WP 5

Activity 5.2

Case Study
Onshore Power Supply Facility at the Cruise Terminal Altona in Hamburg

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CEF	Connecting Europe Facility
CO2	Carbon dioxide
EC	European Commission
EU	European Union
FEG	Fischereihafenentwicklungsgesellschaft mbH & Co. KG
FO	Funding objective
HPA	Hamburg Port Authority AöR
Hz	Hertz
IMO	International Maritime Organisation
kW	kilowatt
kWh	kilowatt hour
kV	Kilovolt
LNG	Liquefied Natural Gas
MW	Megawatt
MVA	Mega volt-ampere
NOx	Nitrogen oxide
OPS	Onshore Power Supply
PM_{10}	Particulate Matter
Ro-Ro	Roll-on Roll-of
SEK	Swedish Krona
SO2	Sulphur dioxide
TEN-T	Trans-European transport networks
VA	Volt-ampere

1. Abstract

Freight and passenger transport is continuously growing. Furthermore, cruise tourism is an increasing business field for ports and cities that generates an additional income for the city and related economic sectors. However, anchoring ships also have an enormous energy demand. Looking at the cruise industry, this energy demand currently is generated with diesel engines onboard which results in harmful emissions for residents, staff and the environment. Hence, especially ports located near to areas of high population density see themselves confronted with new tasks in regard to reduce ships' emissions.

This following case study will present a pilot project from the Port of Hamburg where the problematic situation of the cruise ships' emissions while anchoring has been analysed and an innovative onshore power supply concept has been evaluated. The case study will analyse the project itself including its needed infrastructure, involved actors and stakeholders, the legislative framework which should be respected, funding possibilities and similar projects.

The case study collects fruitful information in terms of projects for reducing ship emissions during their anchoring time which also contributes to reach the European aims towards a sustainable and energy efficient transport.

2. Introduction

Anchoring ships generate noise emissions and air pollution which affect the environment, the staff on board and the people living near the port. Even though emissions from ships can cause damage to the environment and health at great distance, these emissions are especially harmful within the immediate environment.

The European Commission names NO_x, SO_2, CO_2 and PM_{10} as harmful emissions of the maritime industry (EC, 2009). This type of emissions can impact the human health but also foster global warming or the acidification of rain. The maritime industry is of course not the only segment which produces harmful emissions but it takes its part.

The following table shows where and to what extent the maritime emissions are occurring (EC, 2009):

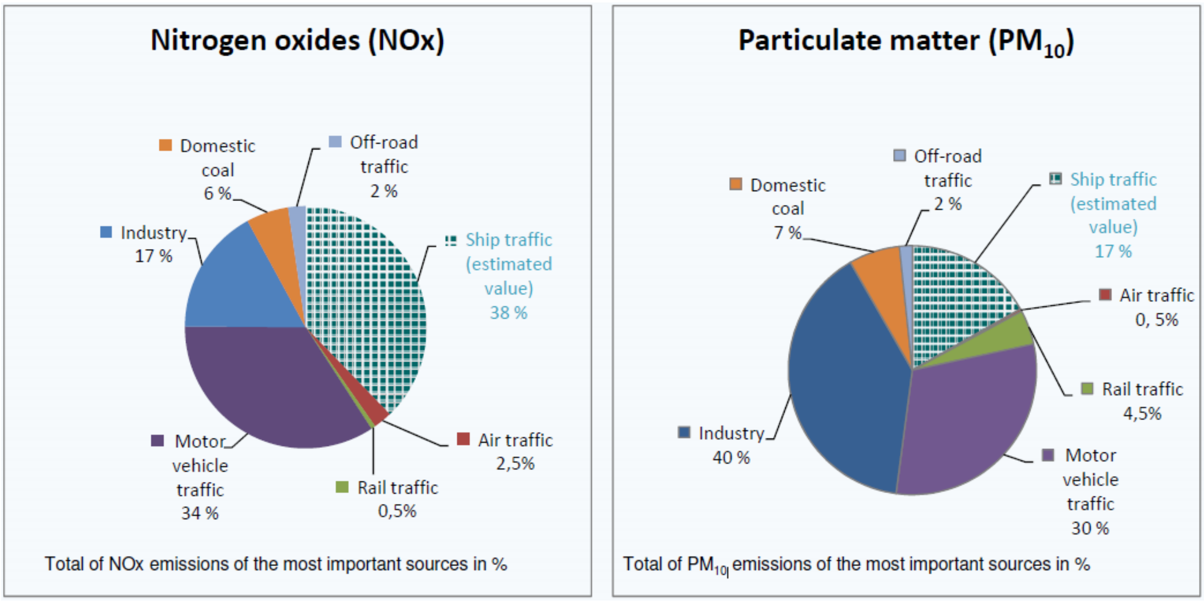
Table 1: Harmful emissions of the maritime sector (EC, 2009)

Emissions (tonnes per year)	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 %
Total	176,817	100 %	96,965	100 %	7,168,331	100 %	17,283	100 %

The table shows that 10 to 15 percent of harmful emissions are occurring within the port and thus close to residual areas. Even though, more emissions of the maritime industry occur on sea, it is important for the ports and European states to reduce the ship emissions within the ports. Inter alia, this is necessary to meet the objectives of the Europe2020 strategy as well as further European and national climate and sustainability strategies, laws and directives (see further information in section 5).

In 2012, the influence of different sources in regard to the emission contribution of two exemplary emission types had been measured specifically for the port city of Hamburg. The following figure visualises the share of the maritime industry of the total emissions in Hamburg.

Figure 1: Emission contribution of sectors in Hamburg (BSU, 2012)



Especially cruise ships which are usually berthing close to residential areas might harm the health of the urban population due to their high energy demand: The European Commission describes the total engine power of a cruise ship as 30-40 MW which is around average in Europe. While berthing, this power consumption is reduced to 9-12 MW (average power use while berthing 20-30%) per hour (EC, 2009)

The Port of Hamburg is located within the city of Hamburg and has historically grown into the urban area. Cargo and cruise ships berth in direct environment of the city population. The cruise ship destination Hamburg is favoured by many positive market factors and thus a high market potential is apparent. The number of cruise ships calling yearly at the Port of Hamburg is determined to increase from 178 in 2013 up to 190 in 2014 and above 300 in the year 2025 (ISL, 2014). This high number of cruise ships combined with the increasing cargo related ship traffic is creating challenges for the Port of Hamburg.

Hereby, especially the harmful emissions such as noise emissions and air pollution of these ships while anchoring make this a sensitive topic for the urban Port of Hamburg where round about 20,000 ships berthed in 2013 (Port of Hamburg Handbook, 2013).

In conclusion, it is possible to state that ship emissions are particularly a challenging topic within ports as they are harmful for residents living close to berthing locations. Especially cruise ships, which have a high energy requirement, are in the focus of authorities on a national and EU level (Directive 2005/33/EC). The European policy not only focuses on a general more sustainable approach in all sec-tors but also shows a comprehensive legislative framework regarding air quality for urban areas. An overview is listed in Section 5 "Applicable Legislation".

As a consequence, to meet European laws as well as to improve the air quality of the City of Hamburg, the City of Hamburg together with the Hamburg Port Authority (HPA) have set up an overall approach to systematically reduce emissions within the port area.

Currently, this approach focuses on one main energy consumer within the port, the cruise ship industry. The cruise ship industry is a relatively homogenous market with regard to energy infrastructure compared to the cargo ship industry which has a wide range of different engine types (Pride and Ferrel, 2014). In the following, one of the actions from the Hamburg approach, the onshore power facility at the cruise terminal in Altona will be presented and explained.

3. Description of the case

3.1. Introduction to onshore power supply

One possibility to reduce the energy consumption of anchoring ships is to shift the location of energy generation from board of the ship to alternative energy supply methods. Generally, emission reduction methods for anchoring ships can be divided into two parts: land-based and ship-based reduction methods. Ship-based instruments are emission reduction systems where certain modifications reduce one specific type of emission. Land-based instruments are commonly used to shift the energy generation from the board of the ship to a more efficient location. Hereby, shore-side power supply replaces the ship internal power supply while the ship is anchoring. This method is also known as "cold ironing" (EC, 2009). When using land-sided electricity supply the engines of the cruise ships can be switched to a low usage mode and thus the emission while berthing will be reduced.

The provision of land-sided electricity requires the attendance to adapt on both sides, ships as well as the port interface. On the port side electricity needs to be generated or provided and connected to the ship (EC, 2009). The (cruise) ship has to be equipped with special installations to be able to use land-sided electricity. In practice, there are occurring a number of obstacles to overcome of which some exemplary are described below.

As already described, the power demand of a cruise ship is substantial. If a port plans to supply multiple cruise ships with power simultaneously the infrastructure needs to be able to provide the power needed without power shortages or blackouts in city areas. Therefore, it is advantageous to connect the electrical power supply to the main power net, which however, involves higher investments (EC, 2009). Another aspect which needs to be taken into account is the difference of power frequency between the USA and Europe. In Europe the common power frequency is 50Hz while the USA is using 60 Hz. The European Commission states that the most common power installations on cruise ships are based upon the American power frequency, due to their leading position on the cruise shipping market and thus a frequency conversion is required (EC, 2009). This conversion can take place on shore as well as on board of the ship but it requires additional investments.

The benefits of shore sided electricity are mainly from an environmental point of view. The emissions while berthing are reduced which also reduce the external costs of (cruise) ships within the port area and thus leads to social and welfare benefits. The reduction of environmental impact is denoted by the European Commission to be around 80% less general emissions within the ports (EC, 2009). It is necessary to evaluate the reduction of emissions by considering how and where the land-sided energy is generated. The European Commission names hereby gas power plants as the best way to reduce harmful emissions, while not considering the renewable energies and nuclear power plants (EC, 2009).

3.2. Hamburg’s environmental policy approach

In order to react to the increasing cruise and cargo shipping developments the Hamburg Port Authority (HPA) plans to counteract the negative impacts with their initiative “Environmental policy”. On the one hand, this strategy includes measures to reduce the energy consumption of the port but on the other hand it also focuses on the reduction of harmful emissions such as NO_x, CO_2, SO_X and $PM_{10;2.5}$ (HPA, 2014c).

As a part of this strategy the concept “smartPORT energy” has been implemented in order to achieve the set objectives. The four main pillars of this concept are Renewable Energy, Energy Efficiency, Smart Energy and Mobility. Under the pillar “Mobility” the strategy sets goals to find innovative solutions to reduce harmful emissions which are caused by related mobility areas (HPA, BSU and BWVI 2014). One sub-project of the initiative is the onshore power facility on the cruise terminal in Altona.

The initiative of the onshore power supply project has been fostered by the „Ministry for Economic Affairs, Transport and Innovations of the Free and Hanseatic City of Hamburg “(BWVI) in cooperation with the HPA. The ministry has been delegated in 2012 by the Free Hanseatic City of Hamburg to develop a scheme for the implementation of an onshore facility for cruise ships on the terminal in Altona and assigned the HPA for the operational implementation. It is planned to provide onshore electric supply to cruise ships calling at this terminal at the 3rd quarter of 2015.

In the description of Hamburg’s senate the environmental benefit of the onshore power facility in Altona is estimated in a reduction of CO_2 emission as the following:

Table 2: CO2 savings (estimated) (Drucksache 20/5316, 2013)

Altona on shore energy supply (estimated need of power: 8,1450.5 MWh)	Average yearly CO_2 emission (t/year)	Difference between usage of cruise ship engines and on shore supply
Emission by cruise ship engine w/o onshore supply (Emission factor: 0.695 kg CO2/ kWh)	5,658	-
Emission by using “normal” onshore electricity (Emission factor: 0.566 kg CO2/ kWh)	4,608	1,050
Emission by using “eco-friendly” onshore electricity (Emission factor: 0.283 kg CO2/ kWh)	2,304	3,354

The table above shows that the potential of emission savings (in this case CO_2) is essential by using ordinary power plant electricity and becomes enormous when the energy is generated by eco-friendly energy sources. In the case of the Altona facility, only renewable energy will be used for the power supply which makes the emission savings significant.

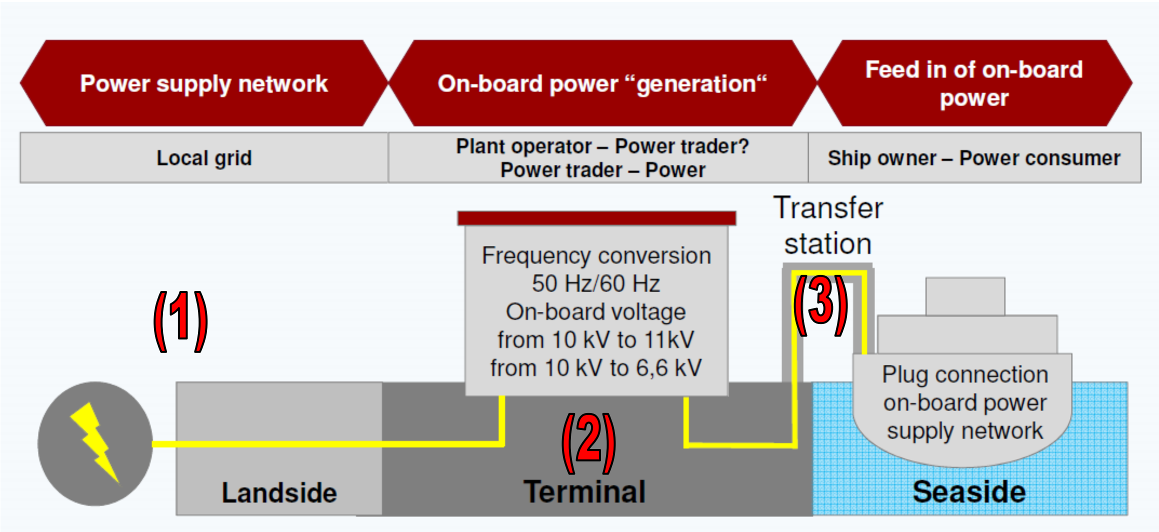
3.3. Design and infrastructure

Putz & Partner (2012) describe the necessity of a comprehensive infrastructure for a land-sided power supply. Two possibilities to provide power to cruise ships occur: generating the power at the terminal or connecting the installation to the main grid of the city (Putz & Partner, 2012). For the terminal in Altona the second option has been rated as the adequate solution and thus one infrastructural requirement is the connection to the 10 kV medium-high voltage main grid of Hamburg.

Furthermore, a frequency converter station and a flexible transfer station to the cruise ship along the dockside are in the building process since July 2014 (HPA, 2014b). The equipment used is designed to provide a power of 12 MVA / 6.6 kV / 60 Hz or 12 MVA / 11 kV / 60 Hz to cruise ships capable of 2,500 passengers. The named frequency converter is essential within the infrastructure. This application is converting and adjusting the frequency from 10 kV / 50 Hz to 60 Hz with a voltage of 11 kV or 6.6 kV respectively. Furthermore, it is important to have a mobile transfer station in order to be able to respond to the different local connection requirements alongside the cruise ships.

The following illustration gives a simple overview about the functional principal and infrastructure of the onshore power supply in Altona:

Figure 2: The functional principle of an onshore power generating plant (HPA, 2014a)

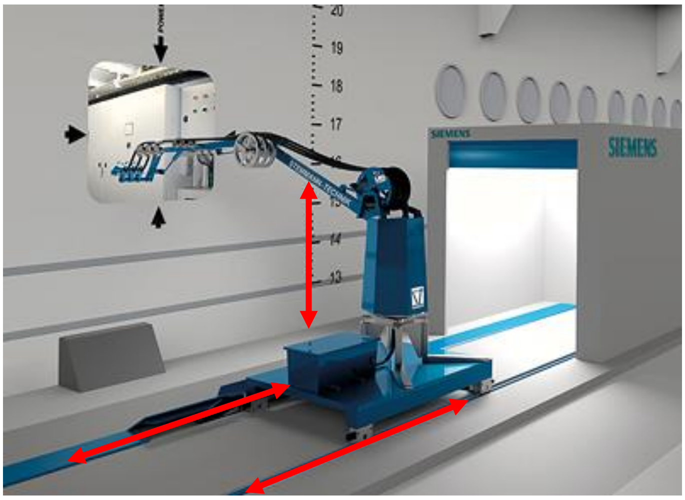


The process of land-sided power supply starts at the connection of the terminal with the main grid of Hamburg (1). The electrical power is led by cables to the Converter Station on the terminal where the energy is converted to suitable energy of the cruise ship (2). This type of frequency converter station is unique worldwide regarding the performance and flexibility.

In the following step energy is led from the converter station to the transfer station which is connected to the cruise ship (3). The transfer station is equipped with a flexible robot-arm which is capable to move alongside of the ship but also to adjust to different tide scales, which apply in the Port of Hamburg. It is planned to control the robot arm via a remote control from the ship side, thus there is no ground staff needed.

The following picture shows the complex transfer station with its flexibility to adjust:

Figure 3: Transfer station (Siemens, 2014)



Due to the fact that cruise ships have different sizes and requirements of heights for land power supply, it is important to have constructed and equipped the transfer station towards these individual requirements. The transfer station of the onshore facility is offering an adequate level of flexibility due to the horizontal and vertical movement opportunities.

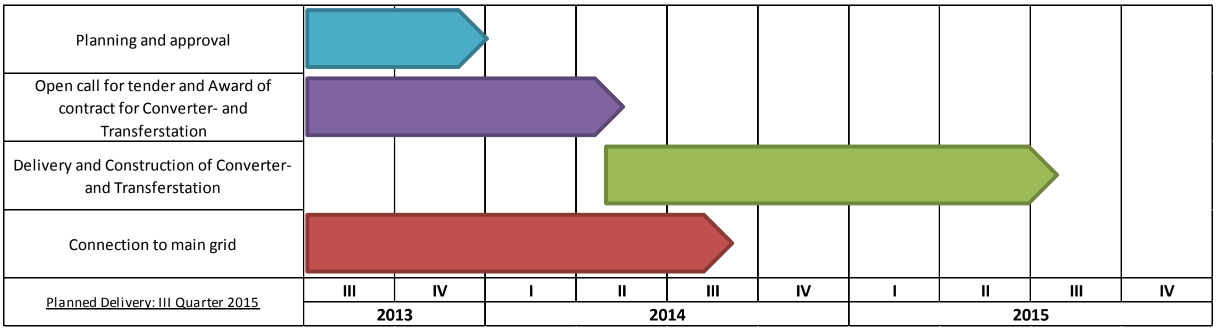
The Altona onshore power supply facility is globally unique and hence a pilot project. No other onshore facility has the ability and flexibility with regards to the frequency conversion as well as the transfer station. The converter station is also the only one globally which is capable to convert the frequency by considering the enormous amount of power needed (Kopp, 2013).

Thus, the project is also considered as a pilot project for further implementations within the field of cargo ships. The power demand of these ships is lower whereas a number of different constructions types is increasing. Therefore, an onshore supply facility for cargo ships would need a certain degree of flexibility for the transfer station especially by considering the cargo traffic occurring on the dockside of the ship. Consequently, this project is aimed to reduce the cruise ship emissions but also gives valuable input for future applications for all kinds of ships.

3.4. Planning timeline

The project horizon for the Altona onshore power supply facility started in December 2011 with the first public tender for a feasibility study and is planned to be finished in the 3rd quarter of 2015. The project is divided into four different sub-projects (Drucksache 20/5316, 2013), whereas the following graph only shows the final stages related to the construction phase without the full planning horizon going back to 2011:

Figure 4: Planning horizon of onshore supply terminal (Drucksache 20/5316, 2013)



3.5. Costs

Costs for shore-side electricity are for cruise ships substantially higher than common shore-side electricity installations for ferries or container ships. The European Commission names two crucial parameters that have an impact on the installation costs (EC, 2009). Firstly, the connection to the main power grid, capable of transporting high or middle voltages, requires certain investment in terms of engineering work but also equipment.

The expensive connection to the main power grid is necessary to fulfil the substantial power demand of cruise ships. The second cost driver in the construction of a shore-side electricity facility for cruise ships is the requirement to adapt to the different frequency. The electricity network on board of cruise ships conforms to the North American network which uses a frequency of 60 Hz while the European network provides 50 Hz. Therefore, a costly converter needs to be installed to adapt to the power needs of the ship.

The costs for Altona are divided into construction costs as well as operating cost. The estimated overall construction costs rise up to 10 million. Euro, while the operational costs are estimated to reach about 84,000 Euro. Table 3 provides an overview of the costs and the planned financing. However, so far the details of the terminal operation are not defined, so that the responsible organisation for carrying the operational costs cannot be named, yet (Drucksache 20/5316, 2013):

Table 3: Cost overview of the onshore power supply terminal (planned) (Drucksache 20/5316, 2013)

Type of cost		Financing
Construction costs	10 Mio €	• Budget "Free Hanseatic City of Hamburg" • EU Funds (TEN-T) • National funding application pending (Federal Environment Ministry)
Operational costs* (*Fixed + Variable [70 yearly cruise ship calls])	84,000 €	• Primary: Cruise Shipping company (User) • Variable costs not covered: Cost absorption by operator of terminal • Fixed cost costs not covered: Cost absorption by Free Hanseatic City of Hamburg

4. Involved actors

Within the project of the onshore power supply facility in Altona several different parties are involved which have a particular role (Drucksache 20/5316, 2013):

1. Awarding authority
2. General contractor
3. Local authorities
4. Energy network operator
5. Owner of suprastructure
6. Cruise ship companies
7. (Residents)

1) Awarding authority:
The Hamburg Port Authority (HPA) will be awarding authority and owner of the terminal applica-tions. The HPA had been assigned by the local Ministry for Economic Affairs, Transport and Innovations (BWVI) to plan, develop, and implement the project. This is founded on the federal law of the Free and Hanseatic City of Hamburg, in which it is stated that the authority is responsible for the development and maintenance of the port (Gesetz über die Hamburg Port Authority (HPAG), § 2 ff.)). Additionally, the HPA applied for funding from the TEN-T programme funds (see section 7). Due to the fact that the estimated construction costs are exceeding 5,186,000 Euro, the public procurement law apply. This makes it necessary to make an EU wide tender, needed to be followed (Commission regulation (EU) No 1336/2013). The public tender led to a contract with the general contractor.

2) General contractor:
The general contractor in this project is the "Siemens" subsidy located in Hamburg. This company has won the tendering with its expertise to built complex and flexible electronic projects. The contrac-tor is also assigning subcontractors for infrastructural construction.

3) <u>Local authorities:</u>
Namely two local authorities are directly involved in the project. Firstly, the “Ministry for Economic Affairs, Transport and Innovations of the Free and Hanseatic City of Hamburg” as the local authority with regards to infrastructural projects within the federal state of Hamburg. The second involved authority is the “Ministry for Urban Development and Environment of the Free and Hanseatic City of Hamburg” which is focusing on environmental aspects of the federal state. Both authorities have been assigned by the Senate of the Free Hanseatic City of Hamburg to check possibilities for a sustainable and environmental friendly concept for cruise tourism in Hamburg.

4) <u>Energy network operator:</u>
In this particular case of the onshore power supply facility in Altona the energy network operator is “Stromnetz Hamburg GmbH”. This company is very important for the project as it is the owner of the nessecary grid and will implement the connection between the main grid and the terminal. The energy supplying company has not been awarded yet, whereas the communication about the necessary amount of power is very important based on the possibility of power bottlenecks for residential households due to the high power demand of cruise ships.

5) <u>Owner of suprastructure:</u>
The owner of the terminal is the “Fischereihafenentwicklungsgesellschaft mbH & Co. KG” (FEG) which is renting their land on long term contracts to the cruise terminal operator. An involvement in the planning procedure is required due to infrastructural constructions, which were planned on the terminal. Between the local authorities and the landlord a commitment has been found, in particular due to the interest of the landlord to increase the environmental friendliness and acceptance of the cruise ship terminal towards residents.

6) <u>Cruise Ship Companies:</u>
On the customer side of the project are to be named the cruise shipping lines calling the Port of Hamburg. Highlighted hereby is the “AIDA” Company, which has frequent berthing in Hamburg, based on their support and contribution to the project. AIDA has been involved in the planning concept, based on the fact that already one of their cruise ships (AIDAsol) has the required infrastructure for onshore supply. Therefore, the company gave valuable input during the planning process of the project.

7) <u>Residents:</u>
Not directly involved but one of the biggest beneficiary of the project are the residents who live close to the cruise terminal as well as the population of Hamburg. The reduction of harmful emissions is significant and is thus contributing to a better life quality.

5. EU and national legislation

5.1. Air quality goals and legislative EU framework

The overall goal of the European Union is a reduction of energy consumption in Europe by 20% by 2020 (EC, 2014a).

Next to the reduction of energy consumption the EU has also recommended for member states to implement onshore electricity supply. In the "Directive (2006/339/EC)" it is recommended for the EU member states to consider the installation of shore side electricity for the use by ships during berth in ports, especially where air quality limit values are exceeded close to residential areas (EC, 2009). This directive specifically encourages the governments of the member states to evaluate the environmental benefits and cost-effectiveness on a case-by-case basis.

However, an essential part of EU legislations dealing with environmental factors are addressing air quality of urban areas. The leading directive in this regard has been the "Air Quality Framework Directive 96/62/EC". This Directive describes the basic principle of how air quality should be assessed in the member states (EC, 2009). This so called Air Quality Framework Directive has four daughter directives namely "Council Directive (1999/30/EC)", "Directive (2000/69/EC)", "Directive (2002/3/EC)" and "Directive (2004/107/EC)". Another important directive is the so called "Directive on ambient air quality and cleaner air for Europe (2008/50/EC)". This directive combines the first three daughter directives but also sets new reduction targets for PM (Particular Matter).

Next to general environmental legislations about air quality, legislations addressing the ship emissions are a legal basis for every measurement in this field. Due to the fact that cruise shipping is an international business the International Maritime Organization (IMO) has been entrusted with the task to develop and maintain a regulatory framework with regard to safety, environmental concerns, legal matters, technical cooperation, maritime security and efficiency of shipping. Based on the recommendations of the IMO the EU developed international legislations on air emission for the shipping sector. The following table shows this legislation on air emissions which are currently in force and which will come up in the future (EC, 2009):

Table 4: Air quality legislative framework from the EU (EC, 2009)

Effective from:	Rules applicable:	Effect to be reached:
July 2000	1999/32/EC	Maximum of 0.2% m/m sulphur content of Marine Gas Oil in EU ports
1 January 2000	Marpol Annex VI	Engines built from Jan 2000 modified existing to comply with Nitrogen Oxide (NOx) Technical code (Tier I, the emission of nitrogen oxides from the engine must be within certain limits, see Revised Marpol Annex VI, as amended on 9 October 2008)
19 May 2005	Marpol Annex VI	Maximum of 4.5% m/m sulphur content of bunker fuel & BDN stating sulphur content and density of fuel delivered (worldwide)
19 May 2006	Marpol Annex VI	Baltic Sea SECA, Maximum of 1.5% m/m sulphur content of bunker fuel
11 August 2006	2005/33/EC	Maximum of 1.5% m/m sulphur content of bunker fuel for Scheduled Passenger Vessels (> 12 passengers) calling EU ports
11 August 2006	2005/33/EC	Maximum of 1.5% m/m sulphur content of bunker fuel for all vessels in the Baltic Sea (SECA)
16 August 2006	1999/32/EC 2005/33/EC	No sale of >1.5% sulphur content of Marine Diesel Oil in EU ports
11 August 2007	2005/33/EC	Maximum of 1.5% m/m sulphur content of bunker fuel for all vessels in the North Sea (SECA)
22 November 2007	Marpol Annex VI	North Sea (SECA), Maximum of 1.5% m/m sulphur content of bunker fuel;
1 January 2008	1999/32/EC 2005/33/EC	Maximum of 0.1% m/m sulphur content of Marine Gas Oil in EU ports; no sale of >0.1% Marine Gas Oil in EU ports
13 April 2008	Marpol Annex VI	All vessels have obtained International Air Pollution Prevention Certificate
1 January 2010	2005/33/EC	Maximum of 0.1% m/m sulphur content of bunker fuel for all vessels at berth (and inland waterways) in the EU
1 January 2010	1999/32/EC	No sale of >0.1% sulphur content of Marine Gas Oil in EU ports
1 July 2010	Marpol Annex VI	Maximum of 1.0% m/m sulphur content of bunker fuel in Baltic Sea (SECA) and North Sea (SECA)
1 January 2012	Marpol Annex VI	Maximum of 3.5% m/m sulphur content o *1 January 2012* Marpol Annex VI * f bunker fuel (worldwide)
Upcoming Legislations:		
1 January 2015	Marpol Annex VI	Maximum of 0.1% m/m sulphur content of bunker fuel in Baltic Sea (SECA) and North Sea (SECA)
1 January 2016	1999/32/EC 2005/33/EC	Engines built from Jan 2011 modified existing to comply with NOx Tier III, the emission of nitrogen oxides from the engine must be within certain limits, see Revised Marpol Annex VI, as amended on 9 October 2008
1 January 2020	Marpol Annex VI	

5.2. Legislation onshore power facility

Next to directives about air emission and the TEN-T Guidelines[1], which relevant articles will be listed in Sector 6, the following table gives an overview about some of the laws and regulations which need to be considered during the construction and operation process of an onshore power supply facility:

Table 5: EU and national laws to be considered for the project

Name of the Law	Abbreviation/Paragraphs	Description
Hamburg Port Authority Gesetz	HPAG § 3	The HPA is in charge all processes related to planning, the development, administration and maintenance of the port infrastructure
Haushaltsordnung der Freien und Hansestadt Hamburg	HmbGVBl. 1971 p. 261, 1972 p. 10, §§ 23, 44	The legal basis for the grant by the City of Hamburg
Hamburgische Bauordung	HBauO	The construction of the terminal demanded the approval of the local authorities within the framework of the HBauO
Commission Regulation (EU) No 1336/2013: Application thresholds for procedures for awards of contract	Art. 1, (1) b	Public Procurement Procedures (EU wide) due to the estimated costs of 10,000,000 € that are exceeding the limit of 5,186,000 €
Directive 2014/94/EU: Directive on the deployment of alternative fuels infrastructure	Art. 4, No. 5-6	Member states shall ensure onshore power supply is available for waterborne vessels which also needs to comply with the technical specifications set out in the directive.
Treaty on the Functioning of the European Union	TFEU Article 107	Regulations about financial aid and competition regulations
Optional Laws		
Energiewirtschafts-gesetz	EnWG §2 ff.	In case that the HPA will become operator of the terminal the authority is acting as an energy provider and hence needs to follow the EnWG.
Gesetz über die elektromagnetische Verträglichkeit von Betriebsmitteln	EMVG § 4 ff.	The operator of the terminal needs to be aware of the fact that during the energy supply process excessive electr-icity is flowing and that connected magnetism affects the environment. Therefore the law of electromagnetic applications (EMVG) needs to be considered

[1] TEN-T Guidelines is the common short form for the official legal European Union document "Regulation (EU) No. 1315/2013 of the European Parliament and of the Council of 11 December 2013 on Union guidelines for the development of the trans-European transport network and repealing Decision No. 661/2010/EU, OLJ 348, 20.12.2013".

In addition, all construction actions have to respect the national laws as the Federal Immission Control Act with the ordonances for its implementation or the Federal Nature Conversation Act with the relevant Hamburg's Act on the its implementation.[2]

6. TEN-T Guidelines

The articles of the TEN-T guidelines which are related to and requirements of the construction of onshore power supply possibilities for vessels are listed below.

Table 6: Related TEN-T guidelines

Article	Title	Description
Chapter II: The comprehensive network Section 4: Maritime transport infrastructure and motorways of the sea		
20 (c)	*Infrastructure components*	Maritime transport infrastructure shall comprise, in particular: c) maritime ports, including the infrastructure necessary for transport operations within the port area;
23 (d)	*Priorities for maritime infrastructure development*	In the promotion of projects of common interest related to maritime infrastructure, and in addition to the priorities set out in Article 10, priority shall be given to the following: d) introduction of new technologies and innovation for the promotion of alternative fuels and energy-efficient maritime transport, including LNG;
Chapter II: The comprehensive network Section 7: Common provisions		
30 (f)	*Urban nodes*	When developing the comprehensive network in urban nodes, Member States shall, where feasible, aim to ensure: f) promotion of efficient low-noise and low-carbon urban freight delivery
32 (a), (d)	*Sustainable freight transport services*	Member States shall pay particular attention to projects of common interest which both provide efficient freight transport services that use the infrastructure of the comprehensive network and contribute to reducing carbon dioxide emissions and other negative environmental impacts, and which aim to: a) improve sustainable use of transport infrastructure, including its efficient management; d) stimulate resource and carbon efficiency, in particular in the fields of vehicle traction, driving/steaming, systems and operations planning;

[2] German original law titles: Gesetz zum Schutz vor schädlichen Umwelteinwirkungen durch Luftverunreinigungen, Geräusche, Erschütterungen und ähnliche Vorgänge; Verordnungen zum Bundes-Immissionsschutzgesetz; Gesetz über Naturschutz und Landschaftspflege; Hamburgisches Gesetz zur Ausführung des Bundesnaturschutzgesetzes.

Article	Title	Description
Chapter II: The comprehensive network Section 7: Common provisions		
33 (b); (c); (f); (h)	*New technologies and innovation*	In order for the comprehensive network to keep up with innovative technological developments and deployments, the aim shall be in particular to: b) make possible the decarbonisation of all transport modes by stimulating energy efficiency, introduce alternative propulsion systems, including electricity supply systems, and provide corresponding infrastructure. Such infrastructure may include grids and other facilities necessary for the energy supply, may take account of the infrastructure-vehicle interface and may encompass telematic applications; c) improve the safety and sustainability of the movement of persons and of the transport of goods; f) promote measures to reduce external costs, such as congestion, damage to health and pollution of any kind including noise and emissions; h) improve resilience to climate change.
35	*Resilience of infrastructure to climate change and environmental disasters*	During infrastructure planning, Member States shall give due consideration to improving resilience to climate change and to environmental disasters.
36	*Environmental protection*	Environmental assessment of plans and projects shall be carried out in accordance with the Union law on the environment, including Directives 92/43/EEC, 2000/60/EC, 2001/42/EC, 2009/147/EC and 2011/92/EU.
Chapter III: The core network		
39 1, 2 (b)	*Infrastructure requirements*	1. Innovative technologies, telematic applications and regulatory and governance measures for managing the infrastructure use shall be taken into account in order to ensure resource-efficient use of transport infrastructure for both passengers and freight transport and to provide for sufficient capacity. 2. The infrastructure of the core network shall meet all the requirements set out in Chapter II. In addition, the following requirements shall be met by the infrastructure of the core network, without prejudice to paragraph 3: b) for inland waterway and maritime transport infrastructure: availability of alternative clean fuels;

7. Funding possibilities

The action of the development and construction of an onshore power supply facility in the Port of Hamburg has been subsidized by the European Union. The total amount of 3.55 million Euro was granted by the European Commission via the TEN-T programme 2007-2013 (HPA, 2014a; Drucksache 20/5316, 2013), the funding programme of the European Commission for projects which supported the construction and upgrade of transport infrastructure in Europe during the named years. The project runs under the full title “Tackling the environmental impact of shipping: Pilot implementtation of a shore-side electricity supply for ships with increased energy demand (market innovation)” (TEN-T project 2012-DE-92052-S) and aims not only at the construction of the pilot case which will help to provide technical feasibility proofs for vessels with high energy requirements but will also involve a study which will develop best practice guidelines and a checklist for similar projects (INEA 2014a).

Furthermore, the HPA has applied for funding from the “Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety”. Hereby in particular the application aimed for the programme “Eco Innovation Programme”. This national funding initiative supports innovative projects which are considered as a suitable pilot project to foster sustainable innovations. (BMU, 2014) The approval of the application is still pending.

In general, projects which come under the TEN-T guidelines are supported by the EU. Under the related Connecting Europe Facility (CEF) Regulation,[3] a total budget of 26.2 billion Euro are disposed for co-funding TEN-T projects in the Member States for the funding period 2014-2020. The CEF Regulation is the legal basic document for the CEF Transport funding programme, which was established by the European Commission in 2014 as successor of the TEN-T Programme. Funding investments of the CEF Transport are programmed in Annual and Multi-Annual Work Programmes, which clarify the different funding priorities and determine the amount of financial investment for each priority in the year of the specific calls. The CEF Transport Work Programmes start with their first calls in 2014 (EC, 2014b, INEA, 2014b).

The 2014 Annual and Multi-Annual calls are divided into different “Funding Objectives (FO)” and their related priorities. Applications have to be submitted by 26 February 2015. Table 7 shows an overview of the calls.

[3] Connection Europe Facility or CEF is the short form for the legal European Union document “Regulation (EU) No. 1316/2013 of the European Parliament and of the Council of 11 December 2013 establishing the Connecting Europe Facility, amending Regulation (EU) No. 913/2010 and repealing Regulations (EC) No. 680/2007 and (EC) No. 67/2010, OJ L 348, 20.12.2013”. The CEF is divided into the three sectors of the overall TEN networks: Transport, Energy and Telecom.

Table 7: Overview of the 2014 annual and multi-annual CEF Transport Calls (INEA, 2014b)

2014 Annual Work Programme			
	Funding Objectives	Priorities	Max. available budget
Annual Call	#1: Removing bottlenecks and bridging missing links, enhancing rail interoperability, and, in particular, improving cross-border sections #2: Ensuring sustainable and efficient transport systems in the long run, with a view to preparing for expected future transport flows, as well as enabling all modes of transport to be decarbonised through transition to innovative low-carbon and energy-efficient transport technologies, while optimising safety #3: Optimising the integration and interconnection of transport modes and enhancing the interoperability of transport services, while ensuring the accessibility of transport infrastructures	○ Projects on the Core Network ○ Projects on the Comprehensive Network ○ Projects to connect with neighbouring countries ○ Innovation ○ Freight transport services ○ Rail freight noise ○ Telematic applications ○ Accessibility ○ Core Network Nodes ○ Multimodal logistics platform	EUR 930 million
2014 Multi-Annual Work Programme			
FO 1	Removing bottlenecks and bridging missing links, enhancing rail interoperability, and, in particular, improving cross-border sections	○ Core Network Corridors ○ Other sections of the Core Network ○ Rail Interoperability ○ ERTMS	EUR 6 billion
FO 2	Ensuring sustainable and efficient transport systems in the long run, with a view to preparing for expected future transport flows, as well as enabling all modes of transport to be decarbonised through transition to innovative low-carbon and energy-efficient transport technologies, while optimizing safety	○ Innovation ○ Safe and secure infrastructure	EUR 250 million
FO 3	Optimising the integration and interconnection of transport modes and enhancing the interoperability of transport services, while ensuring the accessibility of transport infrastructures	○ SESAR ○ RIS ○ ITS for road ○ Motorways of the Sea ○ Core Network Nodes ○ Multimodal logistics platform	EUR 750 million

2014 Multi-Annual Work Programme			
	Funding Objectives	Priorities	Max. available budget
Specific Call for Cohesion Funds	Cohesion Fund allocation	○ Core Network Corridors ○ Other sections of the Core Network ○ ERTMS ○ Innovation ○ Safe and secure infrastructure ○ Motorways of the Sea	EUR 4 billion

Regarding possible future projects for ship energy reduction while berthing, the 2014 Multi-Annual call, FO 2, offers funding possibilities for the deployment of new technologies and innovation to support the decarbonisation of transport systems. Priority is given to initiatives located in the TEN-T core network, with a special focus on the pre-identified projects listed in Annex I / Part I of the CEF Regulation. Special objectives include measures which stimulate energy efficiency, including electricity supply systems (INEA 2014c). Projects including the deployment of new technologies and innovation not covered by the Multi-Annual Work Programme might receive financial support via the 2014 Annual Call, Priority Innovation. This call focuses on actions in the overall comprehensive network with a priority to projects located on sections of the core network but being not addressed by the Multi-Annual programme. (INEA 2014d). All final requirements and definitions for an eligibility of a specific project via the named calls can be found in the Work Programmes legal documents of the European Commission.

Furthermore, the Priority 4 of the “Interreg VB North Sea Region Programme 2014-2020” offers funding possibilities for initiatives which are reducing green house gas emission as well as improving the environmental friendliness of cruise transports (North Sea Region Programme, 2014).

Moreover, the Horizon 2020 programme, which has a funding of EUR 80 billion, is offering funding within the field of Energy, Environment & Climate Action, Innovation and Transport (Horizon 2020, 2014).

8. Similar Projects

This chapter describes similar projects in the field of alternative energy supply for vessels.

8.1. Similar onshore power supply projects

Part of the overall Port of Hamburg approach for an alternative energy supply for cruise ships is another innovative project. On the second cruise ship terminal in Hamburg, called “Hafen City”, the emission of cruise ships are planned to be reduced by providing external power supply. Other than on the terminal in Altona the power is not provided by the main grid but by a mobile power barge. This 76 meter long power barge uses Liquefied Natural Gas (LNG) or E-Power respectively to generate energy in a small but efficient block heating station on board (Drucksache 20/5316, 2013). The pro-duced energy is then, in the next step, connected to the electrical infrastructure on the terminal and provided to the cruise ships. This type of a mobile power unit allows a bigger level of flexibility and opens the opportunity to provide external energy to other ships than cruise ships without the necessity of extensive investment costs. The costs for the electrical infrastructure on the terminal are 2 million Euro and offer the same flexibility as the application on the terminal in Altona (HPA, 2014b). Due to the innovative character of this type of a power barge the approval process has been long lasting while the first barge reached Hamburg in October 2014 (dpa, 2014). The infrastructure on the terminal side is ready for operation since October 2014 and will be completed by end of 2014. The terminal infrastructure costs of this project are financed by the Free and Hanseatic City of Hamburg and funded on a national level by the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety. In particular the funding application, in this case, is aimed towards "Eco Innovation Programme" but the decision about co-financing is still pending. The hybrid barges are developed and financed by private companies.[4]

On a global scale, several ports are offering shore-side electricity connections, whereas most of these are not suitable for cruise ships which have a larger demand for power. The European ports mainly adjusted their onshore power supply for ferries, inland ships and other types of cargo ships (EC, 2009). Onshore power supply is also addressed on a global scale within the work of the World Ports Climate Initiative (WPCI, 2014). Within this conglomerate the world leading ports have come together in a commitment to reduce their greenhouse gas emissions from port operations while continuing their role as transportation and economic centres. As one major initiative to achieve the set goals, the onshore power supply platform has been created which promotes this type of energy supply among the world's leading ports (OPS, 2014).

The following table gives an overview about shore supply on a global scale also including cargo ships (OPS, 2013; EC, 2009):

Table 8: Ports providing onshore energy (OPS, 2013)

Year of Introduction	Port	Country	EU / North America	Facility available for
2000-2010	Gothenburg	Sweden	EU	RoRo, ROPAX
2000	Zeebrugge	Belgium	EU	RoRo
2001	Juneau	U.S.A	North America	Cruise
2004	Los Angeles	U.S.A	North America	Container, Cruise
2005-2006	Seattle	U.S.A	North America	Cruise
2006	Kemi	Finland	EU	ROPAX
2006	Kotka	Finland	EU	ROPAX
2006	Oulu	Finland	EU	ROPAX
2008	Antwerp	Belgium	EU	Container
2008	Lübeck	Germany	EU	ROPAX
2009	Vancouver	Canada	North America	Cruise
2010	San Diego	U.S.A	North America	Cruise
2010	San Francisco	U.S.A	North America	Cruise

[4] For further information about the project, see www.lng-hybrid.com.

Year of Introduction	Port	Country	EU / North America	Facility available for
2010	Verkö, Karlskrona	Sweden	EU	Cruise
2011	Long Beach	U.S.A	North America	Cruise
2011	Oslo	Norway	EU	Cruise
2011	Prince Rupert	Canada	North America	
2012	Rotterdam	Netherlands	EU	ROPAX
2012	Ystad	Sweden	EU	Cruise
2013	Trelleborg	Sweden	EU	
2015	Hamburg	Germany	EU	Cruise

In 2000 the Port of Gothenburg was the first port to introduce a high-voltage on-shore power supply for cargo vessels (OPS, 2014). Already in 1989 the port offered (and still offers) low-voltage shore-side electricity to Ro-Ro-ferries. The main driver of the high voltage project has been the forest and paper supplying company Stora Enso which initiated the project within their green logistic concept. The system is providing power of 6.6 kV and 10 kV at 50 Hz to ships through a transformer substation which is connected to the main grid. Additionally, the port of Gothenburg is capable to provide 60 Hz frequency due to a new implemented frequency converter station implemented in 2011 for the ferry company “Stena Line” (Port of Gothenburg, 2013). In cooperation with the EU and also the Swedish authorities the port of Gothenburg is charging very low, rather symbolic, taxes of 0.005 SEK/kWh (before 0.28 SEK/kWH) for the provided electricity. This initiative is aimed to give more shipping companies an incentive to retrofit their on board machineries towards the onshore power supply infrastructure. Port of Gothenburg (2013) states that the onshore power supply is not only beneficiary for the Port of Gothenburg but also allows the knowledge exchange with other global ports.

8.2. Interreg IVB and TEN-T Programme funded projects

A reduction of emissions and greenhouse gas from ships was the focus of the Interreg IVB North Sea Region Project “CNSS – Clean North Sea Shipping”. The projects objective was to improve the environmental and health situation caused by the ship emissions in ports and at sea in the North Sea Region. CNSS also wanted to pave the way for an incentive and regulatory framework which causes an increased use of environmentally friendly technologies and fuels in shipping and at the same time maintain the competitive position of the North Sea maritime transport.[5]

The Interreg IVB North Sea Region “Cruise Gateway” project aimed to develop the North Sea as a sustainable cruise destination. Environmental challenges for ports caused by the cruise ship industry were addressed in the project. One of the goals was the sustainable growth of the cruise shipping market within the region by implementing environmental certificates for environmental-friendly cruise ships.[6]

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[5] Further information to be found at www.cnss.no.
[6] Further information to be found at www.cruisegateway.eu.

The objective of the cancelled TEN-T project “On Shore Power Supply – an integrated North Sea network” (2011-EU-21002-M) was to build onshore power supply at three different DFDS freight ferry terminals in the North Sea for three ro-ro vessels.[7]

The TEN-T project “Shore power in Flanders” supports the establishment of a shore power network for inland navigation in the Belgium region of Flanders. The action includes studies and pilot implementation in three different locations, which also involves the implementation of payment systems and the development of the related web application.[8]

Diverse TEN-T projects involve actions regarding pilots or studies in the field of alternative fuel technologies for vessels, such as LNG or methanol: An overview of all projects can be found on the website of the TEN-T programme: inea.ec.europa.eu/en/ten-t/ten-t_projects/ten-t_projects.htm.

[7] Further information to be found on the TEN-T projects website: inea.ec.europa.eu/en/ten-t/ten-t_projects/ten-t_projects_by_country/multi_country/2011-eu-21002-p.htm.
[8] Further information to be found at http://inea.ec.europa.eu/en/ten-t/ten-t_projects/ten-t_projects_by_country/belgium/2012-be-92063-s.htm

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