of the Vessel Operator's vessels that berth at the Port during a calendar year. (2) Tier 2 incentive (40nm): Any Vessel Operator demonstrating that 90% or more of all of its Vessel Trips at a Weighted Average Speed of 12 knots or lessin a zone that extends 40 nm from Point Fermin during any calendar year, commencing with calendar year 2010, is eligible to receive a Voluntary VSR Program Dockage Grant upon written notice from the Executive Director or his/her designee of the Port that the Vessel Operator has qualified to receive this grant. The annual grant will be equivalent to 30% of the first day of dockage per Vessel Visit as published in Tariff No. 4, Section 4, Dockage, for all of the Vessel Operator's vessels that berth at the Port during a calendar year The annual grant will be paid out upon receipt of an invoice from the Vessel Operator in the subsequent year. A Vessel Operator shall be eligible to receive a grant to offset the fuel cost differential between Low Sulfur Marine Fuel and Heavy Fuel Oil for a Vessel Trip if the Vessel Operator (i) produces evidence satisfactory to the Executive Director that it utilised Low Sulfur Marine Fuel in Main Engines for that Vessel Trip and in Auxiliary Engines at all times while at berth immediately before or after that Vessel Trip, and (ii) is in compliance with the Item 2045 of Tariff No. 4, the Voluntary Vessel Speed Reduction Program, for that Vessel Trip.
Authority in charge of the scheme	Port managing body. Approval from another level of government or an independent regulator is needed
Incentives for short-sea shipping	-
Incentives for terminal operators or other stakeholders	-
Port certified with	ISO 140001 certification

Port of Metro Vancouver

*Data not yet validated by the port

Country	Canada
Geographic setting	River/Seagoing Canal port
Ownership/governance	Mixed position
Owner of the land	Port authority
Terminals operated by	Private company
Port specialisation	Container: 2>3 mln TEUs / year Liquid bulk: 5 < 15 mln tonnes/ year Dry bulk: 50 < 100 mln tonnes/ year Passengers (cruise): < 1 mln/ year
Environmental charging scheme based on	Green Award Environmental Ship Index Clean Shipping Index Rightship Energy Efficiency Design Index Other
Scheme description	The EcoAction Program focuses on emissions from auxiliary engines used by vessels while at anchor and at berth when calling at Port Metro Vancouver. A variety of fuel quality, technology options and environmental management practices are eligible to receive discounted harbour due rates. Vessels may qualify for one of three award levels GOLD, SILVER or BRONZE, provided that they meet any one of the environmental criteria corresponding to that rate. The EcoAction Program promotes emission reduction measures that exceed the current North American Emission Control Area (NA-ECA) requirements adopted under the International Maritime Organisation, while vessels operate within Port Metro Vancouver's jurisdiction. Port Metro Vancouver harbour due rates per gross registered tonne (GRT) in Canadian funds, are as follows: BASIC $0.094/GRT GOLD $0.050/GRT (i.e. 46,8% reduction) SILVER $0.061/GRT (i.e. 35.1% reduction) BRONZE $0.072/GRT (i.e. 23,4% reduction) The criteria to qualify to one of the three award level are as follows (meeting any of them makes the vessel eligible to the corresponding award level): 1) Using cleaner fuels - Bunker fuel with a sulphur content ≤ 0,1% will determine a gold level, while a bunker fuel with a sulphur content ≤ 0,5% will determine a silver level - Natural gas will determine a gold level - CombustALL as a fuel additive will determine a bronze level - Biodiesel blend and fuel/water emulsion will determine an award level based on actual performance of emission reduction measure evaluated by the port of Vancouver 2) Adhering to an environmental programme - Environmental Ship Index will determine a silver level with a score ≥ 31, and a bronze level with a score from 20 to 30 - Green Marine will determine a gold level with a 'Level 5 SO_x' and 'Level 2 General', a silver level with only a 'Level 5 SO_x', and a bronze level with only a 'Level 2 general' - RightShip will determine a silver level with an 'Environment 3+ AND EVDI A,B,C', and a bronze level with 'Environment 3+ OR EVDI A,B,C'

	- Clean Shipping Index will determine a silver level with a 'Score of Green', and a bronze level with a 'Score of Yellow - A Green Award certificate will determine a bronze level - An Energy Efficiency Design Index 'better than required' will determine a bronze level 3) Adopting specific vessel and engine technologies - Ship side infrastructure for shore power will determine a gold level - Vapour Control/Recovery certified for tankers will determine a bronze level - Seawater scrubber, Selective catalytic reduction, Exhaust gas recirculation, Direct water injection, and Combustion Air Humidication will determine an award level based on actual performance of emission, evaluated by the port of Vancouver 4) Obtaining a certification by ship classification societies - an EP Designation by the Lloyd's register will determine a bronze level - an ES Designation by the American Bureau of Shipping will determine a bronze level - a CLEANSHIP Designation by Bureau Veritas will determine a bronze level - an EA Designation by Nippon Kaija Kyokai will determine a bronze level - a GREEN STAR Designation by Registro Italiano Navale will determine a bronze level - a CLEAN DESIGN Designation by Det Norske Veritas will determine a bronze level
Authority in charge of the scheme	Port managing body. There is autonomy in tariff setting.
Incentives for short-sea shipping	-
Incentives for terminal operators or other stakeholders	-
Port certified with	Port Metro Vancouver has established an in house Environmental Assessment Procedure to review all project proposals involving physical works in the Port’s jurisdictio

Port of Singapore

*Data not yet validated by the port

Country	Singapore
Geographic setting	Coastal Port
Ownership/governance	Mixed position
Owner of the land	
Terminals operated by	Private company
Port specialisation	Container: > 5 mln TEUs / year Liquid bulk: > 100 mln tonnes/ year Dry bulk: > 100 mln tonnes/ year Other cargo: > 100 mln/ year
Environmental charging scheme based on	Green Award
Scheme description	The Port of Singapore implements the Green Award initiative and provides a 5% reduction in tonnage dues for all Green Award certified vessels entering BGTW (British Gibraltar Territorial Waters) and calling at the Gibraltar Port.
Environmental charging scheme based on	Energy Efficiency Design Index
Scheme description	The Green Ship Programme focuses on Singapore-flagged ships and aims at improving the environmental performance of the ships by reducing carbon dioxide and sulphur oxides (SOx) emissions. In this context, the ships that exceeds IMO's requirements in relation to Energy Efficiency Index (EEDI) and scrubber technology can receive a reduction of the Initial Registration Fees and a rebate on Annual Tonnage Tax. Specifically, the initiative envisages that ships that adopt: - Energy efficient ship designs exceeding IMO's EEDI will enjoy 50% reduction of Initial Registration Fees and 20% rebate on Annual Tonnage Tax. - Approved SO_x scrubber technology exceeding IMO's emission requirements will enjoy 25% reduction of Initial Registration Fees and 20% rebate on Annual Tonnage Tax. - Ships that adopt both energy efficient ship designs and approved SO_x scrubber technology exceeding IMO's requirements will enjoy 75% reduction of Initial Registration Fees and 50% rebate on Annual Tonnage Tax.
Environmental charging scheme based on	No index / certification
Scheme description	The Green Port Programme addresses only to deep-sea vessels calling at the Port of Singapore aiming at reducing ship-based emissions. Eligible are the vessels that use approved abatement/scrubber technology or burn clean fuels (sulphur content of less than 1.00% m/m). Specifically, the Initiative provide 25% discount in port fees during ship's port stay within the Singapore Port Limits or 15% while the ship is at berth. The Green Technology Programme aims at providing local maritime companies financial incentives for the development and adoption of environmental friendly technologies. Companies can apply for grants of up to 50% of qualifying costs to co-fund the development of green technologies. Each project can receive up to $2 million, or $3 million in case the development of a certain technology can bring more than 10% reduction of air emissions. The program is addressed only to Singapore registered companies which are active in the maritime sector such as terminal operations, ship operations and harbour craft operations. Additionally, whenever a ship is involved in a project the condition of flying the Singapore flag and ship's remaining is over a specific period of time is required.
Authority in charge of the scheme	Port managing body. There is autonomy in tariff setting.
Incentives for short-sea shipping	-
Incentives for terminal operators or other stakeholders	-
Port certified with	ECO Office Green Label Certification issued by Singapore Environment Council

Annex III
SWOT Analysis

The SWOT analysis is a very useful tool at the start of strategy formulation process[134]. It gives an overview of both internal and external elements, positive and negative, influencing a given policy of a strategy issue, or the organisation as a whole.

The SWOT should be a multi-disciplinary, multi-stakeholder based exercise, with various iterations so that all internal and external stakeholders agree on a common base and principles before they engage in further activity (i.e. formulating and evaluating alternative strategies).

SWOT analysis should be presented on one page (maximum A3 landscape) as its added value is to be found in the synopsis of both internal/external and positive/negative elements; strategy or policy responses are mostly based on combining elements from a SWOT table, e.g.:

- Use internal strengths to capture opportunities or defend against external threats;
- Mitigate internal weaknesses to fend off external threats;
- SWOT elements should be formulated concisely, to-the-point, but at the same time with enough explanatory value.

In this study, the SWOT analysis was used mainly as (i) an inspiration to formulate scenarios, (ii) create alignment between stakeholders, (iii) confront the long list of schemes as a pre-evaluation to the SWOT analysis.

One of the main elements as a starting point in the SWOT analysis is the definition of the focal organisation from whose viewpoint the analysis is carried out. Since this study focuses on port managing bodies in the context of green port infrastructure charging, we chose these as the focal organisation for the SWOT analysis. More specifically, the starting point of the SWOT analysis is the question: "what are the SWOT elements for the port managing body related to the decision whether or not to adopt environmentally differentiated port dues, regardless of the scheme considered?".

The SWOT analysis on green infrastructure charges was carried out by the Consortium in charge of the study. As part of the research path, the SWOT was integrated with feedback from stakeholders, gathered during a panel discussion that took place in April 2015.

The SWOT feeds into the second phase of the Study, where it was used as one of the criteria to assess the schemes surveyed in order to identify which of them (i) build most on strengths, (ii) reconvert weaknesses into strengths, (iii) best capture the opportunities, and (iv) mitigate the threats. Together with other considerations detailed in the next section, the results of the SWOT analysis were used to select the case study ports for the assessment phase.

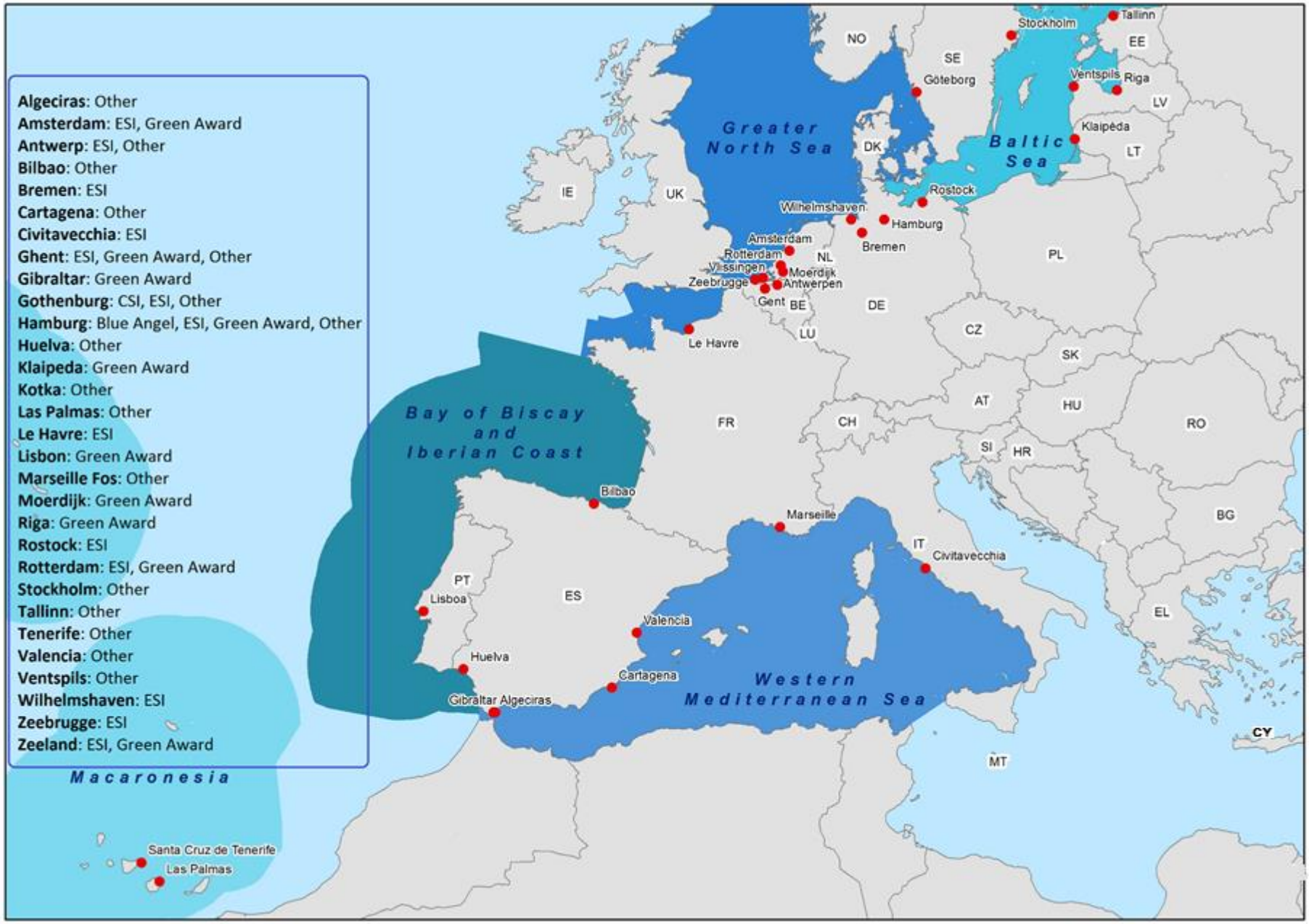
[134] For references on the use and misuse of SWOT analysis, see Hill and Westbrook (1997) and Pickton and Wright (1998).

Strengths	Weaknesses
• A large number of European port authorities explicitly identifies environmental objectives in their mission and vision statement; • Contribution to a sustainable port image (from a commercial and marketing point of view); • Contribution to the 'social license to operate' (from a broader stakeholder point of view, e.g. local, regional and national government), through the explicit contribution to regional and national policy objectives with regard to environmental policy (e.g. emission reductions / climate change); • Reduction of negative environmental externalities linked to shipping inside the port area; • Reduction of negative environmental externalities linked to shipping outside the port area (at regional level or beyond the city); • Contribution to reaching emission reduction objectives in the port area and/or port city area (for instance compliance with air quality targets); • Increase of environmental awareness inside the port managing body in a cross-functional way (finance, marketing, environmental departments are all involved – in principle). • Relatively strong bargaining position of some port managing bodies towards shipping lines (in specific markets / on specific routes);	• Existence of different approaches, systems and data sources (e.g. ESI, others) to develop a charging scheme based on ship environmental performance – as a result it is currently unclear for port managing bodies which schemes are most appropriate under which circumstances; • Setting up a good system requires a lot of slack resources in the organisation of the port managing body to follow-up the results (most port managing bodies might lack the staff, system, or competences) e.g. a lot of port managing bodies experience challenges in measuring environmental impacts; • Tariff rebalancing might be needed if port managing bodies want to alter behaviour or avoid financial / operational or market risk (port dues are a very important revenue source for cost recovery and investment in infrastructure); • Port dues are often not the decisive factor for port choice from the point of view of shippers / shipping lines (but to managing bodies they do matter); • Increase of administrative complexity and/or lack of transparency of tariff formulas towards customers, given already existing rebate structures; • High investment costs or stakeholder complexity to provide the auxiliary elements (e.g. cold irony or LNG fuel infrastructure) linked to environmentally differentiated charging schemes; • Increase of complexity to communicate and implement the policy for the port managing body towards economic stakeholders e.g. existence of parallel systems (e.g. Annual Awards/Certificates for Users and Charging Schemes existing next to each other); • Difficulty to communicate pricing policies and results to non-economic stakeholders, such as local communities / public in general.

Opportunities	Threats
• Development of new services and products linked to environmental performance, thereby increasing port competitiveness (and revenue-generating potential, outside of the actual charging scheme which should be behaviour altering oriented and not revenue generating); • Large shippers (or other societal pressure groups) imposing shipping lines and port managing bodies to be at the frontier of environmental pro-activeness; • Foster partnerships and dialogue between stakeholders (operators, managing bodies, shipping lines, local communities) to develop further research and development to limit environmental externalities; • Fundamental rethinking of port pricing / port business models (given need to rebalance tariff formulas); • Structural embedding of existing EU/North-America led initiatives such as the Environmental Ship Index initiative; • Enlarge the approach taken for ship dues to concession fees, i.e. use the knowledge and positive experiences with green ship dues to implement other charge-based initiatives; • Complement and possibly reduce the need or intensity of regulatory initiatives at IMO or EU level to reduce pollution and/or carbon emissions from shipping. • Raise the environmental profile of short sea shipping as an alternative to congested land transport corridors (contribute to the development of Motorways of the Sea)	• Strong diversity in ports (and ship portfolios) => not all port managing bodies would be willing to adopt the instrument; • Lack of autonomy in tariff setting preventing both the development of such schemes and/or changes / learning from results; • Neighbouring non-EU ports (e.g. Russia, Morocco, Turkey) not implementing these schemes leading to competitive disadvantage for EU ports from a cost perspective (and resulting non-willingness to implement in ports subject to competition from outside EU); • Unintended traffic shifts between EU ports (leading to macro-inefficiencies) for traffics subject to high price elasticity; • No universally accepted system to determine the environmental profile of ships, including costs of permanent auditing / inspection; • Increase of transport costs of the European industry / economy (if badly implemented) and/or loss of connectivity; • Relatively weak bargaining position of port managing bodies towards shipping lines (in specific markets); • Port managing bodies do not control the evolution of the shipping fleet; general economic factors influencing integration of more environmentally friendly ships.

Annex IV

Map of EU ports that differentiate charges based on environmental criteria


Algeciras: Other
Amsterdam: ESI, Green Award
Antwerp: ESI, Other
Bilbao: Other
Bremen: ESI
Cartagena: Other
Civitavecchia: ESI
Ghent: ESI, Green Award, Other
Gibraltar: Green Award
Gothenburg: CSI, ESI, Other
Hamburg: Blue Angel, ESI, Green Award, Other
Huelva: Other
Klaipeda: Green Award
Kotka: Other
Las Palmas: Other
Le Havre: ESI
Lisbon: Green Award
Marseille Fos: Other
Moerdijk: Green Award
Riga: Green Award
Rostock: ESI
Rotterdam: ESI, Green Award
Stockholm: Other
Tallinn: Other
Tenerife: Other
Valencia: Other
Ventspils: Other
Wilhelmshaven: ESI
Zeebrugge: ESI
Zeeland: ESI, Green Award
Greater North Sea
Baltic Sea
Bay of Biscay and Iberian Coast
Western Mediterranean Sea
Macaronesia
NO
SE
DK
EE
LV
LT
IE
UK
NL
BE
DE
PL
CZ
SK
AT
HU
RO
FR
CH
SI
HR
BG
PT
ES
IT
EL
MT
CY
Stockholm
Tallinn
Göteborg
Ventspils
Riga
Klaipeda
Rostock
Wilhelmshaven
Hamburg
Bremen
Amsterdam
Rotterdam
Vlissingen
Moerdijk
Zeebrugge
Antwerpen
Gent
Le Havre
Bilbao
Marseille
Civitavecchia
Lisboa
Valencia
Huelva
Cartagena
Gibraltar Algeciras
Santa Cruz de Tenerife
Las Palmas

Annex V

Existing certifications and indexes used for environmental charging

It is acknowledged throughout the sector that port initiatives on differentiated port infrastructure charges may influence the environmental performance of shipping to mutual advantage of the sector, industry and society at large. The motives and mechanisms, rates of up-take and actual implementation are far from being harmonised or evenly distributed. There is no doubt that a growing number of port authorities are factoring-in the environmental performance of shipping into their fee structure signaling benefits in terms of environmental quality, costs and enhanced public relations. However, another, interwoven consideration is the part played by voluntary initiatives related to environmental ship class notations applied to vessels that comply with requirements for environmentally safe design, construction and operation. The recognition of 'Green Shipping' is a fundamental component of potential fee structures.

The recognition of Green Shipping as a qualifying criterion is of fundamental significance to this study because it offers another research pathway for assessing the actual impact and costs, of such standards through their associated certificates and award systems. Port authority policies on differentiated fees will have no beneficial effect on sustainability or environmental quality unless implemented. Similarly, voluntary certification of shipping through independent Foundations will have no impact unless applied and subsequently recognised.

As assessment of the uptake and recognition of the various ship certification schemes provides another mechanism for assessing the benefits and costs of differentiated port infrastructure charges through

i) Identifying the aspects managed or controlled;

ii) Providing an indication of the up-take and distribution of ports that recognise the qualification;

iii) Allowing a broad assessment of the environmental benefits that may accrue;

iv) Offer an indication of costs and benefits.

The Environmental Ship Index (ESI)

www.environmentalshipindex.org

The ESI identifies seagoing ships that perform better in reducing air emissions than required by the current emission standards of the International Maritime Organisation, the Environmental Ship Index. The ESI evaluates the amount of nitrogen oxide (NO_X), sulphur oxide (SO_X) that is released by a ship and includes a reporting scheme on the greenhouse gas emission of the ship. The ESI is a good indication of the environmental performance of ocean going vessels and will assist in identifying cleaner ships in a general way.

The index is intended to be used by ports to reward ships when they participate in the ESI and will promote clean ships, but can also be used by shippers and ship owners as their own promotional instrument. It should be noted that while the ESI will provide a total score, the rewards can either be based on that total or on each of its constituent parts separately. The programme is completely voluntary and the World Ports Climate Initiative (WPCI) hopes that the global port community will assume its role in improving the maritime and port environment.

With regard to the further development of the ESI, the following should be noted. The ESI is a flexible instrument that may be adapted having due regard of the principles underlying IMO's approach of the regulatory framework for the protection of the marine environment and also taking into account the priorities of ports in general with regard to the environmental performance of ships that ports wish to promote. This may mean that the weighing of the scores between the different constituents of the formula might change and that the evaluation of the performance can be adjusted to be more in line with experiences gained and technological developments. Additionally, new constituents may be added and

existing ones deleted; discussions with stakeholders that have an interest in ESI, form part of this process. Deletions will be made if a measure has proven to be effective and the behavioural change has become widespread. However, to maintain the score predictability and the program stability, changes will be few and never take place more than once a year.

The overall ESI formula is built up of different parts for NO_X, SO_X and CO_2; additionally, a bonus is awarded for the presence of an OPS. The ESI Score ranges from 0 for a ship that meets the environmental performance regulations in force to 100 for a ship that emits no SO_x and no NO_x and reports or monitors its energy efficiency; in other words, a ship with a score of 0 points is actually in full conformity with the applicable requirements, and the ship with 100 points has zero air emissions. Actually, apart from certain LNG carriers, the best performing ships, have scores that hover around 60 points; LNG carriers using boil-off gases as fuel top the list with around 80 points.

Ships have to comply with MARPOL 73/78 Annex VI. This Annex specifically sets limits on fuel sulphur content limits which reduce emissions of SO_X and sets engine standards for NO_X emissions from ships exhausts and prohibits deliberate emissions.

The ESI, established in 2011, is an international program developed through the WPCI of the International Association of Ports and Harbors (IAPH). IAPH/WPCI seeks international collaboration among ports and shipping lines to further reduce air emissions, greenhouse gasses and promote sustainability.

Through ESI, ports and other interested parties promote ships to use cleaner engines and fuels and receive preferential treatment by allowing discounts on port dues, granting bonuses and other benefits commensurate with the level of cleanliness.

In the ESI Program four main groups of emissions are distinguished as follows:

- NO_X emissions mainly dependent on the engine properties;
- SO_X emissions mainly dependent on the fuel's sulphur content;
- PM (particulate matter) emissions related to SOX emissions;
- CO_2 emissions mainly dependent on the amount of fuel used.

NO_X, SO_X and PM have a direct effect on air quality in a port area and they are the main constituents of the formula for calculating the ESI Score (see below). It has been demonstrated that the "damage potential" of both SO_X and NO_X with respect to negative effects on human health (pulmonary diseases, etc.) and the environment (acidification, etc.) are about equal; however, in combustion processes a double amount of NO_X units is produced. This is reflected in the formula by doubling the result of any reduction of the average NOX emissions. CO_2 emission reduction - as a consequence of increased fuel efficiency - results in positive changes in the global air quality (climate issues); its effects are not immediately reflected in the conditions in a port area. The willingness of ship owners to engage in measures to improve fuel efficiency in ships, is considered to be a direct sign of their positive attitude towards taking measures for the environment in general and increasingly this aspect is taken into account in the ESI Score - although now for a small part only. CO_2 emission reductions will focus on increasing ship fuel efficiency resulting in reduced consumption and generally less pollution on a per mile basis (http://esi.wpci.nl/Content/Documents/ESI-Fundamentals.pdf).

The list of Participating ports in the ESI certification scheme was studied using the source http://www.environmentalshipindex.org/Public/PortIPs and the incentives were identified in terms of ESI qualifying index score, discount applied, overall incentives and support observations.

Summary of ESI components factored-into differentiated port infrastructure charges

Environmental Ship Index

The minimum score to have a discount is 20 points (except 1 port that gives discount with a score of less than 20)

12 ports (out of 25) provide discounts from a minimum ESI score of 20 points or more

2 ports (out of 25) provide discounts from a minimum ESI score of 25 points or more

9 ports (out of 25) provide discounts from a minimum ESI score of 30 points or more

Only 1 port provides discounts from a minimum ESI score of 50 points or more

Ports from USA provide a discount in dollars (not in a percentage as the rest of ports)

Average percentage discount of all ESI is 20% aprox of the port fees

Average percentage discount of 20 points in the ESI score is 10% of the port fees

Average percentage discount of 30 points in the ESI score is 14% of the port fees

Average percentage discount of 40-50 points in the ESI score is 37% of the port fees

The formulae for EPI are stated at: http://www.environmentalshipindex.org/Public/Home/ESIFormulas

The index calculation methodology is based on MARPOL Annex VI Indicators and tools.

The following table summarises the ESI incentives as recognised by participating ports:

Environmental Ship Index (ESI)				
Name of the port	**Country**	**Environmental Ship Index (ESI) Score**	**Discount**	**Observations**
Port of Amsterdam	Netherlands	20 points or more	Not mentioned	An extra reward up from 31 points.
Port of Antwerp	Belgium	31 points or more	10%	The discount is given on a quarterly basis, with retroactive effect. The discount is calculated on the net invoiced tonnage dues (including all discounts). In order to get a discount, a ship must be registered and be published on the public part of the ESI-website
Port of Rotterdam	Netherlands	31 points or more.	10%	A maximum of 20 calls per single ship per quarter. The discount will be doubled if the ship also has an individual ESI-NOx score of 31.0 or more
Port of Oslo	Norway	From 25 to 50 points	20%	
		50 points or more	40%	
Port of Hamburg	Germany	20 points or more	10%	Ships that are exclusively powered by LNG (ESI-SOx score > 99) are entitled to a 15% discount on the GT portion of the port fees
Ports of Bremen/Bremerhaven	Germany	From 30 to 40	5%	Only the best 25 seagoing vessels will receive a discount
		41 or more	10%	
Port of Wilhelmshaven	Germany	31 or more	5%	no more than EUR 750.
Port of Kiel	Germany	30 or more	10%	
Port of Zeebrugge	Belgium	30 or more	10%	with a limit of 750 euro per call.
Port of Le Havre	France	31 or more	up to 10 % max	Applicable to the 10 cleanest container or Ro-Ro shipping lines
Port of Brunsbüttel	Germany	From 20 to 30	5%	750 € max for the 5% and 1000€ max for the 10% discount. Applicable to the 10 ship entries with the best ESI-scores. In case of equal ESI-scores the chronological order of ship entries is relevant.
		31 or more	10%	
Port of Ashdod	Israel	31 or more	Not mentioned	Container and Ro-Ro vessels
Port of Los Angeles	United States	40 more	$1.250 per	

Environmental Ship Index (ESI)				
Name of the port	**Country**	**Environmental Ship Index (ESI) Score**	**Discount**	**Observations**
			call	
		35-39	$1.000 per call	
		30-34	$750 per call	
New York	United States	30 or more	$2.500	
		20-29	$1.500	
Port of Prince Rupert	Canada	From 20 to 30	10%	
		From 31 to 50	20%	
		50 or more	50%	
Port Metro Vancouver	Canada	40 or more	47% aprox	
		From 31 to 39	35% aprox	
		From 20 to 30	23% aprox.	
Port of Rostock	Germany	20 or more	up to 3%	The use of fuel containing less than 0.1% sulphur as well as the use of onshore power supply is regarded equivalent to an ESI value above 20.
Port of Sohar	Oman	20 or more	5%	
Port of Oldenburg	Germany	From 20 to 30	2,50%	Applicable to ten ship entries per shipping company
		From 30.1 to 50	5%	
		50.1 or more	10%	
Busan Port Authority	Korea (South)	31 or more	15%	
Atlantic Port La Rochelle	France	Less than 20	0% - 20	
		Less or equal to 30	10%	limited to 1.000 € excl.tax
		From 30 to 60	13%	limited to 1.200 € excl.tax -
		60 or more	15%	limited to 1.500 € excl.tax
Port of Ålesund	Norway	50 or more	50%	
Port of Göteborg	Sweden	30 or more	10%	

Environmental Ship Index (ESI)				
Name of the port	**Country**	**Environmental Ship Index (ESI) Score**	**Discount**	**Observations**
Port of Tokyo	Japan	From 20 to 29.9	30%	
		From 30 to 39.9	40%	
		More than 40	50%	
Port Nelson	New Zealand	From 20 to 30	5%	
		30 or more	10%	
Port of Stavanger	Norway	From 25 to 50	30%	
		50 or more	50%	

The Green Award

http://www.greenaward.org/

The Green Award Requirements address issues related to quality, safety, environment and technical areas related to the ship and the ship manager's office. The requirements also pay extra attention to crew elements. The most recent update of the Green Award requirements covers for example Monitoring of Ship Exhaust Emissions, MARPOL NO_x emission limits, ECDIS and Hot Work procedures.

Examples of requirements related to environment:

- Exhaust emissions
- Water ballast
- Anti-fouling
- Ship breaking
- Navigation in 'sensitive areas'
- Waste management

Composition

The Green award requirements consist of three parts:

1. Basic requirements (statutory elements related to ISM, MARPOL)
2. Ranking requirements (Weighted items, minimum % to be attained)
3. Visual inspection (seaworthiness, good housekeeping)

By rewarding high safety and environmental standards in shipping, Green Award claims to make above standard ship operation economically more attractive. The Green Award certification scheme is open to oil tankers, chemical tankers and dry bulk carriers from 20.000 DWT and upwards, LNG and container carriers and inland navigation vessels.

The Green Award procedure is carried out by the Bureau Green Award, the executive body of the independent non-profit Green Award Foundation. The certification procedure consists of an office audit and an audit of each individual ship applying for certification. Amongst many others, the assessment focuses on crew, operational, environmental and managerial elements.

At ports in Belgium, Canada, Latvia, Lithuania, the Netherlands, Oman, New Zealand, Portugal and South Africa, the Green Award vessels receive a considerable reduction on port dues. Private companies also appreciate the extra quality which Green Award guarantees. Several incentive providers, government institutions as well as private companies, grant benefits to a vessel with a Green Award certificate, which subject to annual verification, is valid for three years.

Benefits claimed for Green Award incentive providers include:

- Increase in number of quality ships
- Reduced Risk (safety and environment)
- Tool to address air quality issues
- Tool to address Corporate Social Responsibility policy
- Improvement of environmental awareness of administrators and port authorities

- Increase of efficiency in ship/shore interface
- Shorter visiting period of ship to port
- Enhancement of positive image

Green Award

- Average discount of 10% of the port fees (based on 38 ports)
- The discount is applicable basically to inland barges (13 ports) and to oil tankers (16 ports)
- The countries that have the strongest representation in the Green Award Scheme sample are Netherlands (11 ports), South Africa (8), Portugal (4), and Canada (4)

The Green award scheme is an independent foundation

A summary illustrating participating ports by country and including discounts and relevant observations follows:

Green Award			
Name of the port	**Country**	**Discount**	**Observations**
Ghent	Belgium	15%	Sea-going vessels for which a valid bulk Green Award certificate can be submitted
		20%	Sea-going vessels not used for ro/ro operations or recorded in Lloyd's Register of Shipping as "pallets carrier" for which a valid shortsea Green Award certificate can be submitted
		10%	inland navigation vessels
Metro Vancouver	Canada	23.40%	for oil tankers and bulk carriers.
Montreal	Canada	10%	
Sept-Iles	Canada	10%	only to all GA certified vessels from 01-01-2012
Prince Rupert	Canada	10%	
Hamburg	Germany	3%	For crude oil, product and chemical tankers and LNG carriers of any size that hold the Green Award certificate
Gibraltar	Gibraltar	5%	
Kitakyushu	Japan	10%	Green Award certified LNG carriers
Riga	Latvia	10%	for oil tankers
Klaipeda	Lithuania	20%	on waste reception facilities
Taranaki	New Zealand	5%	
Wellington	New Zealand	3%	For bulk carriers and oil tankers
Nelson	New Zealand	5%	for all tankers and bulk carriers certified by Green Award.
Sohar	Oman	5%	for tankers
Sines	Portugal	5%	for Crude oil/Product Tankers
Douro e Leixões	Portugal	3%	for Crude oil/Product Tankers
Lisboa	Portugal	5%	for Crude oil/Product Tankers
Setúbal	Portugal	3%	for Crude oil/Product Tankers

Green Award			
Name of the port	**Country**	**Discount**	**Observations**
Richards Bay, Durban, Ngqura, East London, Port Elisabeth, Mossel Bay, Cape Town, Saldanha	South Africa (8 ports)	10%	for Crude oil/Product Tankers
Groningen	Netherlands	5%	Inland barges
Bergen op Zoom	Netherlands	5%	Inland barges
Meppel	Netherlands	6%	Inland barges
Amsterdam	Netherlands	6%	for Crude oil/Product Tankers
		5%, 10%, 15%	for inland barges by level: Bronze, Silver, Gold
		10%	Inland barges with certificates issued before the 17th of June 2014
Dordrecht	Netherlands	6%	for Crude oil/Product Tankers
		15%	for inland barges
Rotterdam	Netherlands	6%	for Crude oil/Product Tankers and LNG carriers.
		15%	for inland barges
Utrecht	Netherlands	30%	Inland navigation vessels
Wanssum	Netherlands	10%	for inland barges
Zevenellen	Netherlands	10%	for inland barges
Moerdijk	Netherlands	6%	for Crude oil/Product Tankers
		15%	for inland barges
Zeeland Seaports	Netherlands	6%	for Crude oil/Product Tankers and LNG carriers.
		10%	inland barges from 1-01-2013

The Clean Shipping Index

http://www.cleanshippingindex.com/

The Clean Shipping Index (CSI) is a business to business tool for cargo owners to select clean ships and quality ship operators. Transport buyers use it to calculate and minimise their environmental footprint. Shipowners present the environmental profile of their fleet to a network of large customers who consider this in procurement situations. Shipowners also use it as a bench-marking tool in order to identify areas for environmental improvement. CSI is driven by a non-profit organisation.

The scoring in Clean Shipping Index is based on five areas and groups of environmental impacts which are all important to address, those are CO_2, SO_x & PM, NO_x, Water & Waste, and Chemicals. Each area of emission has a maximum score of 30 points each. The scoring system may be seen as a tool to estimate how well a vessel or an entire carrier is doing in each area and/or to obtain a picture of the overall performance. Our basis for scoring in CO_2 is how well a vessel performs compared to a reference ship. To get scores vessels must have emissions below this reference. It is also possible to view answers about ship recycling policies.

The final index score on the carrier level is the total average score multiplied with the percentage of reported ships of the totally owned or managed fleet. Whilst the final score on separate ship level is an average point based on each field of environmental impact. Furthermore, the ranking can be made and displayed for any of the parameters separately both on a ship and carrier level. Data can also be analysed in much more detail, down to the level of NO_x emissions for a single engine or stern tube oil usage on a single ship for example. A vessel or shipping company cannot perform well in only one area of the index (for instance sulphur emissions) and get a good overall performance. The index is dynamic; what is good environmental performance at one time might change as new technology gets accessible and/or the environmental legislation becomes stricter. As basic guidance, a Low, Medium or Good performance is given on both vessel and carrier level based on the scores.

CO_2

Information needed for carrying out the CO_2 calculations is the cargo carried, the distance travelled and the fuel consumption. Operational factors are accounted for by using estimates of average load- and payload factors. Two ways of submitting CO_2 data are accepted; either CO_2 emissions in grams/tonne-nm calculated according to IMO's Energy Efficiency Operational Indicator or calculated CO_2 emissions in grams/TEU-km according to the Clean Cargo Working Group calculation formula. Calculations cover a period of one calendar year.

NO_x

The basis for NO_x scoring is how the NO_x emissions from main/auxiliary engines relates to the standards set in the Revised MARPOL Annex VI. Only complying with global standards does not score. The reference emission levels are tied to the same levels as defined in the Tier I, II and III in the Annex VI. Pre- and post combustion reduction techniques are rewarded.

SOx and PM

Scores can be obtained if sulphur content in fuel during a calendar year is lower than global standards for both main and auxiliary engines. A distinction is made between operations in ECAs (emission control areas) and non ECAs. Particulate matter is included because of the close link between SO_x emissions and PM emissions. Use of abatement technologies is rewarded.

Chemicals

Scoring relies on the environmental effects of different types of chemicals used on board. Properties of chemicals present in antifouling, stern tube oils, external hydraulic fluids, gear oils for thrusters and/or controllable pitch propellers, boiler/cooling water treatment, cleaning agents and refrigerants are covered by the index. For example, non-toxic antifouling coatings i.e. coatings without chemical or biological activity and water lubricated stern tubes get high scores.

Water and Waste control

Questions in this section are about ballast water treatment, sewage/black water treatment, garbage handling, sludge oil handling, bilge water treatment and – last but not least – crew awareness. The basis for scoring on ballast water treatment is how international vessels are treating their ballast water for to hinder transport of invasive species. The basis for scoring regarding sewage is how sewage water is treated in PSSAs (Particularly Sensitive Sea Areas). The options are either an approved sewage treatment plant according to MEPC (20) – Certificate of Type Approval for Sewage Treatment Plant – and a control of its usage and function through a maintenance record. An alternative option is that no sewage discharge in PSSAs can be shown through operation manuals. Connected to waste collected on board, there should be no incinerator on board or documentation of no incineration of garbage. Additionally, there should be no waste overboard (food waste excluded) and separate garbage handling for reuse, recycling and disposal. When it comes to sludge, there should be no incinerator on board or documentation of no incineration of sludge oil. Additionally, there should be documented disposal of sludge oil to treatment facilities on shore. Bilge water mixtures are often complex and results in stable oil/water emulsions, hard to be broken in traditional gravimetric separators. Scoring is received only if active treatment equipment is installed on board. The basis for scoring regarding crew awareness is a documented education for all crew on board with special emphasis on engine room personnel and handling of heavy fuel oil.

N.B. information on port partners is not publicly available for the CSI. The organisation has been contacted by the Consortium to enquire whether they would share this type of information, but no reply has been received as of the time of writing.

Synoptic table of indexes/certifications

As emerged from the first phase of this study, the indexes and certification schemes described above are very popular in the port and shipping sector, and are increasingly used by port managing bodies when it comes to implementing an environmental charging scheme. These indexes / certifications are perceived as reliable and the level of uptake in the industry is high. This offers several advantages both to port authorities and ship owners. Port authorities can rely on a third party that assesses and certifies how green a ship is, thus reducing the workload that would result from introducing a new system from scratch. At the same time, ship owners may find it useful to apply for a certification and / or an index that is widely recognised across the EU (and worldwide), because in doing so they are more likely to cumulate rebates in several ports of call.

The table below summarises pros and cons of the most common indexes and certification systems that are currently used in environmental charging schemes. Despite the increasing success of these initiatives, it should be noted that none of them was specifically conceived for environmental charging. The pros and cons outlined in the table below simply draw on the feedback gained during the first and second phase of the study, and do not aim to suggest that certain initiatives are inherently better than others. As a matter of fact, the ESI, Green Award, and the CSI can serve a multitude of purposes, and the ultimate choice as to their effectiveness should remain up to users.

Table 100 – Pros and cons of indexes and certification systems used in environmental charging[135]

Index/Certification	Managing body	Pros	Cons	Uptake prospects	Fees
Environmental Ship Index (ESI)	International Association of Ports and Harbours (in the framework of the World Ports Climate Initiative)	- Extremely 'easy-to-use'. A score from 0 (perfect compliance with current standards) to 100 (no emissions whatsoever) is assigned to each of its constituents (NO_x, SO_x, CO_2, plus a bonus for Onshore Power Supply - OPS). - High uptake worldwide, most likely because it was developed in the framework of the IAPH.	Only focused on air quality and CO_2.	The ESI is by far the most used initiative in environmental charging in the EU, with an increasing number of ports and ship owners adopting it. This is a competitive advantage which suggests that the uptake may further increase in the future, because both ports and ship owners are more likely to choose an index if it recognised worldwide.	Ship owners pay no fees for participation. Incentive providers are expected to contribute in the costs for any changes, additions, renewals, improvements, of the website. No fees are due for audits and inspections, because the ESI relies on self-declaration and does not require any data to be verified or certified by external auditors; the data are randomly checked for inconsistencies and obvious mistakes
Green Award (GA)	The Green Award Foundation, a neutral, independent foundation, established 1994 on the initiative of the Rotterdam Municipal Port Management and the Dutch Ministry of Transport. Since 1 January 2000 Green Award has been completely independent.	- It is quite comprehensive, as its requirements address aspects related to safety, quality, environment and technical areas related to the ship and the ship's manager office. There are over 50 subjects and examples of requirements related to environment are 'exhaust emissions, water ballast, anti-fouling, ship breaking, navigation in 'sensitive areas', waste management). - High uptake worldwide. - It is recognised by users as delivering 'extra quality'.	- More complicated criteria and inspections (it is a certification and 'has to be' more complicated than the ESI and the Clean Shipping Index - CSI). - Only for oil tankers, chemical tankers, dry bulk carriers from 20.000 DWT up, and for LNG and container carriers and inland navigation vessels).	Green Award is the second most popular initiative used for environmental charging in the EU. It is also well established worldwide, which suggests that its uptake may increase further in the future. In addition, there is no competition with the ESI, in that GA is not limited to emissions, but covers a broader range of environmental aspects as well as safety aspects to ultimately protect the environment. GA and ESI actually cooperate as GA performs ESI data check on GA-certified ships and also gives extra points when a ship has higher ESI scores.	Ports do not pay any fee (fees are paid by ship owners / managers to cover: - Shipping office audit fee (every three years) - Application fee per ship (costs vary depending on ship type and tonnage from ca. € 4.000 to ca. € 8.000). - Annual fee per ship (costs vary depending on ship type and tonnage from ca. € 2.500 to ca. € 5.000) - Additional costs for every office audit and survey (mainly travel and subsistence expenses for auditors)

[135] This table has been compiled based on publicly available information from the following websites:
http://www.environmentalshipindex.org/Public/Home
http://www.greenaward.org/
https://www.cleanshippingindex.com/
https://www.blauer-engel.de/en

Index/Certification	Managing body	Pros	Cons	Uptake prospects	Fees
Clean Shipping Index (CSI)	The Clean Shipping Index is the core around which the organization is gathered. The users of the index are members of the non-profit association Clean Shipping Network which is composed both by cargo owning companies, from a variety of branches, and forwarders	A user-friendly score (similarly to the ESI) is assigned for CO_2, SO_x and PM, NO_x, water and waste, and chemicals.	- Not very popular among EU ports, and so 'less attractive', because ship owners cannot benefit from multiple rebates. - Details on uptake by port are not available online.	The CSI is relatively less popular as an initiative used for environmental charging, and its scope partly overlaps with the ESI (although the CSI also includes waste on board and sewage and ballast water). This makes it relatively less attractive when compared with the ESI; ports may be induced to prefer the ESI, because more ships can be eligible for a rebate.	A membership fee of € 2.700 per year is required. There is no reference online as to the cost of audits and inspections.
Blue Angel	Blue Angel is managed by 4 entities: - The Environmental Label Jury is an independent body composed of representatives from associations, unions, industry, trade, crafts, local authorities, science, media, churches and landers. - The Germany Ministry for the Environment Nature Conservation and Nuclear Safety is the owner of the label. - The Federal Environment Agency acts as office of the Environmental Label Jury and develops the technical criteria - RAL gGmbH is the label-awarding agency.	- Flexible criteria: 10 binding requirements plus 20 optional requirements - Management instruments as well as social conditions, operation and technology are covered - Emission of black and grey sewage waters, bilge waters, disposal of wastes on land are included in the Blue Angel awarding system	- Blue Angel is not as popular as the other initiatives surveyed, with only one EU port granting rebates to Blue Angel-certified. - Oil tankers and product carriers, chemical tankers, gas carriers, ships coming under the High Speed Craft Code, fishing vessels, recreational ships and navy ships are not included.	With just one EU port recognising it as a valid certification to be eligible for a rebate, the uptake prospects of Blue Angel in environmental charging are considerably low.	There is a one-off fee of 250 EUR (plus the statutory level of VAT) for processing the application for the use of the Blue Angel ecolabel. A yearly fee based on a graduated scale is also to be paid. The size of the fee is determined by the total yearly sales of all of the products or services awarded with the environmental label in accordance with the corresponding Basic Award Criteria. The yearly fees range from a minimum of 270 EUR to a maximum of 6.000 EUR.

Annex VI

Environmental charging and the cruise industry

It may also be interesting to look at a scenario that focuses on cruise shipping. As also mentioned during the 1st panel discussion with stakeholders, the cruise industry has very specific needs when it comes to environmental charging, which may be different from other shipping sectors. Indeed, a cruise ship that typically calls a certain number of ports (cruise itinerary) several times throughout the year would benefit from a more consistent approach to environmental charging, because that would make it possible to obtain reductions on port dues or waste collection fees in every port of call, based on a set of similar rules. This, in turn, would allow cumulating the rebates, while at the same time reducing the administrative and technical costs of becoming compliant with the scheme.

However, at present, environmental charging in the EU is far from being applied consistently throughout ports, with different ports applying different schemes, offering different rebates, and rewarding different environmental programmes (e.g. Environmental Ship Index, Green Award, etc.).

A scenario is thus developed to test whether and to what extent the cruise industry could benefit from a more consistent approach to environmental charging. The scenario envisages several ports adopting the same type of scheme, in such a way as to determine what would happen if a cruise ship were applied the same scheme in every port of call of her itinerary.

The scenario envisages a ship calling at 5 different ports across the Mediterranean and the Atlantic Ocean. The 'fictional' cruise ship is relatively large: it can board up to 3.800 passengers and has a total gross tonnage of 137.936 tonnes. Its volume amounts to 113.646 m^3. It was necessary to calculate the volume of the ship, because in France, contrary to the majority of EU ports, port dues are based on ship volume (expressed as the product of length, breadth and maximum summer draught).

The subsequent steps consisted of calculating the amount of taxes that our cruise ship would pay in each port[136]. A few assumptions had to be made:

- The cruise does not have a home port, nor does it have a destination port. All ports are considered as port of call. This was necessary because, different fees are applied in all ports considered, based on this aspect. So, the arbitrary choice of one port of home/destination over the others, would have determined different results in the calculation.
- Regardless of different nomenclatures, the tariffs and taxes considered were what are normally referred to as 'port dues', which 'cover ship, cargo (not in this case), berthing and/or passenger dues that are levied to ships calling at the port to cover the general use of the port. Land lease or similar charges, and service charges were not factored in the scenario, exception made for mooring and waste collection fee. The choice on which taxes to factor in was based on empirical evidence from the first task of the Study: most ports give rebates on tonnage tax and/or waste collection fees.
- Many ports specify on their websites that their taxes and tariffs are subject to private negotiation, especially when there is a strategic interest for the port in attracting certain categories of ships, as well as when a ship makes numerous call throughout the year. Naturally, albeit quite frequent, these private negotiations could not be factored in the scenario. It should be noted that, realistically, large cruise ships like the one of our scenario do not pay taxes and tariffs as they are stated officially, but can benefit from ad-hoc discounts.

Based on the taxes and tariffs published on line, the cruise ship would pay the following amounts in each port[137]:

Port 1 € 13.286,67

[136] It should be noted that the taxes levied on our ship are based on real data from 5 ports. Ports are not expressly named as this would be irrelevant for the scope of the Study.

[137] Detailed figures for each port are available in Annex

Port 2 € 81.831,51

Port 3 € 121.615,15

Port 4 € 37.892,05

Port 5 € 81.467,48

It is assumed that the 5 ports adopt a similar type of scheme, i.e. a rebate on the tonnage/volume tax and a rebate on the waste collection fee, upon possession of a valid certificate released by an acknowledged environmental initiative. To make the scenario more realistic, it is assumed that each port applies different discount percentages, as it is the case in the EU at present. Again, this type of scheme is based on the empirical evidence from the first task of the Study, where this was by far the most common typology of scheme applied. The results are as follows:

Port 1 € 12.478,65 (15% rebate)

Port 2 € 77.301,15 (20% rebate)

Port 3 € 114.433,45 (12% rebate)

Port 4 € 36.542,69 (10% rebate)

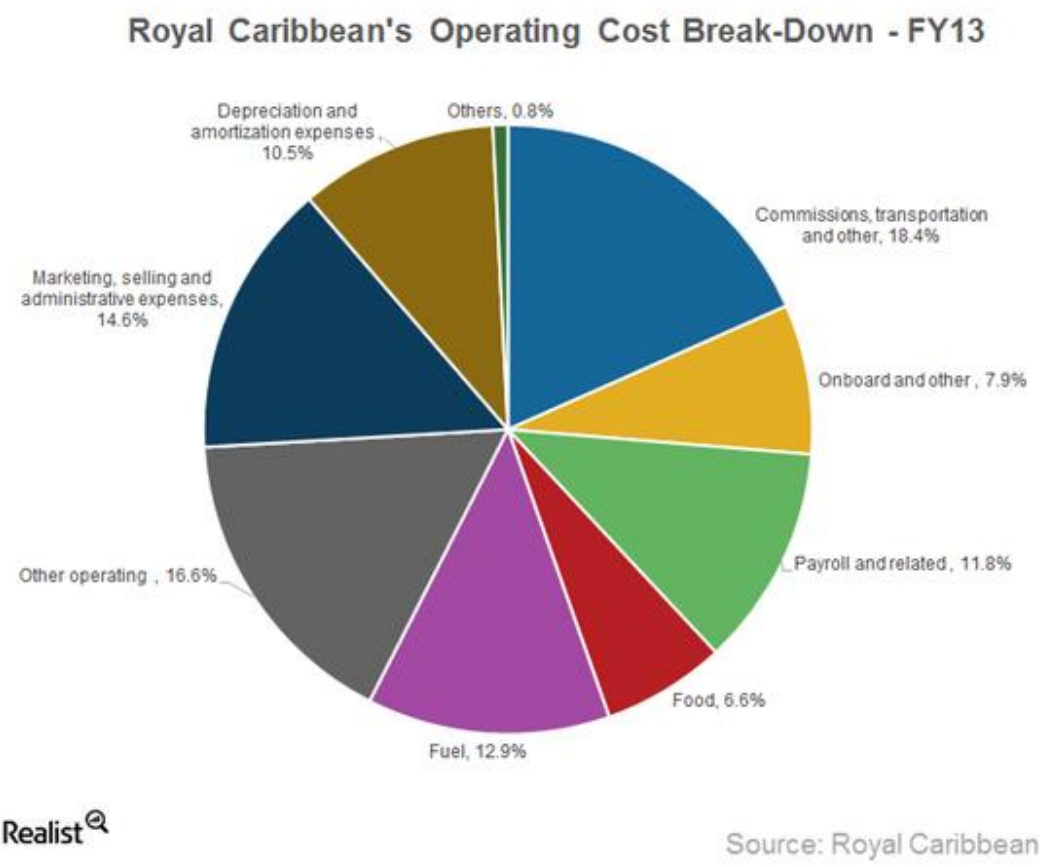
Port 5 € 76.714,30 (10% rebate)

Having a series of schemes based on similar rules in all ports of call would make it possible to save € 18.622,61, i.e. 5,54% in port dues per each cruise. 5,54% per cruise may seem a good incentive for cruise operators to go greener, especially if that amount is multiplied by the number of cruises each year. For instance, all things being equal, a cruise operator may save € 93.113,05 over 5 years.

However, one should also bear in mind that port dues are only a fraction of the total costs borne by a cruise operator. If other costs were factored in, such as capital costs, fuel, crew salaries, purchases, travel agencies, etc. the benefits of environmental charging may become less evident, and so would the incentive to become greener. It is difficult to provide a precise estimate of port charges on total operating costs of a cruise ship. While it has been estimated that port charges may account from 3% to 15% of operating costs for cargo ships[138], to our knowledge, no precise estimate is available for the cruise industry, most likely because port charges are generally not considered a crucial cost factor. For instance, if one looks at the breakdown of operating costs for Royal Carribean in the year 2013:

[138] See Alderton, P. M., Reeds Sea Transport, Operations and Economics, 2011, p. 138. See also Trujillo, L. and Nombela, G. (1999), Privatisation and Regulation of the Seaport Industry. Policy Research Working Paper No 2181. The World Bank. Washington D.C.

Figure 21 – Royal Carribean's Operating Cost Break-Down (2013)



Port charges are not even listed individually, while they are included under 'other operating costs', together with repair and maintenance, fixed port costs, lease costs, and costs related to insurance and entertainment

Furthermore, one should also consider that cruise operators' and travellers' demand for a certain destination is considered to be not very elastic to port pricing. For instance, a cruise that calls Venice would be very unlikely to move to a different neighbouring port on account of lower costs, as the number of passengers would inevitably decrease. Competition between destinations in the cruise industry is a reality only in certain areas and under certain conditions. While lesser-known destinations can actually compete on tariffs because they can be seen as virtually interchangeable, 'big players' have a comparatively stronger bargaining position, and thus might have little incentive to give rebates to cleaner ships from a merely economic viewpoint. Again, to our knowledge, no studies have been carried out to measure demand elasticity to port charges in the cruise industry, most likely because of the negligible impact that these may have on the choice of destination.

Should one conclude that a harmonised approach to environmental charging could not possibly have an impact on the cruise industry? Not exactly, as other factors should also be taken into consideration.

Even if the idea of competition between famous cruise destinations is ruled out, or if it is maintained only for lesser-known destinations, from the point of view of a port, harbouring cleaner ships would mean to improve (or try to) significant environmental aspects such as air quality and waste basically at the cost of the environmental charging scheme budget, or at no cost at all in the case of revenue-neutral schemes.

From the cruise companies' viewpoint, on the other hand, while there may be little economic incentive in becoming greener if only taxes and tariffs reductions are taken into account, one should also consider that the cruise industry has long been on an effort to reduce its environmental footprint, also on account of significant criticisms voiced by environmental organisations as to the negative impact of cruise ships in port

cities. As part of this effort, several cruise lines have already taken measures to adopt more stringent standards than those required by law. The costs connected with the process that in the scenario would also make the ship eligible for rebates should be analysed within the wider context of 'becoming greener', and not simply as a way to pay lower tariffs.

If one takes into account the overall framework, different considerations are to be made. Under such a scenario, a more consistent approach to environmental charging might be considered a weak incentive for cruise companies to become greener from a merely economic perspective. Nonetheless, albeit not particularly significant, the incentive still exists and would make it possible to save a certain amount of money in port dues per each cruise. Furthermore, acquiring a certification from an environmental initiative as in our scenario would carry positive implications in terms of image, and could also be seen as one of the steps to reduce the overall environmental footprint of the industry; an effort whose costs would be partly compensated by the incentives from reduced port dues.

From the point of view of port cities, having ascertained that environmental charging would not be a determinant factor in competition between destinations, harbouring cleaner ships would inevitably improve air quality and contribute to better waste management at little to no cost.

In other words, a more consistent approach to environmental charging for cruise ships could be seen as a 'win-win' situation, where basically none of the parties has anything to lose, while all of them can harvest the benefits of cleaner air and better waste management, both in terms of reduced environmental footprint and improved reputation.

References

ACCIARO M., *A real option application to investment in low-sulphur maritime transport*, International Journal Shipping and Transport Logistics, vol. 6, n. 2, 2014.

ALDERTON P. M., Reeds *Sea Transport, Operations and Economics*, 2011

BERGQVIST R., EGELS-ZANDÉN N., *Green port dues – The case of hinterland transport*, Research in Transportation Business & Management, 2012 (5), pp. 85-91.

BIERWIRTH P.N., Carbon dioxide toxicity and climate change: a serious unapprehended risk for human health, 2014.

BIMCO, *Business Case: Marine gas oil or scrubbers when operating in an ECA?* Available on line at https://www.bimco.org/en/Reports/Market_Analysis/2013/0424_ECAStory.aspx

CAMPLING P. et al., *Specific evaluation of emissions from shipping including assessment for the establishment of possible new emission control areas in European Seas*, Final Report produced under the Service Contract on Monitoring and Assessment of Sectorial Implementation Actions (ENV.C.3/SER/2011/0009) of DG-Environment of the European Commission, 2013.

CLEAN NORTH SEA SHIPPING, Onshore Power Supply (OPS) Survey, March 2014.

COHEN AARON J., ROSS ANDERSON H., OSTRO Bart, DEV PANDEY Kiran, KRZYZANOWSKI Michal,′ KÜNZLI Nino, GUTSCHMIDT Kersten, POPE Arden, ROMIEU Isabelle, SAMET Jonathan M. and SMITH Kirk (2005), The Global Burden of Disease Due to Outdoor Air Pollution, Journal of Toxicology and Enviromental Healt, Part A: Current Issues, vol. 68, issue 13-15, pp. 1301-1307.

APICE (2013), Reducing atmospheric pollution in the Mediterranean port cities; The results of the APICE project, Financed by ERDF.

AIRCLIM (2011), Briefing: Cutting SOX emissions from shipping. Retrieved from: http://www.eeb.org/?LinkServID=270BA1F9-5056-B741-DBCD226EF9B74D51&showMeta=0&aa.

BADINO A., BORELLI D., GAGGER T., RIZZUTO E. and Schenome C. (2012), Analysis of airborne noise emitted from ships. In E. Rizzuto and G. Soares(Eds). Sustainable Maritime Transportation and Exploitation of Sa Resources, Taylor & Francis Group, London, UK.

BLIGHT, L.K., BURGER, A.E., 1997. Occurrence of plastic particles in seabirds from the eastern North Pacific. Marine Pollution Bulletin 34, 323–325.

BUTT N. (2007), The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, Marine Policy, 31, 591-598.

CAMPLING P., JANSSEN L., VANHERLE K., COFALA J. HEYES C. and SANDER R. (2013), Specific evaluation of emissions from shipping including assessment for the establishment of possible new emission control areas in European Seas, Final Report produced under the Service Contract on Monitoring and Assessment of Sectorial Implementation Actions (ENV.C.3/SER/2011/0009) of DG-Environment of the European Commission.

CHUTE D. O. (2012), Noise Control Methods for Shipbuilding, Final Report, Presented to National Shipbuilding Research Program. Access from: http://www.nsrp.org/3-RA-Panel_Final_Reports/2011-2_Noise_Control_Methods-FINAL.pdf.

CLEAN NORTH SEA SHIPPING (2014), Final Report. Key Finding and Recommendations. Retrieved from: http://www.hzg.de/imperia/md/images/hzg/presse/pressemitteilungen/imperiamdimagesgkssspressepressemitteilungen2014/cnss_finalreport.pdf.

COFALA Janusz, AMANN Markus, HEYES Chris, WAGNER Fabian, KLIMONT Zbigniew, POSCH Max, SCHÖPP Wolfgang, TARASSON Leonor, JONSON Jan Eiof, WHALL Chris, STAVRAKAKI Andrianna (2007), Analysis of Policy Measuresto Reduce Ship Emissions in the Context of the Revision of the National Emissions Ceilings Directive. Final Report. IIASA Contract No. 06-107.

CORBETT et al. (2007), Mortality from Ship Emissions : A global assessment. Environmental Sci. Tehnol., 41, 8512-8518. http://earthjustice.org/sites/default/files/black-carbon/corbett-2007.pdf.

COSTELLO M.J and READ P. (1994), Toxicity of Sewage Sludge to Marine Organisms: A Review. Marine Environment Research, 37, 23-46.

DE LANGEN P., The Analyst: sense of green port dues, published on Port Economics on 7 October 2016. Available at: http://www.porteconomics.eu/2016/10/07/4010/

DEN BOER E., HOEN M., Scrubbers – *An economic and ecological assessment*, prepared for NABU in 2015

DERRAIK G.B.J (2002), The pollution of the marine environment by plastic debris: a review, Marine Pollution Bulletin, 44, 842–852.

DEVANNEY J., The impact of EEDI on VLCC design and CO_2 emissions, 2011. Available online at http://www.tandfonline.com/doi/abs/10.1080/17445302.2010.546651

DIESCH J.-M., DREWNICK F., KLIMACH T., and BORRMANN S.(2013), Investigation of gaseous and particulate emissions from various marine vessel types measured on the banks of the Elbe in Northern Germany, Atmos. Chem. Phys., 13, 3603–3618.

ESPO (2012), Green Guide. Towards excellence in port environmental management and sustainability. Retrieved from: http://esci-ksp.org/wp/wp-content/uploads/2014/04/espo_green-guide_october-2012_final.pdf.

EPA (2008), Cruise Ship Discharge Assessment Report. Section 4: Oily Bilge Water. Retrieved from: http://water.epa.gov/polwaste/vwd/upload/2009_01_28_oceans_cruise_ships_section4_bilgewater.pdf.

EUROPEAN ENVIRONMENTAL AGENCY, (2013), The impact of international shipping on European air quality and climate forcing, Technical report No 4/2013. Retrieved from http://www.eea.europa.eu/publications/the-impact-of-international-shipping.

EUROPEAN MARINE EQUIPMENT COUNCIL (2010). Green Ship Technology Book. Existing Technology by the Marine Equipment Industry: A contribution to the Reduction of the Environmental impact of Shipping.

EUROPEAN ENVIRONMENTAL SAFETY AGENCY (2008), Preventing Pollution From Ships

EYRING, V., H. W. KÖHLER, A. LAUER, and LEMPER B. (2005), Emissions from international shipping: Impact of future technologies on scenarios until 2050, *J. Geophys. Res.*, 110.

EYRING V., CORBETT J.J., LEE S.D. and WINEBRAKE J.J. (2007), Brief summary of the impact of ship emissions on atmospheric composition, climate and human health. Document submitted to the Health and Environmental sub-group of the International Maritime Organisation on 6 November 2007.

FABER et al (2009), Technical support for European action to reducing Greenhouse Gas Emissions from international maritime transport. Tender DG ENV.C3/ATA/2008/0016. Retrieved from: http://ec.europa.eu/environment/air/transport/pdf/ghg_ships_%20report.pdf.

GRASSLE, J.F., LASSERE, P., MCINTYRE, A.D., RAY, G.C., 1991. Marine biodiversity and ecosystem function. Biology International Special Issue 23, 1–19.

HAMMINGH P., HOLLAND M.R., GEILENKIRCHEN G.P., JONSON I.E. and MAAS R.J.M (2012), Assessment of the environmental impacts and health benefits of a nitrogen emission control area in the North Sea, PBL Netherlands Environmental Assessment Agency.

HARROULD-KOLIEB E. (2008), Shipping Impacts on Climate: A source with solutions. Oceana Protecting the World's Oceans. Retrieved from: http://www.cleanshipping.org/download/Oceana_Shipping_Report1.pdf.

HILL T., WESTBROOK R., *SWOT Analysis: It's Time for a Product Recall*, Long Range Planning, Vol. 30, No. 1, pp. 46 to 52,1997.

HOLLAND M. et al., *Damages per tonne emission of $PM_{2.5}$, NH_3, SO_2, NO_x and VOCs from each EU25 Member State (excluding Cyprus) and surrounding seas*, 2005. Available at http://ec.europa.eu/environment/archives/cafe/activities/pdf/cafe_cba_externalities.pdf.

HOLMAN C. (1999) Sources of air pollution. In: Air pollution and health. Holgate ST, Samet JM, Koren HS, Maynard R, eds. Academic Press, London.

HUNG-KHOO I. and NGUYEN T-H., (2011). Study of the Noise Pollution at Container Terminals and the Surroundings. Final Report. METRANS PROJECT 09-09.

IMO (2000), Study on Gas Emissions from Ships. Issue no 2-31 March 2000.

IMO (2014), Reduction of GHG emissions from ships. Third IMO GHG Study 2014-Final Report.

JONSON J. E., JALKANEN J. P., JOHANSSON L., GAUSS M., and DENIER VAN DER GON, H. A. C., Model calculations of the effects of present and future emissions of air pollutants from shipping in the Baltic Sea and the North Sea, Atmospheric Chemistry and Phisics, 2015.

JUN P. et al. (2001), CO_2,CH_4 and N_2O emissions from transportation water borne navigation. in Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. Available at: http://www.ipcc-nggip.iges.or.jp/public/gp/bgp/2_4_Water-borne_Navigation.pdf.

KÅGESON P., *Economic instruments for reducing emissions from sea transport*, Air Pollution and Climate Series NO. 11 / T&E REPORT 99/7, 1999.

KJØLHOLT J. ET AL., *Assessment of possible impacts of scrubber water discharges on the marine environment*, Danish Environmental Protection Agency, Environmental Project No. 1431, 2012.

KOMAR, I. and Antomic, R. (2010), Air pollution prevention from volatile organic compound on shuttle tankers, 14th International Research/Expert Conference "Trends in the Development of Machinery and Associated Technology" TMT 2010, Mediterranean Cruise, 11-18 September 2010.

KONTOVAS, C.A. and PSARAFTIS, H.N., (2009), An Open Online Calculator for Ship Air Emissions, Working Paper, National Technical University of Athens, September 2009.

KONTOVAS, C. H. and PSARAFTIS (2011), 'The link between economy and environment in the post-crisis era: lessons learned from slow steaming', Int. J. Decision Sciences, Risk and Management, 3(3/4), 311-326.

KRISTENSEN Hans Otto (2012), Energy demand and exhaust gas emissions of marine engines, Project no. 2010-56, Emissionsbeslutningsstøttesystem Work Package 2, Report no. 05.

KUNNAALA-HYRKKI et al., *Corporate Social Responsibility trends in maritime logistics*, Baltic Rim Economies, Special issue on corporate social responsibility, issue 2/2015, pp. 29-30.

LAIST, D.W. (1997), Impacts of marine debris: entanglement of marine life in marine debris including a comprehensive list of species with entanglement and ingestion records. In: Coe, J.M., Rogers, D.B. (Eds.), Marine Debris—Sources, Impacts and Solutions. SpringerVerlag, New York, pp. 99–139.

LEE S.W. et al., *Fuel Sulphur Effects on Particulate Emissions from Fuel Oil Combustion Systems under Accelerated Laboratory Conditions*. Work Performed for Environment Canada by the Advanced Combustion Technologies CANMET Energy Technology Centre-Ottawa (2002).

LINDSTAD H. et al., GHG emission reduction potential of EU-related maritime transport and on its impacts, TNO, 2014.

LJUNGSTRÖM T., *The environmental differentiated fairway dues system*, Swedish Maritime Administration, 2010.

MADJIDIAN J., BJÖRK S., NILSSON A., HALÉN T,. *CLEANSHIP – Clean Baltic Sea Shipping,* 20143 Available at: http://www.clean-baltic-sea-shipping.com/uploads/files/CLEANSHIP_final_report_for_download.pdf

MERK Olaf (2014), Shipping Emissions in Ports, International Transport Forum, Discussion Paper 2014-20. Retrieved from: http://www.internationaltransportforum.org/jtrc/DiscussionPapers/DP201420.pdf.

MIOLA A., PACCAGNAN V., MANNINO I., MASSARUTTO A., PERUJO MATEOS DEL PARQUE A., Turvani M. (2009), External Costs of Transportation. Case Study: Maritime Transport, JRC Scientific and Technical Report (JRC 51275). Retrieved from: http://publications.jrc.ec.europa.eu/repository/bitstream/JRC51275/reqno_jrc51275_reqno_jrc51275_maritime_external_costs.pdf%5b1%5d.pdf-

MOHEE et al. (2012), Inventory on waste streams in an industrial port and planning for a port waste management system as per ISO 14001. Ocean & Coastal Management, 61, 10-19.

MOORE F. and DIAZ, D., *Temperature impacts on economic growth warrant stringent mitigation policy*, Nature Climate Change, 2015.

MORRETTA M. et al. (2008), The Port of Livorno noise mapping experience. Acoustics Paris,2008. Retrieved from: http://webistem.com/acoustics2008/acoustics2008/cd1/data/articles/001422.pdf.

MURPHY E. and KING E.A. (2014), An assessment of residential exposure to environmental noise at a shipping port, Environmental International, 63, 207-2015.

MURRAY R. GREGORY (2009), Environmental implications of plastic debris in marine settings—entanglement, ingestion, smothering, hangers-on, hitch-hiking and alien invasions, Phil. Trans. R. Soc. B, 364, 2013–2025.

MUSTONEN Maria (2013), Noise as an environmental challenge for ports, TFK Transport Research Institute. Rapport 2013:x. Retrieved from: http://projects.centralbaltic.eu/images/files/result_pdf/PENTA_result4_noise.pdf.

OECD (2010), The Competitiveness of Global Port-Cities: Synthesis Report. Retrieved from: http://www.oecd.org/gov/regional-policy/Competitiveness-of-Global-Port-Cities-Synthesis-Report.pdf.

OHLENSCHLAGER J. P. and GORDIANI G., Study on the Delivery of Ship-generated Waste and Cargo Residues, EMSA, 2012. Available at: http://www.emsa.europa.eu/emsa-documents/latest/download/1972/1607/23.html

OSPAR Comission (2010), North Sea Manual on Maritime Oil Pollution Offences. Retrieved from: http://www.ospar.org/html_documents/ospar/html/north_sea_manual_on_maritime_oil_pollution_offences.pdf.

PICKTON D. W., and WRIGHT S., *What's swot in strategic analysis?*, Strategic Change, Volume 7, Issue 2, pp. 101–109, 1998.

PSARAFTIS, H. and KONTOVAS, C., (2009). CO2 emission Statistics for the world commercial fleet. WMU Journal of Maritime Affairs 8 (1), pp- 1-25.

RECHE et al. (2011), New considerations for PM, Black Carbon and particle number concentration for air quality monitoring across different European cities, Atmos. Chem. Phys., 11, 6207–6227. http://www.atmos-chem-phys.net/11/6207/2011/acp-11-6207-2011.pdf.

RICE, S. A., 2004. Human health risk assessment of CO2: Survivors of acute high-level exposure and populations sensitive to prolonged low-level exposure. Third Annual Conference on Carbon Sequestration. May 3-6, Alexandria, Virginia, USA.

RIZZUTO et al. (2010), Ships oriented Innovative soLutions to rEduce Noise and Vibrations, W1:Noise-related needs, quantification an justification. FP7 - Collaborative Project n° 234182

RUDD J. H. and Hill N.A. (2001), Measures to Reduce Emissions of VOCs during Loading and Unloading of Ships in the EU, AEAT/ENV/R/0469 Issue 2. Available at: http://ec.europa.eu/environment/archives/air/pdf/vocloading.pdf.

SAX, T. and ALEXIS, A. (2007) A *Critical Review* of *Ocean-Going Vessel Particulate Matter Emission Factors*. California Air Resources Board, Sacramento, CA. Retrieved from: http://www.arb.ca.gov/msei/offroad/pubs/ocean_going_vessels_pm_emfac.pdf.

SCHWARZ W. And RHIEMEIER J-M. (2007). The analysis of the emissions of fluorinated greenhouse gases from refrigeration and air conditioning equipment used in the transport sector other than road transport and options for reducing these emissions Maritime, Rail, and Aircraft Sector. Final Report prepared for the European Commission (DG Environment). Access from: http://ec.europa.eu/clima/policies/f-gas/docs/2_maritime_rail_aircraft_en.pdf.

SVENSSON E. (2011), The Regulation of Global SOx Emissions from Ships IMO proceedings 1988-2008, Thesis for the degree of licentiate of philosophy, Department of Shipping and Marine Technology Chalmers University of Technology, Gothenburg, Sweden. Retrieved from : http://publications.lib.chalmers.se/records/fulltext/140528.pdf.

TANG-HUNG Nguyen and I-Hung Khoo (2013), Noise mapping of container terminals at the port of Los Angeles, METRANS Project 11-26. Access from: http://www.metrans.org/sites/default/files/research-project/11-26_Nguyen-Khoo_Final_0_0.pdf.

TREICHEL P. and WIEWIORA A. (2007), The basics of oily water dispersion measures. PROBLEMY EKSPLOATACJI, 3, 215-222. Retrieved from : http://yadda.icm.edu.pl/baztech/element/bwmeta1.element.baztech-article-BAR0-0031-0020.

TRUJILLO L. and NOMBELA G., *Privatisation and Regulation of the Seaport Industry*, 1999.

Tzannatos, E. (2010), Cost assessment of ship emission reduction methods at berth: The case of the Port of Piraeus – Greece, *Maritime Policy & Management*, (IF: 0.816), 37:4, 427-445, 2010.

UNCTAD, Multi-Year Expert Meeting on Transport and Trade Facilitation: Maritime Transport and the Climate Change Challenge, 16–18 February 2009, Geneva, Summary of Proceedings. UNCTAD/DTL/TLB/2009/1.

UNCTAD, *Review of Maritime Transport*, 2013.

UNEP DTIE (2010), Manual for refrigeration Servicing Technicians. Retrieved from: http://www.unep.org/pdf/7443-e-Ref_manual_servicing_technicians.pdf.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, *Emissions Factors & AP 42, Compilation of Air Pollutant Emission Factors,* Fifth Edition, 1998.

VIANNA et al. (2014), Impact of maritime transport emissions on coastal air quality in Europe, Atmospheric Environment, 90, 96-105.

WHALL et al. (2007), CONCAWE Ship Emissions Inventory-Mediterranean Sea. Final Report. Entec UK Limited. Retrieved from: http://www.amec-ukenvironment.com/downloads/Concawe_Final_Report_170407_v1_WEB_LOWRES.pdf.

WINKEL R. et al., *Potential for Shore Side Electricity in Europe*, Ecofys, January 2015. Available online at http://www.ecofys.com/files/files/ecofys-2014-potential-for-shore-side-electricity-in-europe.pdf

WITTE J. (2010), Noise from moored ships, Internoise 2010, Noise and sustainability, June, Lisbon, Portugal. Access from : http://dgmr.nl/uploads/files/Internoise_2010_Rob_Witte_Noise_from_moored_ships.pdf.

World Health Organisation (2015), http://www.who.int/topics/air_pollution/en/.