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IS COLD IRONING HOT ENOUGH?

An Actor Focus Perspective of On Shore Power Supply (OPS)
at Copenhagen's Harbour

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"After all this time, coming all this way,
You're getting far too close to stop.
Get a grip on this rock, and get a grip on yourself
If you're gonna make it to the top.
Be brave, little Alice. Believe in yourself
'cuz here's the most important part.
While all the others remember to use their heads,
You just remember to use your heart."

Said the Cheshire Cat to Alice.

Taken from "Alice in Wonderland" by Lewis Carroll

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Going back to school has been an intense and enriching journey. And now I feel a bit nervous, a bit excited and with a good splash of curiosity in my eyes: basically happy!

Abstract

This thesis focuses on cold ironing for vessels while berthed at port, with the port of Copenhagen as main case study. With the use of this technique, which is considered by the International Marine Organization (IMO) as a measure to reduce air pollution and noise deriving from shipping activities in ports and coastal areas, vessels are able to shut down their auxiliary engines in order to generate power and replace it with electricity supplied by the shore.

From next year, in 2014, Copenhagen will have a new cruise ship terminal and the port of Copenhagen, in conjunction with the City of Copenhagen are currently investigating the feasibility of installing cold ironing for the new quay. Existing uncertainties regarding the magnitude of the investment risk hindering the implementation of this technique and therefore there is a need for a leader that can push this shift. After a brief mapping of the key players involved, the role of the municipality of Copenhagen, because of its strong local contextual proximity, has been considered as the most suitable in facilitating this harbour's transition.

The research tries to detect some of the measure that the municipality of Copenhagen could undertake to encourage the development of cold ironing for the new terminal. The findings of the study highlight the strong political dimension of this transition and identify the necessity of creating a pool of Danish and Baltic municipalities in order to exert the indispensable pressure for changing the legislative framework related to the use of cold ironing as a main priority.

Keywords: cold ironing, on shore power supply, shore side electricity, alternative maritime power, transition, ships' emissions, Copenhagen, municipality

Executive Summary

With still a high dependence on fossil fuels, maritime transportation contributes significantly to air pollution in coastal areas. Marine transportation is expanding and so are its emissions that have damaging effects in several atmospheric components and on human health as well. Smokestack emissions from shipping activities are estimated to be responsible for up to 60.000 cardiopulmonary and lung cancer deaths per year and annual mortalities are expected to increase proportionally to the growth in maritime traffic. If no preventive action is taken, the European Commission forecasts that emissions from ships could reach already in 2020 the amount of land based emissions in the European Union.

Several ways exist to reduce emissions at ports: implementation of emission control technologies, like use of filters, selective catalytic reduction or scrubbers; the use of cleaner fuels, with a lower content of sulphur; speed control; and use of shore side electricity while at berth. Shore side electricity, also known under the name of cold ironing, has been pinpointed by the European Commission already back in 2005 as of the three main strategies for reducing shipping emissions. With the employment of this technique, which is also recognised by the International Marine Organization (IMO) as an emission reduction measure, vessels are able to shut down their auxiliary engines in order to generate power and replace it with electricity supplied by the shore.

Despite the maturity of the technology and the existence of several studies confirming the environmental benefits that cold ironing can bring, it is still a niche phenomenon, with not many ports worldwide ready for it. Developing and implementing a cold ironing system is a demanding process, which requires the concerted action and commitment of all port stakeholders, as well as a significant investment. Existing uncertainties regarding the magnitude of the investment risk hindering the implementation of this technique and therefore there is a need for an actor that takes the leadership and pushes for this change.

With more and more people moving to cities, municipal governments are increasing their capability of solving locally environmental issues of global nature. For this reason, capacity to steer this transition is to be found within the level of governance that is mostly open to democracy and closest to its citizens and thus most likely to accomplish the community's environmental needs: the municipality.

The objective of this research is to explore the transition mechanism behind the shift to shore side electricity, keeping an actor focus perspective to examine the capacities employed to facilitate the desiderated change. The transition that the port of Copenhagen is undergoing is analysed with a key focus on the actions undertaken by the municipality .The role and the capacity of Copenhagen's municipality are thus dissected in order to try to speculate on the different measure that could be taken to encourage the development of this technology. This thesis seeks to answer the following question: *"How can the Municipality of Copenhagen incentivize the use of on shore power supply?"*

This research is carried out mainly in the Danish context where Copenhagen's harbour is taken in as a case study. Existing foreign experiences within Scandinavia and the Baltic region are also embraced in order to provide a reference for a more comprehensive understanding of the barriers and opportunities that the transition towards shore side electricity can encounter as well as to grasp the role that municipalities can play.

The methodology employed for the research is based on different tools and techniques. Concepts expressed by the Transition Management Theory (TM) are utilised to systematically

collect and analyse data. TM was selected as a suitable framework because it provides a multi actor perspective that allows for understanding the relationship among the various actors, as well as a multi-phase and multi-level one, differentiating among different types of activities that take place in the different phases.

This thesis comprises elements of both quantitative and qualitative methods, with data triangulation carried out whenever possible. For gathering the necessary data, mainly two approaches were used: a desk research and a primary one. The findings presented in this paper derive mainly from secondary data retrieved from literature analysis and primary data accessed through interviews or personal communications via telephone or electronic mail. For the analysis of the collected data TM was integrated with elements of another theory, the policy arrangements approach (PAA), in order to highlight the political aspects of the transition.

The findings of the study put emphasis on the political dimension of the transition that the port of Copenhagen is undergoing. The municipality has expressed a strong interest in implementing cold ironing for the new cruise terminal. Furthermore, the municipality has also shown awareness on the necessity of amending the legislative framework for shore side electricity at national or even European level in order to make it attractive for all the actors involved. However, the actions taken so far to facilitate this change seem pretty limited. The municipality has entered into a dialogue with only few actors, acting mainly on its own, showing to underestimate the importance of engaging all the different actors and stakeholders that are directly or indirectly involved in this transition.

Based both on the findings and on the opinions received during the interviews the following recommendations are elaborated:

- The municipality needs to act as a facilitator, having the capability and the capacity in terms of resources, knowledge, connections and authority to engage the broader public and connect the several actors involved in this transition.

- The municipality shall also intensify its communication efforts, in order to encourage a bottom up change, raising awareness and outreaching all societal levels.

- The municipality should join forces with the tourism industry in order to promote Copenhagen as a green capital and sustainable cruise destination, thus putting pressure on the cruise industry to switch to shore side electricity.

- The municipality would benefit from establishing a network of Danish municipalities to strengthen cooperation in environmental and maritime protection matters. This exchange of knowledge could accelerate and positively influence the outcome of the transition.

- The municipality shall aim at creating a pool of municipalities among the Baltic capitals, in order to make cold ironing a benchmarking criterion among the ports generally visited by a cruise vessel on a Baltic itinerary. This would as well put pressure on the cruise industry.

- The municipality shall intensify its lobbying activities to be able to breach the system and improve the legislative framework for shore side electricity on national and European level. This shall be seen as a main a priority, having the creation of networks at Danish and Baltic level as a prerequisite for conducting more effective lobbying activities.

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Abbreviations

AE Auxiliary Engine

AMP Alternative Maritime Power

CO Carbon monoxide

CO_2 Carbon dioxide

CMP Copenhagen Malmö Port

DKK Danish currency unit (kroner)

EC The European Commission

ECA Emission Control Areas

EEDI Energy Efficiency Design Index

EPA Danish Environmental Protection Agency

ESD Emergency Shut Down

EU The European Union

GHG Green House Gasses

HC Hydro Carbon

HELCOM Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area

HVSC High-Voltage Shore Connection

HVSP High Voltage Shore Power

HZ Hertz

ICLEI International Council for Local Environmental Initiatives

IEC The International Electro technical Commission

IEEE The Institute of Electrical and Electronics Engineers

IMO The International Maritime Organization

IPPC Integrated Pollution Prevention and Control

ISO International Organization for Standardization

KBH2025 Copenhagen Climate Plan

MARPOL International Convention for the Prevention of Pollution from MCR Maximum Continuous Rotation

MDO Marine Diesel Oil

MEPC Marine Environment Protection Committee

MFO Marine Fuel Oil

MGO Marine Gas Oil

MLP Multi Level Perspective

MWh Mega Watt hour

N2 Nitrogen

NECA Nitrogen Oxide Emissions Control Area

NO_x	Nitrogen Oxide
NO_2	Nitrogen Dioxide
NOK	Norwegian currency unit (kroner)
OPS	On Shore Power Supply
PAA	Policy Arrangements Approach
PM	Particle Matter
PSSA	Particularly Sensitive Area
RO-RO	Roll on – Roll Off
SCR	Selective Catalytic Reduction
SECA	Sulphur Emissions Control Area
SEEMP	Ship Energy Efficiency Management Plan
SEK	Swedish currency unit (kroner)
SNM	Strategic Niche Management
SO_2	Sulphur Dioxide
SO_x	Sulphur Oxide
TM	Transition Management Theory
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNCLOS	United Nations Convention on the Law of the Sea
V	Voltage
VOC	Volatile Organic Compounds
WHO	Word Heath Organization

1 Introduction

1.1 Background on Emissions from Ships

Transport in general is an energy intensive economic sector, which last year accounted for 26,6 per cent of the total energy use (IEA, 2012) and in 2005 was calculated to be responsible for 14,3 per cent of the world energy related greenhouse gasses (GHG) emissions (Duduta & Bishins, 2010). Looking more specifically into the marine sphere, the global shipping industry contributes considerably to air pollution, especially in coastal areas: emissions to air are calculated to amount to 1 billion tonnes per year, accounting for 3 per cent of the global GHG emissions and 4 per cent of the EU total emissions (EC, 2013). As a matter of fact, nearly 70 per cent of ship emissions take place within 400 km from the coastlines (Corbett et al., 2007; EEA, 2013) because 80 per cent of the world fleet is either in port or navigating in coastal areas (van der Meer, 2012). When the harbour is situated within an urban area, emissions from ships can have a strong effect on local scale, being often a major source of pollution (Eyring et al., 2007).

A research carried out by Dalsøren et al. (2009) on emissions and environmental impacts from international ships, has shown that different types of vessels have a different impact on the environment in different regions. North-west Europe and Scandinavia are considered among the regions mostly affected by shipping activities operating close to coastal areas. Ships' emissions mainly relate to vibrations, noise, ozone, particulate matter (PM), carbon monoxide (CO), carbon dioxide (CO_2), hydrocarbon (HC), volatile organic compounds (VOCs), sulphur dioxide (SO_2) and nitrogen oxide (NO_x[1]) (Corbett and Winebrake, 2008). According to recent studies, it is estimated that ships cause 10 to 15 per cent of the total global NO_x emissions and 4 to 9 per cent for global SO_2 (Premuda et al, 2011; Schembari et al, 2012). With respect to Scandinavia, Dalsøren et al. (2009) report that shipping activities cause 25 to 50 per cent of nitrates deposition and 15 to 25 of sulphate present in this area. In fact, Scandinavian countries rank among those with the highest proportion of air pollutant deposits of SO_2 and NO_x deriving from seaborne transportation, as shown in table n. 1.

	SO_2	NO_x
Denmark	***39 %***	***28 %***
Netherlands	31 %	21 %
Sweden	25 %	25 %
Norway	25 %	23 %
U.K.	18 %	20 %
France	18 %	15 %
Italy	15 %	15 %
Belgium	13 %	16 %
Finland	12 %	17 %
Germany	10 %	10 %

Table 1: Countries with a high proportion of air pollutant deposits of sulphur and oxidised nitrogen from shipping. Adapted from AirClim (2011)

[1] NO_x is the collective name for NO and NO_2 emissions (Winnes, 2010).

If no preventive action is taken, the European Commission (2013) forecasts that NO_x and SO_2 emissions could duplicate in the next forty years (AirClim, 2011), reaching already in 2020 the amount of land based emissions in the EU (Schembari et al, 2012).

As summarized on table n. 2, emissions from ships affect several atmospheric components, having detrimental effects on ecosystems especially through ozone formation; GHG creation, which leads to global warming and consequent climate change; eutrophication and acidification of soil and water; and on human health (Dalsøren et al., 2009).

	Pollutant					
Impact categories	**Particles**	**SO_2**	**NO_x**	**CO_2**	**HC**	**CO**
Health effects	x	x	x			x
Acidification		x	x			
Photo – oxidant formation			x		x	
Eutrophication			x			
Climate change				x	x (CH_4)	

Table 2: Emissions from ships. Adapted from Winnes (2010)

There is a well-established linkage between high concentrations of particulate matter (PM) in coastlines or cities near major ports and adverse health conditions, which include diseases like lungs inflammations, asthma, cardio pulmonary pathologies, lung cancer, heart attacks and premature deaths (WHO, 2005). According to a study carried out by Corbett et al. (2007) on mortality from ship emissions, smokestack emissions from shipping activities are responsible for up to 60.000 cardiopulmonary and lung cancer deaths per year[2]. Corbett et al. (2007) estimate that 3 to 8 per cent of PM related mortalities can be attributed to marine shipping activities. Annual mortalities caused by these emissions are expected to increase proportionally to the growth in maritime traffic.

Emissions from shipping activities can have both trans-boundary and local effects. If it can be argued that CO_2 geospatial distribution is not of real importance, it cannot be said the same about other pollutants. In fact, while CO_2 emissions are mostly related to greenhouse gasses formation and consequent global warming, PM, NO_x, and SO_2 emissions are chiefly having detrimental environmental effects on regional and local scale, rather than on a global one. Besides, air pollution can travel in the atmosphere over several hundreds of kilometres, ergo emissions from vessels cause air quality issues also on land even when they actually occur at sea. Thus it is very important to control as much as possible emissions related to shipping activities.

1.1.1 How to Reduce Emissions at Berth?

A recent report issued by the European Environmental Agency (EEA, 2013), has highlighted that maritime transportation contributes significantly to air pollution and climate change[3] mainly for two reasons: because it is one of the areas whose emission sources are least regulated and because of its high dependence on fossil fuels. In fact, due to the combustion characteristics of vessels engines, which in most cases consist of a four stroke diesel engine

[2] This has been quantified into an annual cost to society of more than € 58 billion (AirClim, 2011).

[3] Carbon dioxide emissions (CO_2) related to international shipping departing from EU ports has increased by 35 per cent between 1990 and 2010 (EEA, 2013).

for propulsion, and the use of unrefined fossil fuels, such as marine fuel oil (MFO), marine diesel oil (MDO), marine gas oil (MGO), many impurities of residual fuel are expelled from the ship's stack. While the main engines are normally switched off after berthing, the auxiliary engines keep on running in order to produce the electricity necessary to continue the activities on board, such as heating, lightning, air conditioning, cooling, running of the galley and all the different equipment used in the cargo loading and unloading procedure. Auxiliary engines most of the time function on cheap and low quality fuels (Ericsson & Fazlagic', 2008) and this fact associated to the high power requirements needed to run them, makes ships highly polluting while at berth.

The European Commission in a study on abatement technologies for main and auxiliary engines installed on ships carried out in 2005 pinpointed three main strategies: NO_x emissions abatement techniques; SO_2 abatement techniques with focus on sea water scrubbing; and shore side electricity while at berth[4]. Also Winnes in her doctoral dissertation about air pollution from ships (2010), after a throughout analysis of ships' emissions to air, concludes that the results from her impact assessment indicate that the most favourable solutions for reducing NO_x and SO_2 emissions focusing on a local perspective are selective catalytic reduction (SCR)[5], shore side electricity connection and the use of a fuel with a reduced sulphur content.

The EU has been trying to limit the sulphur content in marine fuel[6] in order to reduce SO_2 emissions. However, as this Directive does not tackle pollution related to other emissions, like CO_2, PM and NO_x, which remain still unregulated, switching off the engines on board and connecting to the electricity supply on shore side, could be recommended (Ericsson & Fazlagic', 2008). Yang et al. (2011) report that the use of shore side electricity is directly linked to a reduction of local emissions as it is mainly effective in reducing SO_2, NO_x, and PM emissions that principally impact the local environment.

Additionally, the use at berth of electricity coming from the local grid is to be considered an emission reduction measure as this power supply is more likely to come from energy sources with lower emission factors per megawatt-hour (MWh), like wind, hydro, or nuclear for instance (ECDCE, 2005) and thus avoid the negative local environmental and health impacts. Moreover, land based power plants are often subject to more stringent emission controls[7] and thus supplying electricity on shore side rather than utilizing the ships' auxiliary engines can result in emission abatement.

1.1.2 Problem Definition: Why is Shore Side Electricity not Mainstream?

Despite several studies (Hall, 2010; Trozzi 2012) confirming the environmental benefits that the use of shore side electricity can bring, not many[8] ports worldwide have their electrical infrastructure ready for it, and shore side electricity, also known as on shore power supply

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[4] This technique is also known as cold ironing or on shore power supply (OPS).

[5] This is used for converting NO_x into diatomic nitrogen (N_2) and water with the aid of a catalyst.

[6] Directive 2012/33/EU which amends Council Directive 1999/32/EC as regards to the sulphur content of marine fuel.

[7] In the EU, for example, the Directive 2008/1/EC concerning integrated pollution prevention and control (the IPPC Directive) regulates the issuance of permits for industrial and agricultural activities that carry a high risk of pollution while the Directive 2001/80/EC (the LCP Directive) limits the amounts of pollutants coming into the air from large combustion plants.

[8] There are around 20 ports worldwide offering high voltage on shore power supply and an equal if not higher number of ports considering installing it (OPS, 2013).

(OPS) is thus still to be considered a niche phenomenon. In North America as well as in Europe, OPS systems have been developed for seagoing ships in the last decade. The experience of the port of Gothenburg in Sweden, which has been the first port worldwide to offer shore side electricity for cargo vessels (WPCI, 2013) has proven that the system can be simple and work efficiently when high-voltage systems are used (HELCOM, 2005).

A study conducted in 2005 by the Baltic Ports Organization in association with TransBaltic on a development perspective for the harbours in the Baltic region, has highlighted that the way a port develops is strictly connected to its underlying management system. Different forms of sea port management exist within the EU and in the Baltic area. While in central Europe, like in Germany, Belgium or The Netherlands it is mainly the local and regional administrations that intervene, in the Northern Baltic Area, like in Denmark, Sweden or Finland there are predominantly municipal ports. In Denmark, for instance, only few ports are privately owned. The existing ports can operate as independent bodies in the organizational structure of the city, or as private companies with the cities and therefore the municipalities as shareholders. In the latter case, the ownership can also be mixed, with both private companies and the municipalities as shareholders (Rozmarynowska & Oldakowski, 2011).

Developing and implementing an OPS system is a strategic choice that requires the concerted action and commitment of all major stakeholders (WPCI, 2013). From a more generic port management perspective, according to Frémont and Franc (2010), three categories of port stakeholders can be found:

- Economic agents, which are directly involved in the organisation of the port operations: these include shippers, shipping lines, freight handlers;

- Public authorities, which include all different levels of decision makers at International, European, National and local level;

- Community groups, representing social demands.

Even though very different necessities or benefits might lie underneath their interests, they are all concerned about costs, environment and traffic flow (Frémont and Franc, 2010).

Several are also the actors and the stakeholders involved in the use of OPS technology (WPCI, 2013), which are related to the mentioned categories: the energy companies as electricity suppliers; the shipping companies, especially the so called frequent or regular callers; the municipality, which can often assume different roles and act within different capacities; harbour authorities; port and terminal operators; the local community that might be harmed by the negative environmental effects of shipping pollution; and the suppliers of the automation technology (WPCI, 2008).

Nevertheless, regardless of who is primarily pushing for this change, it has to be feasible and economically convenient. There can be many drivers for the implementation of OPS: it could be pressure from people living near city harbours, as ships' emissions have a negative effect on their health; a political choice taken at local or governmental level; the entry into force of new regulations and so on.

OPS can give good results depending on the attitude of the parties on the land as well as the ship-owners (WPCI, 2013). However, several barriers to its success have been identified: the difference in price between electricity produced on board and on shore side; the adaptability of the existing fleet of ships to shore connection; compatibility of electricity parameters, as no uniform voltage and frequency requirements exist (HELCOM, 2005). If it can be argued that technological barriers are easier to overcome (Ericsson & Fazlagic', 2008), the main barriers are fundamentally of financial and economic nature, relating mainly to the cost of energy and of the infrastructure at terminals (Arduino et al., 2011), which can vary to a great extent depending on the port. The cost of supplying electricity at shore side will differ greatly depending on whether the port terminal exists already and the installation of OPS infrastructure will therefore be retrofitted, or whether the OPS infrastructure can be installed when constructing a new quay or terminal. The cost will also be influenced by the electricity infrastructure in the area where the harbour is located, as it might also need to be upgraded in order to satisfy the additional electricity demand (ECDGE, 2005).

It becomes obvious that the financing of port development is a fundamental issue and in order to implement an OPS system in the most cost efficient way, some of the stakeholders need to be included in the process at a very early stage, for example during the planning phase of a new terminal or quay (WPCI, 2008). This raises the question of who is or could actually be the most suitable actor or stakeholder to take responsibility to initiate and promote this port transition. Existing uncertainties regarding the magnitude of the investment risk hindering the implementation of this technique and therefore there is a need for a leader that can push this shift.

As many of the current environmental problems are related to human activities that concentrate more and more in cities and to the fact that the number of people moving to cities is steadily growing (Zimmermann, 2012) the solution shall be found within the level of governance that is mostly open to democracy and closest to its citizens and thus most likely to accomplish the community's environmental needs: the municipality.

Over twenty years ago, at the United Nations Conference on Environment and Development (UNCED) held in 1992 in Rio de Janeiro, also known as the Earth Summit, Maurice Strong, General Secretary of UNCED, stressed the pivotal role of cities in reaching sustainable development. The United Nations (UN) with the establishment of local Agenda 21, emphasize the importance of cities and municipal governments in solving locally environmental issues of global nature: they need to lead the way to sustainable development. Also in the book *Urban Future 21,* produced by the World Bank and the International Monetary Fund, the authors (Hall & Pfeiffer, 2000) stress the importance of cities in building a more sustainable society. According to the authors, cities should act as innovation catalyst, encouraging with a bottom up approach a societal change that will eventually involve national governments as well.

Municipalities as local governments are ergo keys in urban sustainable transitions and considering their primary role in port management in the Baltic area, they have a greater sphere of influence than the other stakeholders in steering harbour's transition.

1.2 Objective and Research Question

The objective of this research is to explore the transition mechanism behind the shift to shore side electricity, keeping an actor focus perspective to examine the capacities employed to facilitate the desiderated change. More specifically, as the title of this thesis may suggest, the intended goal of this study is to grasp how the transition to OPS takes place and what makes it happen.

The transition that the port of Copenhagen is undergoing is embraced as a case study, with a key focus on the actions undertaken by the municipality .The role and the capacity of Copenhagen's municipality are thus analyse in order to try to speculate on the different measure that could be taken to encourage the development of this technology. This thesis seeks to answer the following question, which is also indented to guide the research:

"How can the Municipality of Copenhagen incentivize the use of on shore power supply (OPS)?"

In order to gain sufficient insight on the topic and be able to answer the formulated research question adequately, the following sub-questions were designed in order to structure the study:

- *What is the state of the art regarding the OPS technology?*
- *Who are the main actors and what is their respective role in a transition to OPS?*
- *What are the main barriers and opportunities that relate to OPS?*
- *What is the status of OPS at Copenhagen's harbour?*
- *Who are the main actors involved in the transition to OPS for the harbour of Copenhagen?*
- *What is the role of Copenhagen's municipality in the transition to OPS at Copenhagen's harbour?*

1.3 Scope and Limitations

This study focuses specifically on shore side electricity, thus it does not intend to provide a comprehensive picture of the existing initiatives that can contribute to reduce air pollution from vessels in city harbours. However, this thesis supports the positive benefits both to the natural environment and to human health that this technique can generate.

The underlying aim of this thesis is to provide an overview of the existing OPS technology, briefly reviewing the environmental advantages that it brings. Focal attention is placed on the actors and stakeholders that stand behind this transition; more specifically, this paper concentrates on the role of the municipality, in order to understand the spectrum of its action and its capacity in a sustainable harbour transition.

With regards to the geographical scope, this research is carried out mainly in the Danish context where Copenhagen's harbour is taken in as a case study. Existing foreign experiences within Scandinavia and the Baltic region are also embraced in order to provide a reference for a more comprehensive understanding of the barriers and opportunities that the transition towards shore side electricity can encounter, as well as on the role of municipalities in this transition.

It should be noted that OPS technology is known by different names: "Alternative Maritime Power (AMP)", "Cold Ironing", "Shore Side Electricity" and "On-shore Power Supply" are all synonyms (IMO, 2012) and are considered interchangeable for the purpose of this paper. Probably the oldest expression in the naval industry for it is cold ironing, which started to be used in the steamship era when vessels were cold fired, as when a ship was in port there was no need to continue feeding the fire and consequently the iron engines would eventually become cold.

The research is constrained by the limited source of academic works available, although secondary data from scientific literature, mainly in the form of industry reports, are available. To compensate this knowledge and literature gap some interviews were conducted via emails, telephone or private meetings when possible. Availability of interviewees represented in some cases an issue, as the research period ran over the summer and especially July in Scandinavia and more specifically in Denmark is considered vacation time. This implied that some of the actors were not available to participate in interviews, thus limiting the research sample by not reflecting the whole range of the stakeholders identified.

1.4 Audience

The targeted audience of this thesis includes port authorities; terminal operators; shipping companies; policy-makers; public actors, which could include governmental representatives of departments for sustainable urban planning both at national and at local level; researchers; and more in general all actors and stakeholders directly involved or interested in OPS.

Furthermore, as this study focuses mainly on the current situation in Copenhagen and looks into other OPS experiences within Scandinavia and the Baltic area, municipal authorities and local politicians in the area are also to be considered in the intended audience as a mean for understanding the barriers and opportunities of applying OPS technology.

In addition, since this research is conducted for the fulfilment of a Master degree in Sweden, it is written also for audiences less familiar with OPS systems. As such, the thesis is written in such way that is accessible to both researchers and stakeholders with a general interest in shore side electricity solutions.

1.5 Thesis Disposition

In chapter 1, the nature of the problem addressed with the research, its scope, the limitations that might restrict the results as well as the audience are presented. Chapter 2 describes the methodology applied for the data collection and analysis. In addition, the analytical framework used for investigating the research question is presented and its application to the study case is reasoned.

In chapter 3, an extensive analysis of the literature available about OPS systems is put forward, illustrated as well through some experiences coming from Scandinavia and the Baltic region. Chapter 4 focuses on the current situation in Copenhagen, describing the port's current operations and future developments, as well as the legal framework the port of Copenhagen is subjected to.

In Chapter 5 the main findings from the case study are analysed and evaluated through the prism of the selected analytical framework and suggestions are formulated based on the different opinions gathered. In the same chapter, a reflection on the legitimacy on the way the research was conducted is made.

Chapter 6 summarizes the main findings of this study, highlights the most important research contributions and provides suggestions for further investigation.

2 Research Methodology

In this chapter the methodology used during the research is described. This thesis employs a methodology based on different tools and techniques. The data collection and consequent analysis are based on a conceptual framework, which shall be seen as a travel map and thus intended to guide and justify the project and investigate the formulated research question. According to Smyth (2004), a conceptual framework should be regarded as a starting point for developing awareness and contextualising the problem in order reflect upon it. If well-articulated, it helps the researcher investigate the matter and convey a meaning to the subsequent findings. A conceptual framework sews together all the different aspects of the process, like: problem definition, purpose, literature review, methodology, data collection and analysis, giving coherence to the research (Smyth, 2004).

2.1 Conceptual and Analytical Framework

Transition management (TM) is a conceptual framework that employs a multi-level perspective (MLP). TM is a multi-phase and multi-level framework, as it differentiates among different types of activities and different phases. For this reason, TM can be regarded as *"evolutionary governance"* as it deals with changes that concern all societal levels (Kemp & Loorbach, 2008).

The world transition describes the change from one form or state of equilibrium to another, "*the gradual process of societal change, in which society or an important subsystem of society structurally changes"* (Rotmans et al., 2000). A transition is complex, and runs over several decades, as regimes tend to be resistant to change (Raven et al., 2010). Transitions as such cannot be controlled (Loorbach, 2007), but adopting a TM type of governance helps avoiding lock-in situations[9], stimulating innovation and offering solutions that could be beneficial for society as a whole. In fact, TM has focused on ways to influence and direct this structural social change towards a more sustainable society.

Transition is a non-linear process that starts slowly, is followed by a rapid change, until it stabilizes and consequently slows down again (Kemp & Loorbach, 2003).

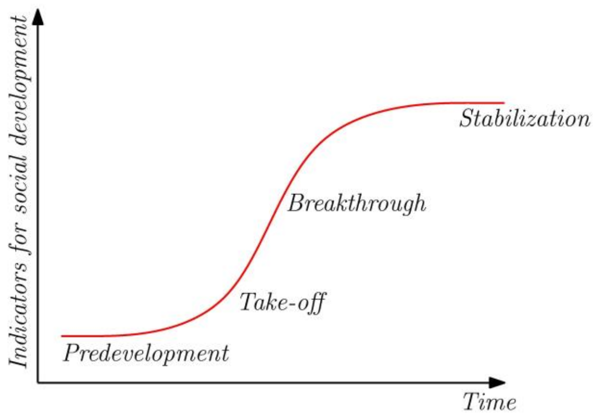


Figure 1: Four phases of a transition. Adapted from Rotmans et al. (2001)

[9] Lock in situations can have three dimensions: 1) institutional; 2) social; 3) technological (Raven et al., 2010).

Rotmans et al. (2001) identify four phases that a transition goes through: predevelopment, take off, breakthrough and stabilization. As shown on figure n. 1, the speed of change differs in every stage. In the predevelopment phase, even though things change slowly, there is a lot of experimentation. What is happening in this phase is thus not visible to society as a whole, but only to few innovative actors that are envisioning how the future could be. This phase is followed by the so called take-off phase, or agenda-building, were real decisions are taken. Change starts taking place at a higher pace and the system begins to oscillate. However, it is in the breakthrough phase that the change becomes visible to the broader society, as the transformation encompasses the socio–cultural, economic, ecological and institutional levels. In the last phase, the system evaluates what recently experimented and stabilizes again reaching a new equilibrium (Kemp & Loorbach, 2003).

MLP is most commonly used as a framework in analysing transition phenomena, as it helps capturing their complexity and their multi dimension nature (Paredis, 2011). A MLP is useful in providing a broad picture of a transition, intended as a change from a socio technical regime to another. Transition is then described as a process, starting from its beginning and following its development pinpointing the mechanisms that have played a significant role in it. A MLP sets three different levels of analysis: niche, or micro; landscape, or meso; and regime, or macro, and explains the transition process though the analysis of the interaction between these three levels (Geels & Schot, 2007). The interaction among the different processes is what causes a change in the system. As explained in figure n. 2, it starts at niche level, where the momentum is created; it then reaches the landscape level which will consequently create pressure on the regime, creating a window of opportunity for innovation (Paredis, 2011). Transition is ergo happening through the interaction of different societal levels: micro; meso; and macro.

The micro level stands for local practices and individual actions; it is also called niche level as it is here that innovation takes place. According to Loorbach (2007), the word innovation has a wide spectrum, referring not only to technological development, but also embracing the formulation of new concepts[10]. Social innovation and technical innovation are strictly interdependent, mutually influencing each other. Innovation is thus to be interpreted as a socio-technical and co-evolutionary process (Raven et al., 2010). Experimentation is happening at niche or micro level, as this is where the different solutions are proposed and tested making space for innovation (Loorbach, 2007).

The meso level represents the regime, the common ground in which the different companies, networks, institutions or organisations operate. The regime includes all dominant practices, methods, procedures that result from common believes, social rules, norms and that influence the decision making (Loorbach, 2007). Physical infrastructure is also to be included in this level. If it can be argued that on one hand the existence of a system of norms and believes commonly recognized and widely accepted provides the regime with stability and solidity, on the other one, it makes it difficult to adapt to new scenarios and it is therefore resistant to change. The meso level is hence more static than the micro one.

The macro or landscape level encompasses the whole society, including the socio-economic, demographic, political and legal context in which both niche and regime operate (Raven et al., 2010). As a result, change at this level is very slow, as it requires acceptance among all societal layers.

[10] This could also include the introduction of new rules, or new legislation.

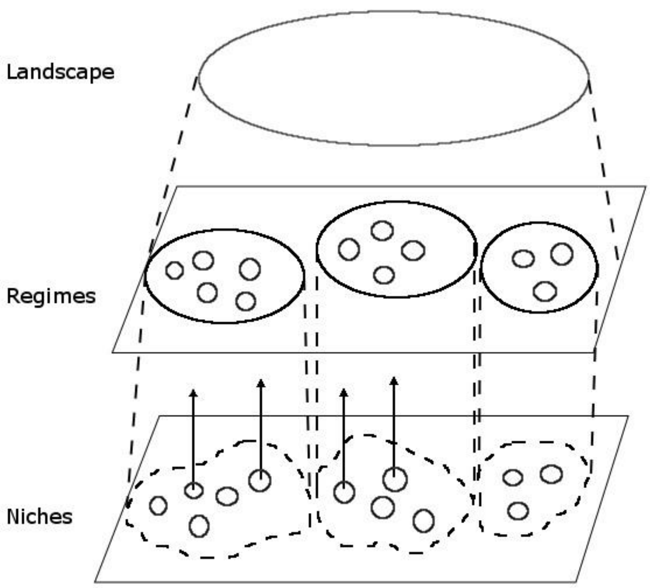


Figure 2: Multi level perspective. Adapted from Geels (2002)

TM classifies also among various types of governance activities, which take place at the different levels and that can be clustered as: strategic, tactical, operational, and reflexive (Raven et al. 2010). This is what Loorbach (2010) defines as Transition Management Cycle, as shown on figure n. 3: a closed loop where all phases are interconnected and influence each other. Strategy includes visioning, establishing what goals to reach in the short and in the long term (Kemp et al., 2005) and depending on these objectives forming a multi actor network. It is on this stage that the so called transition arena takes form. It comprises a small interdisciplinary network of frontrunners, consisting of ten to fifteen innovative individuals willing to work together in order to stimulate a sustainable societal change (Loorbach, 2010). On the tactical level, a transition agenda is built and alliances are formed. Experimentation and the execution of what has been planned and set on the agenda form the so called operational level. In order to close the loop and constantly improve the process, on the reflexive level, monitoring, evaluating and learning activities take place (Rotmans & Loorbach, 2006).

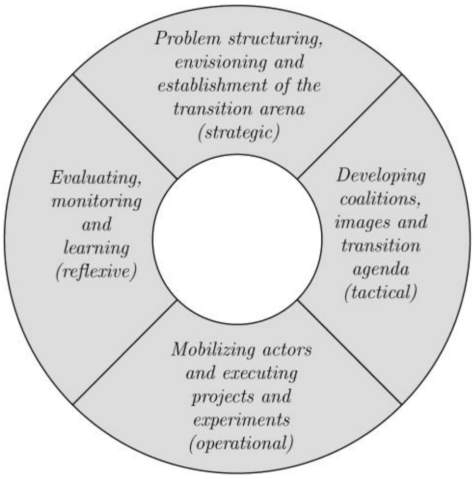


Figure 3: Transition Management Cycle. Adapted from Loorback (2010)

According to Kemp et al. (2005), TM is an adaptive and anticipatory tool that through the set-up of a transition agenda coordinated among the different actors and the organisation of a transition arena, where experiences are shared through participative learning (Frantzeskaki & Rotmans, 2010), investigates and mitigates different visions and routes. TM is a goal oriented governance approach, based on system improvement and innovation (Raven et al. 2010). On a most general level, it can be said that TM assesses how the different actors deal with long term societal chance and their willingness to cooperate towards a more sustainable development.

TM shall be regarded a theory about governance as well as an operational governance approach (Loorbach & van Rack, 2012).

2.1.1 Transition Management Theory applied to Harbours

For the purpose of this thesis, the TM theory was selected as a suitable framework within which conceive and explain how to deal with the sustainability challenge that many harbours are nowadays dealing with. In fact, being a generic framework, TM can lead to a fruitful analysis of a transition that occurs in almost any context (Loorbach & Van de Lindt, 2007).

TM was deemed appropriate as it provides a multi actor perspective that allows for understanding the necessity of coordination among the various actors. TM synthesizes all the attributes of nowadays models of governance: the interaction among key players; their multiplicity; the MLP; and the social adaptive learning (Loorbach & van Rack, 2012). The four levels of TM were thus adapted to harbours' shift to shore side electricity, in order to identify the main actors involved in this transition and detect their respective spheres of influence. As expressed by the TM theory, the different actors have to join forces and form alliances in order to make room for innovation and system improvement.

Furthermore, TM was useful in identifying and evaluating the different levels at which environmental governance is enacted. As the main research question investigated with this thesis is related to governance at municipal level, TM was beneficial in conceptualizing and understanding the role of Copenhagen's municipality in managing the city's port transition towards shore side electricity and how the municipality can favour OPS acting within a Danish, European and International political and cultural landscape.

However, being a generic framework as previously mentioned, TM was combined with elements of different theories, in order to provide more substance to the findings. More specifically, the policy arrangements approach (PAA) integrated the research in order to highlight the political aspects of this type of transition and thus better understand the role of politics and policy innovation. If TM can be intended as a policy niche, set in parallel with regular policies with the aim of introducing a new style of governance (Paredis, 2011), PAA can be useful in making more explicit the policy dimension of a regime. PAA, in fact, dissects policy arrangements, intended as *"the temporary stabilisation of the content and organisation of a policy domain, in a bounded time-space context"* (Arts and van Tatenhove 2004), into four dimensions: actors, which include all the players involved in the transition, and their coalitions; all the resources employed that can be of financial, knowledge or human nature; the so called rules of the game, consisting in all formal procedure involved in the decision making process as well as in its implementation; and the discourse, which is the interpretation of the policy.

The strategic niche management (SNM) also complemented some aspects of TM. In fact, SNM puts technological innovation as starting point, and emphasizes the importance of learning. SNM has a more evolutionary perspective, requiring markets, technologies and institution to develop at the same pace (Raven et al., 2010). This can be achieved creating artificial niches through public policies, for instance, like tax exemptions, investments grants etc.

Both PAA and SNM were therefore beneficial in capturing the role of Copenhagen's municipality in managing a port transition towards shore side electricity.

2.1.2 Other Theories

In order to select the most appropriate analytical framework to guide the study, other suitable theories were taken into account.

As the main research question refers to the role of Copenhagen's municipality in stimulating the development and implementation of OPS, the intervention theory (Mickwitz, 2003), was explored. Intervention theory can be useful in interpreting the results of an evaluation of public intervention. It is important to evaluate public intervention in order to decide if and how the intervention can be improved and whether it should be abandoned or continued. According to Mickwitz (2003), intervention theory solves mainly two functions in a policy evaluation: it helps identify the intrinsic focus of the instrument and its intended goals or effects and at the same time it helps understand in which area, with respect to the outputs and outcomes of the policy, data should be collected.

However, the scope of intervention theory was determined too narrow for the purpose of this thesis. As transitions are too broad phenomena to be managed by one actor alone, analysing the mere intervention of the municipality would have restricted the findings. In fact, in order to draw conclusions on how the municipality in Copenhagen can incentivize the use of shore side electricity, it was important to analyse the capacity and the spectrum of influence of all actors involved and the connections among them. Moreover, as an OPS system is not fully in place yet at Copenhagen harbour, it would be too early to evaluate the intervention of the municipality, as no real feedback from the market could be provided.

2.2 Methods for Data Collection

The definition of the topic to research followed the so called snowballing technique, where an initial and more generic literature review as well as some informal discussions generated the interest to explore the topic in more detail. This lead to further data acquisition and as this was analysed additional actors and stakeholders were identified and addressed.

In order to reduce unavoidable uncertainty and thus gauge objectivity and increase confidence in conclusions, data had to be collected from a variety of different sources. Both quantitative and qualitative methods were employed, so as to present a more comprehensive picture of the phenomenon under study. Triangulation of the information collected was carried out whenever possible.

Mainly two approaches were used in gathering the necessary data: a desk research and a primary one. The findings presented in this paper derive mainly from secondary data retrieved from literature analysis and primary data accessed through interviews or personal communications via telephone or electronic mail.

2.2.1 Literature Review

Conducting a literature review was useful to identify the existing initiatives related to shore side electricity and understand their goals and limitations. Initial background knowledge about OPS and environmental and health problems related to ship emissions was collected through an analysis of technical reports, pertinent web pages, academic journals as well as peer reviewed papers available on academic data bases. Eventually, a more encompassing literature review and analysis was conducted with the intention to provide adequate comprehension of:

- the environmental problem related to air pollution from vessels in city harbours and their negative consequences on human health;
- the state-of-the-art of the current available technology;
- the environmental benefits associated to the use of an OPS system and the opportunities that may arise;
- the policy context and the legal framework under which the planning, development and implementation of an OPS system takes place;
- the barriers and challenges that relate to the employment of this technology;
- the actors and the stakeholders involved in the realisation of an OPS system and their respective roles;
- the relations and interactions among the identified actors, in order to comprehend who can be regarded as more suitable in leading the transition;
- the influence of local policies in shore side electricity initiatives. In particular, to detect to what extend public intervention at municipal level can stimulate the use of OPS and shape the future of this technique at Copenhagen harbour.

The findings resulting from the different steps of the literature analysis led to the consequent formulation of the research question. In order to digest and interpret at a higher level the barriers and opportunities that an OPS system can face, some examples of its implementation in Scandinavia and in the Baltic area were reviewed. Looking into these experiences was very useful in developing the case study.

2.2.2 Personal Communications and Interviews

Acquiring primary data was deemed necessary in order to compass what this type of transitions implies in reality. The second method used for collecting data was ergo through personal communications with relevant actors involved in port management and port operations in the Baltic area and more specifically in the context of Copenhagen. Talking to people that are or have been actually involved in the planning and realisation of this transition was enlightening as it provided an insight that could not be grasped otherwise.

In general, interviews were semi-structured and informal in nature. A semi-structure interview formula was preferred to a more structured one to allow for interviewees to discuss what they felt were the most important factors in this transition. Moreover, this format was also employed to accommodate the fact that some of the actors, especially at the municipality, performed different functions within port management and development.

The interviewees were also selected using the snowballing method, as new contacts were added along the process, asking the contacted person to point out further relevant people to interview. Although it can be argued that this method does not guarantee the representativeness of all stakeholder groups, this proved to be a good way to reach pertinent actors.

2.3 Methods for Data Analysis

In order to explore more in depth the transition that the harbour of Copenhagen, seen in the context of Scandinavia and the Baltic region, is currently facing, different theoretical and analytical approaches and techniques were utilized. Data triangulation was used to compare the information retrieved through literature analysis and interviews and inconsistencies, if found, were re-checked for confirmation.

As afore explained, the choice of TM as analytical framework was justified by the analysis of the available literature on OPS and thus TM, in conjunction with PAA, was used for analysing the current situation in Copenhagen.

3 On Shore Power Supply: State of the Art

The purpose of this section is to provide the reader with an overview of the existing OPS technology, describing its high level of maturity through an analysis of the available literature. A brief description of the environmental benefits deriving from the implementation of this technology is also provided.

3.1 What is it and How does it Work?

The International Maritime Organisation (IMO) considers shore side electricity as a "*measure to improve air quality in ports and port cities, to reduce emissions of air pollutants and noise and, to a lesser extent, to reduce carbon dioxide through ships at berth replacing on board generated power from diesel auxiliary engines with electricity supplied by the shore*" (IMO, 2012). The underlying idea of on shore power supply is to enable vessels to shut down their auxiliary engines while berthed at port, in order to reduce emissions to air. In fact, while in port ships still need to generate a considerable amount of electricity in order to run various activities on board, such as cooling, heating, lighting (the so called "hoteling activities"), unloading and loading of goods, and so on. Plugging in a vessel and connect it to the electrical power network on shore side allows the vessel to switch off its auxiliary diesel generators and use electricity coming from the local grid instead. In this way, at least some of the emissions related to ships activities at berth can be reduced, if not eliminated, while on board activities can continue uninterrupted (OPS, 2013).

According to the EU recommendation 2006/339/EC on the promotion of OPS, an OPS system includes the following elements:

1. A connection to the local grid with a carrying capacity of 20-100 kV. This electricity will then be converted to 6-20 kV in a local substation;

2. Cabling that will transfer the 6-20 kV power from the substation to the quay;

3. Frequency converters;

4. Underground cables, through which electricity will be delivered to the terminal. This cabling infrastructure is often not present in older terminals, which will therefore need to be retrofitted;

5. A cable reel system, as it can improve safety when dealing with high voltage cables;

6. On board, a socket is needed in order to be able to connect the cable. Also in this case, many of the older vessels need to be retrofitted;

7. A transformer on the ship, to transform the high voltage electricity to 400 V;

8. The electricity is then distributed across the vessel, allowing it to switch off its auxiliary engines.

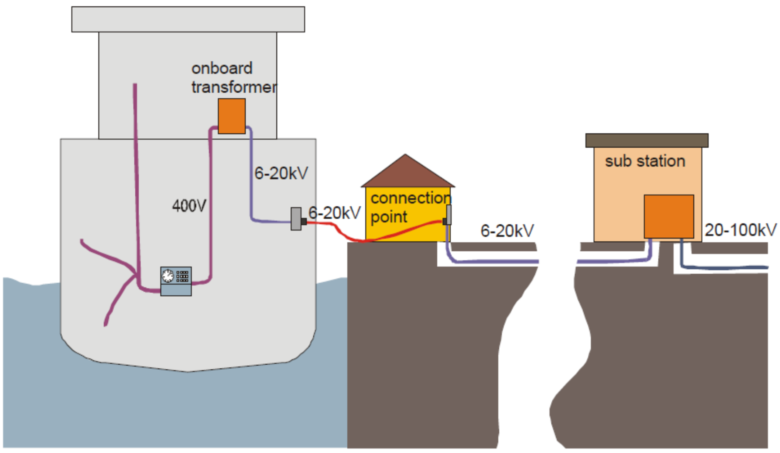
When the infrastructure is set up, the so called frequent or regular caller ships can make the transition to onshore power supply a matter of routine.

If at the beginning, over ten years ago, the first OPS systems operated on a low voltage, nowadays high voltage systems are more frequent, as the lower amount of cabling required has smoothed the operation. The main differences in providing low voltage or high voltage connection are cabling and time. The number of cables is dramatically reduced when providing a high voltage connection which results in a higher transfer speed as well: in fact, a high voltage cable can transfer 25 times more power than a standard low voltage one (400 V) of the same dimension. In practice, being able to offer a high voltage electricity supply distributed through one single high voltage cable makes the operation quicker, safer and more simple (Port of Gothenburg, 2008).

At the moment, despite the recent adoption of an international standard, differences in voltage, frequency as well as in engine structural design make the systems across the world not interoperable as different equipment and solutions may be needed. In fact, different ports, as well as different ships use different voltage levels. Thus, in order to provide vessels with electricity on shore side, it is necessary to have a specific supply arrangement on shore side (Ericsson & Fazlagic' 2010), as there can be a difference in frequency from what used on board and what provided at the harbour. In fact, while the electricity frequency in the EU grid is 50 hertz (Hz), what used on board can be either 50 or 60 Hz[11] (OPS, 2013). A vessel designed for 60 Hz even though it might be able to use 50 for some activities, like lighting or heating, it will still need 60 Hz for the most energy intensive activities, such as pumps, cranes, winches etc. Thus, in order to be able to connect a 60 Hz vessel to a 50 Hz grid, a frequency converter and an on board transformer to 60 Hz will be needed, which will affect to a great extent the total costs of an OPS system (OPS, 2013). As a matter of fact, in 2004, the consultancy firm MariTerm AB calculated that a cost for a frequency transformer would range between 300.000 and 500.00 € (MariTerm, 2004).

3.2 Technology in Place

As shown on figure n. 4 the connecting system as such is pretty straight forward. It basically consists of an electrical infrastructure both at the harbour and on the ship and some sort of connection and control solutions to ensure safety and efficiency of the power transmission (Arduino et al., 2011). The system needs to comply with the international standard set in 2012 jointly by the International Organization for Standardization (ISO), the International Electro technical Commission (IEC) and the Institute of Electrical and Electronics Engineers (IEEE) for high voltage shore connection systems (HVSCS) IEC 60092-510 edition1 IEC/ ISO PAS.



[11] This is mostly common in North America and Japan. 70% of ocean-going vessels are designed for 60 Hz (Radu & Grandidier, 2012).

Figure 4: Onshore Power Supply System. Source: MariTerm (2004)

The power is transferred to the connecting point situated near the ship from a local high voltage substation. While some form of connection point is needed on shore side, the cable that connects the ship to the OPS can be either flexible or stable. Onboard, the vessel needs to have an entrance for the connecting cable as well as a socket for the cable. A transformer that converts the high voltage electricity to 400 V is also needed and this is preferably situated near the main switch board in the engine room. (MariTerm AB, 2004). An OPS system can be structured mainly in two ways: with or without a frequency converter (Radu & Grandidier, 2012). The one without a frequency converter is mostly convenient when ships and shore side operate at the same frequency, like in North America (60 Hz to 60 Hz).

There are several considerations to make before planning and designing a high voltage shore connections (Radu & Grandidier, 2012). They can be summarized as follows:

1. Shore side frequency. A system should be preferably designed for both systems to be able to accommodate vessels designed in different parts of the world;

2. Shore side electricity supply: voltage as well as distance to the supply point. In Europe, many of the city harbours are actually located close to residential areas, and thus high voltage power is generally available;

3. Power requirements on board, especially for frequent callers;

4. Space available on quay side for the new infrastructure;

5. Space available on board the vessel; this is particularly important when a transformer is needed. Some of the old vessels might suffer not only from a lack of space, but might also be restricted by weight restrictions;

6. Installation practicalities both on-board and on shore side;

7. Cost of the electricity coming from the local grid weighted against what could be generated by the auxiliary engines on board, including both fuel and engine maintenance costs as well.

According to MariTerm (2004) the factors that influence the most an OPS system are the frequency used on board the vessel and the cost of high voltage electricity on shore side.

3.2.1 OPS as Retrofit

Implementing OPS often requires structural changes both on board the vessel and at quay side. The changes necessary to adapt to this technology will directly affect the costs of the implementation of the OPS technology.

Retrofitting a vessel in order to allow for high voltage shore connection requires a case by case evaluation, as it might not always be possible to adapt the ship to this technology. In naval design, space is maximized as much as possible and most vessels, especially the old ones, tend to have very limited space available especially in proximity to the switchboard[12]. Lack of space can be problematic especially when there is a difference in frequency among the vessel and the shore side, and thus there is a need for a frequency converter to be placed on board. The size of the converter is dependent on its capacity and it is estimated that a frequency converter needed to converter around 15 and 20 MvH, which is often what is needed to adjust the frequencies, could take around 150 – 200 mt^2 (Port of Oslo, 2012). It thus becomes obvious that retrofitting old vessels is not always possible and for this reason in newer vessels there is often a space reserved for future cold ironing possibilities.

A plug-in cubicle needs to be mounted on the ship but a space bigger than its actual size needs to be reserved as it will be needed for service and connecting the cables. Deltamarin (2011) has estimated that in a cruise vessel, for instance, the cost for this cubicle is around € 120.000 and could exceed € 150.000 if a side steel door is needed to close the room. Another additional cubicle will be necessary to connect to the main bus bar of the switch board and this is calculated to cost € 60.000 (Deltamarin, 2011). Cabling between the plug-in cubicle and the additional one will also be needed. Considering all the modifications required, total costs have been assessed to range from € 500.000 to up to € 1 million per ship (Deltamarin, 2011).

Figure 5: Plug in cubicle on board a cruise ship (Costa Luminosa)

Old terminals will need to be retrofitted as well to include substations, plugs at berth and the necessary underground cables. A transformer and a frequency converter might also be needed, especially when the harbour is not located close to a residential or industrial area. With respect to investment costs, figures vary greatly from € 1 million to € 4 million (OPS, 2013), depending mostly on power requirements and on where the quay is situated. The costs of adapting the new terminal to OPS will also depend on the types of vessels the quay is mostly used for. For example, a study conducted by the port of Amsterdam and the European Commission (EC) registers that converting an old cruise terminal could cost up to € 7 million (van Breemen, 2012).

12 As space is a limiting factor, if direct connection from shore side to the ship is not possible, a barge could be used as intermediary to allow the cable to reach the ship. However, this will represent an extra cost for ship owners (Fiadamor, 2009).

3.2.2 International Standard for the Design of OPS

It was only in 2009 that the first international standard regulating the design of OPS at shore side came into force. The International Maritime Organisation (IMO)[13], which is an United Nations (UN) agency carrying out tasks related to the safety and the security of shipping and the prevention of ship pollution (IMO, 2013) and its preparatory body in environmental protection matters, the Marine Environment Protection Committee (MEPC), submitted a proposal for an international standard that was eventually approved by the International Electro technical Commission (IEC) and the International Organization for Standardization (ISO). The "IEC/PAS 60092-510:2009 *Electrical installations in ships – Special features – High Voltage Shore Connection Systems (HVSC-Systems)*" standard was thus first published at the end of April 2009. This standard has recently been revised and replaced by the "ISO/IEC/IEEE 80005-1:2012 *Utility connections in port – Part 1: High Voltage Shore Connection (HVSC) Systems – General requirements*" during the summer 2012.

Even without analysing into detail the difference among the two standards, it can be said that the adoption of an international standard was highly needed in order to assure the interoperability of systems across the world (IEC, 2012). In fact, the international standard describes how the HVSC system should be designed and installed in order to be able to supply the vessel with electricity on shore side. The standard undertakes important safety issues such as emergency shut downs (ESD) that might incur when the vessel moves outside the designed coverage area. The standard aims at conforming the following (IEC, 2012):

- High voltage distribution systems at shore side;
- Distribution systems on board;
- Shore to ship connection and interface equipment;
- Transformers and reactors;
- Semiconductor and rotating convectors;
- Control, monitoring, interlocking and power management systems.

These requirements, which are specified in appendix n. 1, do not apply when the vessel is dry docking or when the vessel is not in service due to maintenance or repair (Ballini, 2013). The standard does not apply to low voltage systems either.

The adoption of an international standard allows vessels to connect to HVSC at several harbours, without the need to adapt or adjust to a different set up at every port. As a matter of fact, avoiding differences technicalities, like voltages, power plugs, and socket designs improves the efficiency of the use of OPS at different berths (OPS, 2013). The existence of a standard can thus constitute an incentive for those harbours that are currently looking into the feasibility of this type of installation at their facilities, as they could reassure their clients that they would be able to use this technique in different locations. The underlying idea of the standard, in fact, is that the shore side should be identical in every port. For instance,

[13] For more information, see http://www.imo.org/About/Pages/Default.aspx

both Mrs Wilske (2012), Sustainability and Project Manager at the port of Gothenburg and Mrs Neilson (2013) Head of Environment at the port of Oslo, are very positive about the adoption of an international standard as in their opinion it allows for spreading the use of this technique.

Figure 6: Standard HVSP Plug. Source: Port of Oslo (2012)

3.2.3 Key Players in the Market

The aim of this paragraph is to briefly introduce some of the technological solutions available on the market and see what is currently in use in some of the ports that are offering shore side electricity. Nowadays, there are various suppliers for OPS systems in the global market (OPS, 2012). Patton & Cooke Co., Siemens, Cochran Marine, Sam Electronics, Terasaki, Callenberg Engineering AB, Schneider Electric, ABB, Cavotec are among the most known on international level. However some actors have had a more distinguished role in installing this technology in different ports around the world and thus enabling vessels to be connected to the local grid. According to Ericsson & Fazlagic' (2008) some years ago one of the main obstacles was the difficulty in finding suppliers for frequency converters, which often represent the highest cost of an OPS system as well. As afore described, the adoption of an International standard for the design of an OPS system can help overcomes the cost barrier of a frequency converter.

The Swiss company **ABB,** operating within power and automation technologies, can be considered a pioneer in shore to ship technology, as it delivered the one used back in 2000 at the port of Gothenburg, which was the first port worldwide to install a high voltage shore side power connection. In the last decade, the company's experience in this type of installation has increased spreading through Asia and Europe. Most recently, ABB was contracted to perform the installation of the OPS system at the Stena Line ferry terminal at the port of Rotterdam in The Netherlands in July 2012. ABB operates both onshore as well as on board. On board, like in the case of the cruise company Princess Cruise Line[14], as there is a need of integration among the vessel's electrical and automation system and the actual shore power supply, ABB can install the power management and monitoring system. Moreover, ABB has gained experience in changing the vessel's electrical system retrofitting it in order to enable it to receive power from the short side. On shore, taking care of adapting the voltage level and the frequency of the electricity coming from the local grid to what

[14] Princess Cruise Line was the first cruise ship worldwide to operate with shore side electricity.

needed by the vessel and thus making sure that the appropriate supply of power is provided (ABB, 2013).

The German company **SIEMENS** has also gained experience in installing shore side connections following the operation through all its steps: thus, helping the ports willing to undergo this transition to conceptualize and design an OPS system, and eventually implement it and install it. The port of Lübeck in Germany is a reference for the so called "siharbor", the OPS technology developed by Siemens. Siharbor is a modular and integrated system, flexible enough to fit both 50 and 60 Hz vessels (Siemens, 2008). In the siharbor package, a transformer is included in order to make it possible also for old vessels to adapt to the voltage level on shore. Siplink, which stands for Siemens Multifunctional Power Link, is the name of the connection system developed by Siemens; siplink connects the two systems, on board and on shore, even if their frequencies are different. Thus, a vessel operating with 60 Hz could be connected to a local European grid, which operates at 50 Hz. In order to increase safety, an automation system controls the shore side connection to the ship and communication from ship to shore is ensured by a fibre optic cable.

CAVOTEC, a global engineering company active for over forty years in the marine and port sector, has been active in developing and promoting the use of alternative maritime power (AMP) technology. Most recently, in September 2012, the company was involved in the electrical application at the port of Ystad in Sweden. The Ystad installation is the largest high voltage shore connection in the world (Cavotec, 2012). Cavotec's long tradition of shore side connections is proven by the many ports, especially Swedish ones (like Stockholm, Gothenburg, Karlskrona, Trelleborg), relying on their technology (Cavotec, 2012). The company offers several technical solutions, both shore based, like mobile, fixed or barge mounted AMP or vessel based, which can also be fixed or semi fixed. Ericsson & Fazlagic' (2008) report that, due to the high number of solid references, their plugging system has become a standard for the shore side connection. Cavotec can offer two different technical solutions, depending on the space available on the ship and on shore side. The first alternative is setting the cable management system either on the ship or on shore. The shore side will be connected via high voltage cables passing through a technical pit, which does not occupy much space, into the quay. The second option is most suitable when constrained by a lack of space. In fact, it implies having a system similar to the one previously described, but not placing it directly, neither on shore side nor on board the vessel but into a standardized container, which will then be placed on board. The whole system can thus either be fixed or movable, in order to accommodate the ship's route. The latest solution is preferable when both space and time are limited: in fact, it makes the operation quicker as it can be activated immediately upon ship's arrival in port (Cavotec, 2012). The company can actually offer a third alternative, suitable to supply vessels that cannot entirely approach the quay. In this case, a cable management system and all the necessary electrical equipment are placed on a barge instead that on shore side. This solution cannot be supported by a traditional AMP system but rather by an *ad hoc* barge solution that can provide a continuous power supply of 440 Voltage (V). A reference for this solution is represented by the port of Los Angeles, in the U.S.A. (Cavotec, 2012; Sissons & Mc Bride, 2008).

The French company **SCHNEIDER Electric** has also put on the market a standard shore side electricity system called ShoreBoXTM, in compliance with the latest IEC/ISO/IEEE standard. The company has developed a standard plug and sockets for each type of ship in order to be more adaptable to the different electrical frequencies, power needs of the vessels and port infrastructures. The system has a smart reader that is able to track and report data in real time, thus allowing both port and vessel to better meet the electricity demand. The company has helped several ports in California, where there is a strong OPS tradition, to implement shore side electricity systems (Green Port, 2013)

3.3 Environmental Advantages of using OPS

As described in the first chapter of this thesis, many are the emissions related to the use of auxiliary engines while at berth: they mainly relate to $NO_{x,}$ $SO_{x,}$ PM, VOC, and noise (Ericsson & Fazlagic', 2008). Several are the negative effects of these pollutants on human health (Corbett et alt, 2007). NO_x emissions cause several respiratory problems, can provoke heart diseases and damage the lungs. SO_x irritates the lungs airways, causing asthma and other chronic lung diseases. VOCs are also responsible for respiratory problems, as well as headaches, visual disorders and memory impairment. PM can even cause premature death, due to respiratory deficiencies.

A better air quality and health concerns are thus the major drivers for the implementation of OPS technology (WPCI, 2013), as OPS can help reduce the environmental impact of port operations (Wilske, 2008). In fact, the use of OPS is an effective solution for the reduction of noise but especially emission generated by vessels at berth (Fiadomor, 2009). However, the environmental benefits that can result from the application of this technique vary greatly, depending on different factors, like the fuel used for the generation of electricity, the efficiency and the age of the on board engines, the number of hours the ship is at berth etc. (Port of Gothenburg, 2006). Papoutsoglous (2012) also reports that the amount and type of emissions reduced is strictly dependent on how the OPS system is functioning in every single port. Nevertheless the ports that have adopted this technique are experiencing a decrease in pollution from ships at berth (OPS, 2013).

According to a study carried out by Trozzi et al. (2012) on the feasibility of cold ironing in three major Italian ports, the potential for emission reduction is significant, ranging from 80 to 95 per cent for $NO_{x,}$ from 68 to 95 for PM, from 78 to 95 for VOC and being around 35 per cent for $SO_{x..}$ It should be mentioned though, that the researchers are of the opinion that OPS can reduce net emissions to air, also because the generation of electricity on shore side has to comply with emission standards more stringent than those required for ship engines.

It is worth remarking that even if OPS can help reducing emissions from shipping activities at berth, attention should also be given to the way the electricity is generated on shore side, in order to maximize the overall emission reduction. However, opinions differ. For instance, Mrs Grandidier (2013), Shore Connection Strategic Marketing Manager of Schneider Electric, believes that even if the electricity used on shore side was generated using a polluting coal plant, NO_x, SO_x, and PM emissions would still be lower than what generated by the auxiliary engines on board. Moreover, vibrations and noise would also be reduced as power plants are normally located in less densely populated areas than city harbours. Oppositely, Fridell (2009), mentions that if electricity at shore side was generated through a coal power plant, the total amount of CO_2 emissions would be greater than what resulting by the use of the vessels' auxiliary engines. On the contrary, if a renewable energy source, like hydro or wind power, was applied for the generation of electricity, CO_2 emissions could be kept to a minimum level (WPCI, 2013). Of the same opinion is Hall (2009) that conducting an assessment of CO_2 reduction through the implementation of OPS in different parts of the world came to the conclusion that the results achieved can be very diverse. In fact, while the implementation of OPS in the United Kingdom, Japan or Italy can mean significant CO_2 emission reductions, in the United States the reductions would be much lower, due to a different electricity mix. Hall notes that in China switching to OPS would actually lead to an increase of CO_2 emissions of 38 per cent.

In order to provide a more vivid picture of the importance of how electricity is generated on shore side, Hall also investigated the CO_2 emissions of an hypothetical 8 night cruise around the Baltic sea, sailing from Southampton (UK) and transiting in Oslo (Norway), Copenhagen (Denmark), Stockholm (Sweden), Tallinn (Estonia), St. Petersburg (Russia), Helsinki (Finland), and Zeebrugge (Belgium). Southampton was taken as starting and finishing point (turn around port), where the ship would be at berth for around 10 hours. The time spent in the so called port of calls would range between 7 and 10 hours. The total consumption at berth was thus calculated to amount to 511 MWh and if the power was generated through the vessel's auxiliary engines CO_2 emissions would reach 367 tons. If OPS was installed in all the mentioned ports, CO_2 emissions could be reduced to 263 tons, with a 28,5 per cent decrease. However, according to Hall's calculations, it could be more beneficial not to have OPS installed in some of the transit ports, like in Tallinn and in Skt. Petersburg, as these countries rely mainly on fossil fuels for the generation of their electricity. In fact, not having these two ports "on board" could result in an even more significant CO_2 reduction, which could go down to 217 tons, representing a reduction of 41 per cent.

Shutting down the auxiliary engines on board will also mean less exposure to noise (Arduino et al., 2011) for the workers both on deck and at quay side and for the nearby residents. However, not much data on noise reduction seems to be available, as the noise generated depends on the characteristics of each specific ship (Fiadomor, 2009). In fact, noise deriving mainly from ventilation seems to be still an issue (WPCI, 2013). Nevertheless, measurements done at the port of Amsterdam (2007) when using an OPS system, revealed levels of noise not higher than 3 decibels (dB), while a noise level of up to 110 dB can be found for the largest vessels (WPCI, 2013), which proves that OPS can be effective in reducing noise emissions as well.

3.4 Experiences from OPS Implementation in the Baltic Region

The purpose of this section is to provide a brief overview of how the OPS technology has been implemented in some of the harbours in the Baltic region[15], trying to highlight what have been the drivers for adopting this technique, how the main actors have interacted along the way and who has mostly pushed for this change.

In 2005[16], the IMO designated the Baltic Sea, except for the Russian territorial waters, as a particularly sensitive area (PSSA). According to IMO, a PSSA is an area of greatest economic and ecological importance but vulnerable to be damaged by international maritime activities and which therefore needs special protection (IMO, 2013). Moreover, again in 2005, the IMO included the Baltic Sea in the Sulphur Emission Control Areas (SECA), which are sea areas were more stringent requirements for bunker fuels apply. Including the Baltic Sea within SECA means primarily trying to reduce SO_x emissions from vessels, setting a limit for the content of sulphur of the fuels they utilize. The European Commission (2009) believes that considering the Baltic Area as PSSA and SECA could actually help increasing cooperation among the Baltic States, developing a common action in order to improve safety of the marine environment of the Baltic Sea as well as the economic prosperity of the region.

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[15] Technically Oslo is on a bay between the North Sea and the Baltic Sea. However, Oslo is often referred to as a destination city for the cruises that travel along the Baltic Sea as it might be included in the route.

[16] The decision was actually adopted in 1997 but came into force only in 2005.

3.4.1 Gothenburg (Sweden)

The port of Gothenburg has a long tradition of OPS: in fact, already in 1989 two roll on – roll off[17] (ro-ro) and passengers (ro-pax) ferry lines, Stena Scandinavica and Stena Germanica were connected to a low voltage system for the generation of their on board power (Port of Gothenburg, 2012). An old terminal was thus refurbished and adapted to service the two Stena ferries to Kiel with a low voltage 400 V power supply system[18]. However, it is only a decade later, in 2000, that a high voltage shore side connection was introduced, making the port of Gothenburg the first one in the world to offer this type of service for commercial vessels (OPS, 2013).

The project was driven by the private initiative of one of the leading pulp and paper company, Stora Enso, which decided to improve its environmental performance, imposing stricter environmental requirements along all its supply chain. The port of Gothenburg, being one of the suppliers of logistic services for Stora Enso, came to the conclusion that offering shore side electricity could represent a competitive advantage over the other suppliers, as OPS could comprise an environmental friendly shipping solution for its client. The port authorities initiated a multi actor dialogue including different stakeholders: industry, Stora Enso; ship owners, Colbelfret and Wagenborg Shipping; technology supplier, ABB. The profitable collaboration among the afore mentioned actors combined with some funding granted by the Swedish government lead to the OPS installation that enabled the first worldwide cargo vessel to connect to shore side electricity in January 2000 (Green Port, 2012). Mr Wåhlin (2008), shipping manager at Stora Enso Logistics at the time of the first OPS implementation, declared that switching to OPS was not a tough decision to take, as besides the environmental advantages that this technology can contribute to, it also reduces the need of maintenance of the auxiliary engines, as they can be switched off while at berth and this can result in financial savings.

At the moment, around ten vessels frequently calling at the port of Gothenburg are able to use the OPS technology (Green Port, 2012). There are three shipping lines currently using this solution for power supply: Stena Line, Colbelfret and Transatlantic. From a more general perspective, one every three vessels can be serviced by cold ironing while at berth at Gothenburg's harbour, as there are five quays equipped to provide OPS for high speed passengers ferries, ro-ro, and ro-pax (Port of Gothenburg, 2013). The vision of the port authorities is to expand the offer even further, connecting to OPS all ro-ro vessels and 40 per cent of the total vessels that berth at their facilities by 2015. In order to achieve these challenging figures, the port authorities have planned that all new quays will have the infrastructure necessary to provide OPS already in place. Furthermore, in order to make OPS sustainable from a wider life cycle perspective, the port of Gothenburg is also paying attention to the way the electricity supplied is generated. For this reason, the power supplied at its facilities consists primarily of environmentally labelled electricity deriving from renewable resources like wind power for example (Green Port, 2012).

The OPS system currently in use at the port of Gothenburg has been established in several steps and different quays have distinct set ups. The first system set up back in 2000 had to be retrofitted to the existing terminal. A couple of years later, in 2003, a second system, slightly different from the previous one, was established and a new terminal was adapted to OPS. In

[17] The term ro-ro indicates a vessel designed to carry wheeled cargo, like cars, tracks etc. which can be driven on and off the ship, thus without the use of cranes to load and offload the cargo.

[18] The port of Gothenburg is still offering low voltage connections along with the high voltage ones.

2006, another terminal was adapted to high–voltage OPS to serve the passenger ferry to Denmark, Stena Danica operated by Stena Lines. More recently, in 2011 a new and innovative OPS facility was opened for the Stena Lines ferries operating between Sweden and Germany. This facility is to be considered innovative as it is able to convert 50 Hz, which is the standard frequency in Europe, to 60 Hz that is the frequency used in many of the non-European vessels (Green Port, 2012). According to Mr Fazlagic', product responsible for onshore connections at ABB (2013) that has provided the technology for this system, thanks to this ability to transform the frequency, the port of Gothenburg has got the largest shore side electricity capacity in Europe. The new facility that had a total cost of € 1.4 million was financed jointly by the port of Gothenburg and Stena Line, which commissioned the new infrastructure in order to be able to connect its entire fleet of passengers and freight ferries to shore side electricity[19].

From what afore described, it becomes obvious the pivotal role that private initiatives carried out by different industries have had in the development of OPS infrastructure in the port of Gothenburg (Wilske, 2008). However, public engagement has also widely contributed to the success of the operation, providing probably the biggest incentives to the use of OPS. In fact, in 2008 the port of Gothenburg received a so called climate investment grant from the Swedish Environmental Agency which covered up to 30 per cent of the initial investment[20] costs related to the OPS at ro-ro terminals (Green Port, 2012; Dutt, 2012). Furthermore, in November 2011, the Swedish government[21] was allowed by the European Council[22] to significantly reduce the taxation level for the electricity supplied to vessels at berth in Swedish harbours. The electricity price has since then been cut down to 98 per cent of its original price, going from SEK 0,28[23]/kWh to SEK 0,005 (EC, 2011; WPCI, 2013). This reduction in the electricity charges has enacted both shipping companies and port operators to invest in OPS technology, as it has lowered its operation costs making the investment more accessible and ergo feasible (WPCI, 2013).

Based on the experience gained in the past decade, and on the environmental benefits that have resulted from the application of this technology, the port of Gothenburg, in collaboration with some other European ports has recently developed a web page[24] dedicated to OPS, in order to share experiences and increase awareness. Moreover, since 2011 the port is part of the international project Clean North Sea Shipping (CNSS)[25] with the aim of spreading knowledge on OPS and provide recommendations to the ports considering this technology (Green Ports, 2012).

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[19] Stena Lines in 2008 announced its intention to retrofit to OPS the majority of its vessels operating in Scandinavia within the following three years (Green Ports, 2012).

[20] The total investment was of SEK 80 million (Dutt, 2013), corresponding to approx. € 9 million.

[21] A strong lobbying activity was initiated already in 2005 by the port of Gothenburg and some of the ship owners. When the pressure reached the National level, the Swedish Government already in 2006 promised a tax exemption for shore side electricity supplied to ocean going vessels; however, it had to wait for many years before being allowed to do so by the European Council (Dutt, 2013).

[22] Council Implementing Decision of 20 June 2011 authorising Sweden to apply a reduced rate of electricity tax to electricity directly provided to vessels at berth in a port ("shore-side electricity") in accordance with Article 19 of Directive 2003/96/EC (2011/384/EU).

[23] Corresponding to € 0,032.

[24] The web page http://www.ops.wpci.nl/ was launched in 2010 by the port of Gothenburg in association with the ports of Amsterdam, Antwerp and Hamburg as well as the International Association of Ports & Harbours (IAPH).

[25] http://cnss.no/

3.4.2 Oslo (Norway)

While a low voltage connection has been in place at the port of Oslo for many years and it is used on daily basis, a high voltage one is still a niche phenomenon, even though a project to expand its use is currently under discussion.

The port of Oslo has been investigating the adoption of high voltage OPS for many years. In 2008, the port of Oslo asked the Norwegian consultancy company Civitas to investigate the feasibility of investing in OSP for their facilities and the conclusion was that it could be a good investment both from an environmental and from an economical perspective. Civitas drew different recommendations depending on the type of vessel to connect to the local electricity grid. The types of vessels examined were ferries, cruise ships and container ships. According to Civitas, while a 400 V OPS solution for container ships was financially reasonable, the environmental benefits that the employment of this technique could bring needed further study. For what concerned cruise ships, Civitas recommended to wait for an international standardization before starting the transition. If Civitas was a bit more cautious in suggesting OPS for cruise and container ships, the consulting company was firm in indicating ferries as the most environmentally and economically sound solution for the port of Oslo (Port of Oslo, 2012). The reason why ferries could represent the most conceivable solution is that they have scheduled visits as well as fixed amount of hours spent at berth.

On the basis of this report, the port of Oslo initiated a collaboration with the private shipping company Color line that has two regular ferries, Color Fantasy and Color Magic, sailing every other day between Oslo and Kiel. A pilot project was therefore launched in October 2011, connecting the vessel Color Magic, which had to be retrofitted in order to be able to make use of this technology, to the local electricity grid. The other vessel, Color Fantasy, also had to undergo some sort of adaptation, which enabled it to use the OPS technique a year later, during autumn 2012. As in the case of the port of Gothenburg, it should be noted that private companies' initiatives are often key in the development of OPS. As a matter of fact, Color Line made the major investment[26]t in order to adapt their terminal to OPS and this operation had a cost of approx. 24 million NOK[27]. In 2012 Color Line was awarded the Urban Environment Prize by Oslo municipality, which more than a financial grant[28] is to be seen as way of creating awareness about the use of this technology. Mrs Pile, project director at Color Line Marine A/S, claims that switching to shore side electricity produced monetary savings for the company in 2012, due to the low electricity prices in Norway and the high oil prices[29].

As mentioned in the previous paragraphs, since 2012 there is an ISO standard in place which sets the requirements for HVSC. For this reason, even though shore side electricity is still at an early stage in Norway and there are currently no harbours in Europe[30] offering OPS for cruise ships, the port of Oslo is now investigating the possibility of introducing OPS for cruise vessels as well. At the current stage, cabling is not an obstacle, as the port of Oslo has

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[26] The port of Oslo as well as the Public enterprise ENOVA also financed the initiative.

[27] Approx. € 3 million.

[28] It consisted of 50.000 NOK (around € 6.330), which Color Line eventually donated to charity.

[29] According to Mr Pile, in August 2012 the price the company paid for electricity was NOK 0,42/kWh, while the price of the same amount of electricity generated with oil was NOK 1,26/kWh.

[30] Worldwide shore side electricity is available for cruise ships only in the West Coasts of the U.S.A., Canada and Alaska. As many of the cruise ships utilise a 60 Hz frequency, there is no need to convert the voltage as it is the same used at shore side.

already sufficient high voltage cables at its facilities to serve up to two cruise ships and the existing ferries at the same time (Port of Oslo, 2012). On the contrary, space represents an issue, as the OPS infrastructure requires the allocation of a vast area in order to be implemented (Nielson, 2013). In fact, as the part of the port of Oslo normally used for cruise vessels is very close to the Opera House and the city centre, the municipality of Oslo would need to sacrifice part of its seaside promenade in favour to the installation of OPS.

Despite the technical barriers that might be encountered, the vision of Oslo' municipality is that within a couple of years, all cruise and ferry ships berthing at Oslo' harbour will be offered shore side electricity (Oslo Go Green, 2012). However, Mrs Neilson[31], Head of Environment at the port of Oslo, reports that for the time being the port of Oslo has not received any support on the economical side of this project from the municipality itself. According to Mrs Neilson, politicians at the municipality of Oslo do no fully grasp the complexity that this technique entails and therefore are not willing to allocate the financial resources that would be required.

In order to meet the energy demand, the port of Oslo is thus planning on building a main power transformer station at the passengers' terminal to be able to provide high voltage electricity at both 50 Hz and 60 Hz. In fact, the port of Oslo aims at being able to offer 50 Hz connection for passenger ships in 2014 and a 60 Hz one for cruise ships in 2015. Hence, the port of Oslo has entered a dialogue with another ferry line, DFDS, which has two vessels sailing daily between Oslo and Copenhagen and a cruise ship, Holland America Line that is transiting at Oslo's harbour during the summer season and has a long experience with shore side electricity.

The calculated costs for establishing OPS at the passenger's terminal amount to 60 million NOK[32] and the public company Enova SF[33], owned by the Ministry of Petroleum and Energy, has approved a grant of 8 million NOK[34], which roughly corresponds to 13,3 per cent of the estimated cost. The port of Oslo is at present trying to create synergies among the different stakeholders and receive funding for the new installation.

3.4.3 Ystad (Sweden)

The port of Ystad, the 5th largest port in Sweden, portraits itself as a forward-thinking and sustainable port, active for the development of its customers, the city itself and the region (Port of Ystad, 2011). As a matter of fact, high voltage shore side electricity facilities were introduced at the port of Ystad very recently, only one year ago in August 2012 (CNSS, 2012) and inaugurated on September 26th 2012 by the Swedish Minister of Environment Lena Ek (Port Strategy, 2012). During an interview released at the inaugurating ceremony, Mrs. Ek expressed her confidence in the successful application of this new green technology (Port of Ystad, 2012).

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31 Private telephone communication held on 30.08.2013.

32 Corresponding to € 7.5 million.

33 Enova provides financial support for more sustainable and efficient energy consumption patterns. The company is financed through the Norwegian Energy Fund, which is respectively financed by an additional charge to energy bills. For more information, see http://www.enova.no/about-enova/about-enova/259/0/

34 Corresponding to € 1 million.

The application at Ystad's port is considered one of the biggest HVSC in the world (Port Strategy, 2012; Green Port, 2013) and the municipality of Ystad invested 35 million SEK[35] in this new shore facility. The main driver for this installation was the decision taken by the Environmental Court at the beginning of 2011[36], which stated that the port of Ystad in cooperation with Ystad's municipality should be able to offer shore side electricity within 18 months from the decision (Växjö Miljödomstol, 2011). In Sweden, ports authorities need an environmental permit to operate and the Environmental Court put OPS as a prerequisite for running the operations, intended as a measure for reducing air pollution from vessels at berth, as many residents had been complained about the noise and the smell deriving from vessels at the harbour (Boström, 2013).

Mr. Boström, Managing Director of the port of Ystad is sure that the investment was worth especially because of the positive effects that this technique will have on the environment and therefore on Ystad's citizens (CNSS, 2012). According to the audit conducted by the consulting company Rambøll in 2009, installing OPS at the port of Ystad would result in a reduction of noise and emissions ranging between 27 and 53 per cent. Including the effect of sulphur reduction in fuel as per EU agreement, which sets a sulphur limit of 0,1 per cent for SECAs areas from 2015 (Kedziersky, 2012), emissions are expected to reduce of 97,5 per cent. The total socioeconomic balance is therefore positive. Moreover, being the shore side electricity prices kept at a symbolic level in Sweden the port of Ystad is able to charge the vessels for the amount of electricity they consume plus a small additional fee, which will help the port recovering the money invested; in this way, Mr. Boström estimates that the payback time for the investment made will be of only ten years (CNSS, 2012), assuming that all ships will connect to OPS in the nearest future.

The plant is able to serve up to four vessels at the time at the frequency of both 50 and 60 Hz and the quay side offers a 11kV system with a power of 6,5 MVh (Port of Ystad, 2013). The current set up is the result of the profitable cooperation of the company ABB, which has been responsible for the design; the supply; and the installation of the technology (ABB, 2011) with the Swedish company Processkontroll Elektriska AB, electrical system specialist. Cavotec was also involved for the supply of the cabling system necessary to connect the vessel to the local electricity grid.

Currently, one ferry[37] sailing to Swinoujscie in Poland is using the OPS facilities (Port of Ystad, 2013). Mr. Boström calculates that when all ferries sailing from Ystad's harbour will be connected to the local grid, they will be able to save approx. 2000 mt^3 of fuel (Port Strategy, 2012).

3.4.4 A Common Path

In order to better capture the above described experiences in the Baltic Sea Area, it might be beneficial to try to identify whether they share common features.

The **drivers** behind this transition differ from port to port: while for the port of Gothenburg it was the necessity to gain a competitive advantage against other service providers; for the ports of Oslo it was more for the environmental advantages that could derive from the

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[35] Corresponding to € 4 million.

[36] Deldom 01.02.2011, Växjö Tingsrätt, Miljödomstole

[37] Both ferries Polferrier and Unity sailing to Swinoujscie in Poland are willing and adapt to connect, but for the time being one is experiencing some technical issues (Ejlertsson, 2013).

implementation of the OPS technology; and for the port of Ystad was the necessity to abide by an environmental regulation. Understanding the existence of different drivers will help policy makers to introduce policies that can better support the interests at stake.

With respect to the **actors** primarily involved in the adoption of this technique, while the port and the municipality of Ystad have collaborated, for the ports of Gothenburg and Oslo it could be argued that their experiences have relied mainly on private initiatives embraced by individual companies. In fact, the collaboration initiated with the different enterprises, mainly ferry lines has been crucial for the development and the financing of the operation.

For what concerns the **costs** involved in the implementation of OPS, even though it should be noted that the related investment is always significant, figures differ depending on the age of the terminal, whether it needed to be retrofitted or if it was built with the OPS infrastructure in place. In the case of the port of Ystad, the whole costs of the terminal adaptation have been covered by the municipality, while for the cases of both Gothenburg and Oslo private companies have invested in it either adapting old terminals or building a new one with OPS infrastructure and public funds have been received.

In order to grasp the role that the different **municipalities** have played in this transition, it should be noted that the three outlined ports are all municipal ports. The municipalities of the respective cities are the ports only shareholder but are not financially involved in the business activities of their daughter companies, which shall then be considered self-financing. On the contrary, the ownership of the port infrastructure varies and the different ownership set up allows for a distinct sphere of intervention.

The port of Gothenburg, Göteborgs Hamn AB, is 100 per cent owned by the City of Gothenburg, which defines the tasks and the direction the company should take. The port of Gothenburg owns the land and the port infrastructure that it is operating but it might also rent it out to international port operators (Port of Gothenburg, 2013). The port of Oslo, Oslo Havn KF, is a municipal enterprise owned 100 per cent by the municipally and which reports directly to the department of transport and environment of the city of Oslo (Port of Oslo, 2013). The port infrastructure is owned by the port itself, which rents it out to the different terminals operators. In fact, private enterprises are responsible for the terminal operations, with the only exception of the cranes that are under the responsibility of the port of Oslo (Neilson, 2013). The port of Ystad, Ystad Hamn Logistik AB, is also fully owned by the municipality of Ystad, which does not conduct any business operation. The port infrastructure is owned by the municipality and leased by the port of Ystad that manages all port operations (Port of Ystad, 2013).

The three municipalities have enabled the switch to shore side electricity in different ways. The municipality of Gothenburg has assisted the port of Gothenburg in applying for the funding granted by the Swedish Environmental Agency. Even though the municipality has not given financial support as such, it has acted as a facilitator enabling the port to establish a connection with the National authorities (Dutt, 2013). The municipality of Oslo is also making an effort in communicating to the broader public the port of Oslo's endeavours to make this shift possible (Neilson, 2013). A more tangible intervention was made by the municipality of Ystad, which being also the owner of the port infrastructure, borne the costs of the investment, which is added to the lease that the port of Ystad pays annually to the municipality.

4 Copenhagen Harbour

In this chapter the main case study is presented.

The aim of this section is to provide an overview of what is the status of Copenhagen's harbour, going through its current organisational set-up, business operations and future developments.

4.1 CMP Company

Copenhagen Malmö Port (CMP) AB is the company operating at Copenhagen's harbour. CMP is both port and terminal operator for Copenhagen, in Denmark, and for Malmö, in Sweden. CMP, in fact, is a Danish – Swedish joint venture, founded in 2001 merging the terminal activities in Copenhagen and in Malmö in one single legal entity across the Øresund region. From a legal perspective, CMP is a Swedish registered limited liability company with the ownership equally (50 per cent) divided among Sweden and Denmark (CMP, 2012), as shown on figure n. 6. The Danish side is represented by the profit oriented company Copenhagen City & Port Development I/S (Udviklingsselkabet By & Havn I/S), which is jointly owned by the City of Copenhagen (55 per cent) and the Danish State (45 per cent) (By & Havn, 2013). The Swedish side comprises of both private investors (23 per cent) and the City of Malmö (27 per cent). The Board of the company consists of 12 members, of which 8 are elected among the shareholders according to the respective shares, and the remaining 4 are employees' representatives equally distributed between the two countries (CMP, 2012).

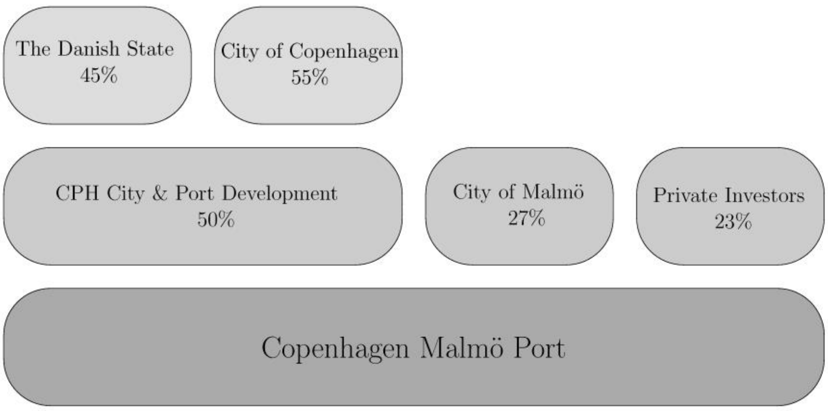

Figure 7: CMP ownership structure. Adapted from CMP, (2012)

It becomes obvious that the ownership structure reflects both private and public interests within two different countries and jurisdictions, Sweden and Denmark. For this reason, it can be argued that CMP comprises several stakeholder groups within its structure.

CMP is the largest port operator in the Øresund region in terms of traffic and ranks among the biggest in the Nordic region (CMP, 2013). The company manages terminals in both cities and its operations are divided into three main business areas all operating both in Malmö and in Copenhagen: cruise & ferries; oil; and port and terminal operations. The permanent facilities like quays, shipping lanes, operational buildings and in general all type of infrastructure that CMP uses for its operations, are not owned by the company as such, but are actually leased from the Municipality of Malmö and Copenhagen City & Port Development to whom CMP therefore pays annual concession fees. The current concession agreements with the owners of the harbour facilities will last until 2035, when the company will undergo new negotiations (CMP, 2013).

4.1.1 Traffic and Facilities

CMP facilities can offer transport and logistics services of all sorts, being equipped to receive and serve all types of freights and vessels (CMP, 2013). Every year CMP serves about 7.800 vessels for the transport of building materials, new cars, oil, consumer goods, and so on. Navy vessels, ro-ro vessels, ferries and cruises also make up a consistent part of the company's operations (Mærsk Broker Agency, 2013) and the latest is actually a growing business for CMP and the city of Copenhagen, where the majority of cruise ships berth. In fact, as shown on figure n. 7, cruise traffic increased of 3 per cent in 2012 compared to the previous year and 372[38] cruise calls took place at Copenhagen harbour for a total of 75 cruise ships, 38 cruise lines and 840.000 passengers[39] (Cruise Copenhagen, 2013). Copenhagen thus confirmed its leading role in the cruise industry of the Nordic region being a major hub for the entire Baltic region; it should thus not come as a surprise that in 2012 CMP was voted[40] the European Cruise Leading Port for the third consecutive year (World Travel Awards, 2013).

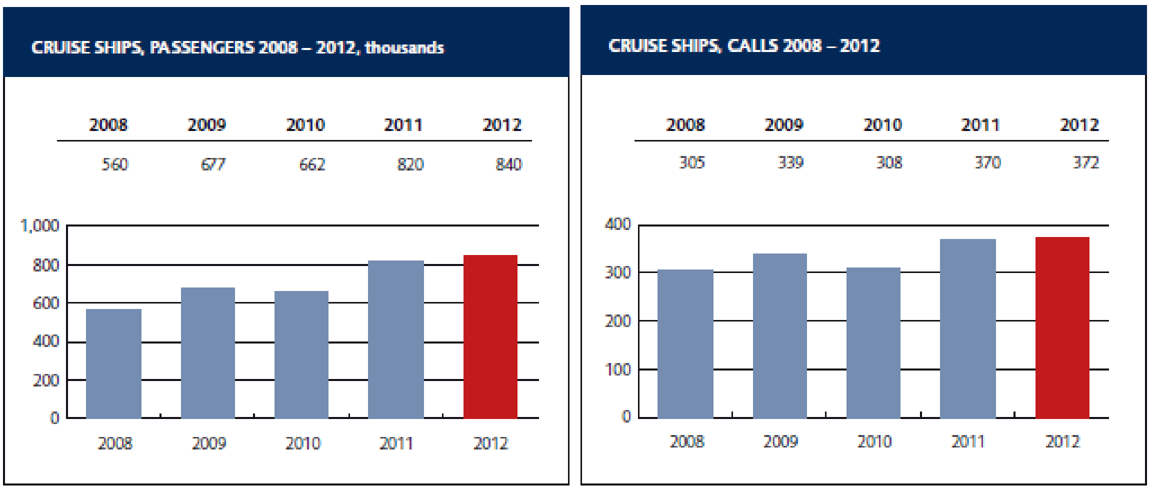

Figure 8: Cruise ship calls in Copenhagen. Source: CMP Annual Report (2012)

The European Commission has identified 319 key European seaports which play a crucial role in the development of the European internal market; among those, 83 have been recognised as EU core network points (EC, 2013), because of their strategic position (Rozmarynowska & Ołdakowski, 2012). CMP has been nominated as one of them and Mr

[38] 173 turnarounds took place in Copenhagen in 2012. A turnaround harbour, also called home port, means that passengers' disembarkation and embarkation takes place there. On the contrary, a port of call harbour means that the vessel arrives and leaves with the same number of passengers. Copenhagen is a turnaround harbour for the majority of the cruise lines that sail around the Baltic capitals or towards Oslo and the Norwegian fiords (Mærsk Broker Agency, 2013). For more information, see http://www.maerskbrokeragency.com/OFFICES/DENMARK/COPENHAGEN.aspx

[39] This year in 2013, the number of cruise vessels calling at Copenhagen's harbour was 361. However, a cruise service was established in Malmö as well where 10 calls were made (CMP, 2013). For more information, see http://www.cruisecopenhagen.com/cruise-line/port-of-copenhagen

[40] For more information, see http://www.worldtravelawards.com/award-europes-leading-cruise-port-2013

Röstin, CEO at CMP, believes that this is a good incentive to continue investing in new infrastructure and new equipment (CMP, 2013). As a matter of fact, in 2012 significant investments in new machineries were made at the container terminal in Copenhagen, in order to increase productivity and at the same time decrease the environmental impact of their operations (CMP, 2013). CMP is particularly proud of being included into the core port list as the company believes that this will facilitate cooperation with neighbour harbours as well as it will enable CMP to get more public support for their future investments and developments.

4.1.2 Future Developments

Due to the stable growth of the cruise market over the past ten years (Deltamarin, 2011), CMP has decided to focus on the cruise side of its operations (CMP, 2013). In fact, the company has invested 500 million SEK[41] into the construction of a new cruise terminal. As visualised on figured n. 8, the cruise operation is currently divided among three harbours in Copenhagen: Nordre Tolbod; Langelinie; and the Freeport (Frihavn) that has five quays. Nordre Toldbod and Langelinie are mainly used for smaller vessels and for port of call ships, because of their strategic location in the hearth of the historic centre of the city. On the contrary, larger vessels and turnaround cruise ships are scheduled at Frihavn.

Figure 9: Map of Copenhagen Harbour. Source: CMP (2010)

From next year, in 2014 Copenhagen will have a new cruise ship quay, called Oceankaj, suitable for turnarounds (figure n. 9). CMP will therefore move part of its cruise traffic, which is at present taking place at the Frihavn to a new terminal situated closer to the Øresund coast line. The new quay, which has been under construction for the past three years, will occupy an area of 3.300 square metres and will be 1.100 meters long and approx.

[41] Corresponding to € 57.5 million.

70 meters wide (CMP, 2012). The new quay will be spacious enough to accommodate three cruise vessels at the same time allowing CMP to receive up to 500 cruise vessels per year. Moving part of the cruise operation further out will create positive environmental effects on the surrounding residential area which will thus be less subject to noise and air emissions. In fact, the biggest cruise vessels will be scheduled to berth at Oceankaj, with smaller cruise ship still mooring at the old quays in Frihavn (Schmidt, 2013). The Tolbod and Langelinie harbours, situated in the city centre, will remain operative mainly for port of call vessels.

Figure 10: New quay for cruise ships in Copenhagen. Source: Jansson (2012)

The project of the new quay has been undertaken in cooperation between CMP and the owner of the facilities in Copenhagen, By & Havn. The new harbour will be prepared for high voltage OPS, by means of allocation of land and necessary infrastructure (canalisation) in place (Jansson, 2012). However, it is not clear if and when CMP will be able to offer shore side electricity to its clients. In 2011 CMP, jointly with By & Havn asked the consultancy company Deltamarin LTD to carry out a feasibility study on the implementation of cold ironing at the cruise terminal of Copenhagen and the results of the study did not reveal the existence of a profitable business case for the time being. According to the investigation accomplished by Deltamarin, the main threats to the implementation of shore side electricity in the Baltic area can be summarised as:

- Weak standardisation of port equipment;
- High investments costs needed at port;
- High electricity prices, if normal tax rates apply to electricity supplied at berth;
- Low number of harbours in the region offering on shore power supply;
- Reduced number of cruises navigating in the Baltic Sea, if too strict environmental rules should apply (Deltamarin, 2011).

Deltamarin utilised data available for the cruise season 2011 and 2012 in order to compile a statistic of the number of vessels calling at Copenhagen harbour that would be able to use the OPS technique. The investigation showed that only 4 out of the 67 vessels, representing the 9,3 per cent of the totality of vessels visiting the port of Copenhagen, would be able to connect to OPS. On average there are 2,5 new vessels entering the Baltic cruise market per year (Deltamarin, 2011), which means that the percentage of vessels able to use shore side electricity is increasing every year. However, figures remain pretty low for the coming years. Considering the high costs for retrofitting old vessels to OPS, which is often combined with a lack of space on board, it is reasonable to argue that it will be most likely new vessels switching to OPS. Deltamarin calculated that if only new vessels were to use OPS, with a market penetration rate of 2 new vessels per year, it would take about 20 years to have the majority of cruise vessels (80 per cent) to utilise OPS at Copenhagen's harbour.

For this reason, CMP is not considering to invest in OPS equipment for the time being (Jansson, 2013). Furthermore, it would be difficult for CMP as a port operator company to convince its clients to make use of the facilities, as the current prices for electricity are considerably high[42] in Denmark compared to the conventional fuel used on board, diesel that is tax free as used mainly at sea; hence switching to electricity coming from the local grid would not be economically valuable from a ship owners' perspective. In fact, it is calculated that for a seven days cruise, vessels use at berth approx. 13 per cent of total amount of fuel burned (Deltamarin, 2011). Thus, the percentage of fuel saved if using OPS at the port of Copenhagen would be pretty low, especially if Copenhagen was the only harbour during the cruise offering this possibility, which would therefore not make OPS an attractive option for cruise companies. Cold ironing for cruise vessels is a very new concept in Europe and with a very low penetration in the Baltic Area, where few of the current vessels navigating this route are equipped for this technology and no port yet able to offer this service.

However, from an environmental and societal perspective, installing OPS at the new quay could be considered a good investment. In fact, Ballini (2013) in his feasibility study about the implementation of cold ironing technology for the cruise operation at Copenhagen harbour has calculated that the use of OPS would result in consistent external health cost savings due to lower emissions of NO_x SO_2 and PM. Ballini has calculated that in summer 2012, from May to October, which is the length of the cruise season in Copenhagen, the total emissions related to cruise vessels were 408 tons of NO_x, 9 tons of SO_2, and 4 tons of PM. Ballini has considered two different scenarios in order to quantify the emission savings related to an OPS installation at Copenhagen's port: 100 per cent of cruise ships able to connect to OPS; and a more realistic[43] one of 60 per cent.

As shown on table n. 3, OPS could bring substantial emission reductions, if all ships were connected to the local energy grid. The so called Nordic Energy Mix comprises both renewable sources, like hydro power, wind, and bioenergy as well as non-renewable sources, like oil, natural gas, nuclear power and coal (Norden, 2009). It should be noted that neither nuclear nor hydro power are actually available in Denmark.

	SO_2 (t)	**NO_x** (t)	**PM** (t)	**CO_2** (t)	**Energy demand** (MWh/season)
Emissions from auxiliary engines (AEs) using 0,1% sulphur marine gas oil (MGO)	6	418	10	20430	31674

[42] Deltamarin calculates that the price for electricity produced at berth would be approx. 15 per cent higher than what produced on board, especially because in Denmark over 50 per cent of the price per kilo Watt hour represents fees or taxes (Jansson, 2012). It is calculated that vessels through their auxiliary engines are able to self-produce power for 1,24 kr./KWh while they buy shore power for 1,40 kr./KWh which includes taxes and 0,6 kr./kWh at full duty (DanskEnergi, 2013).

[43] The new quay should in fact be able to accommodate 60 per cent of the vessels calling at Copenhagen.

Emission from shore power (OPS) using Nordic Energy Mix	2	10	1	13493	31674
Difference	4	408	9	6937	
Percentage	*65%*	*98%*	*90%*	*34%*	

Table 3: Total emission reduction if 100% of cruise vessels had switched to OPS in summer 2012. Adapted from Ballini (2013)

As previously mentioned, the new quay will be able to offer OPS to approx. 60 per cent of the cruise vessels calling at Copenhagen. In table n. 4 it is calculated the percentage of emissions reduction that could be achieved if only 40 per cent of the vessels kept on using their auxiliary engines (AE) to generate the electricity used while at berth. Reductions are still pretty significant.

	SO_2 (t)	**NO_x** (t)	**PM** (t)	**CO_2** (t)	**Energy demand** (MWh/season)
Emissions generated by 40% of vessels from auxiliary engines (AEs) using 01% sulphur marine gas oil (MGO)	2,5	167,2	3,8	8171,8	12669
Emission generated by 60% of vessels from shore power (OPS) using Nordic Energy Mix	1,3	6,1	0,6	8095,8	19004
Total	3,8	173,3	4,4	16267,6	
Difference among 100% vessels using AE and 60% using OPS + 40% using AE	2	245	5	4162	
Percentage	*39%*	*59%*	*54%*	*20%*	

Table 4: Total emission reduction if 60% of cruise vessels had switched to OPS in summer 2012. Adapted from Ballini (2013)

As described in the previous paragraphs of this thesis, there are many diseases related to air pollution attributable to vessels while at berth. Thus, reducing these emissions will result in improved health conditions for people leaving in the surrounding areas. As a consequence, this will generate external health cost savings, which in a country like Denmark, where health care is considered a public task, will partly result in saving public funds. Ballini (2013) has assessed the socio-economic impact of OPS, applying an advanced external air pollution evaluation model. Ballini calculated that during the cruise season 2012 the total external health cost of emissions from cruise ships at berth in Copenhagen amounted to €5.384.086. In a scenario of 60 per cent of cruise vessels switching to OPS, the societal health cost savings related to this change would almost reach € 3.000.000 annually (Ballini, 2013).

It becomes obvious that even though installing OPS would bring both environmental and health benefits, its installation raises the question of who should actually bear the costs of this investment. Mr Jansson[44], Chief Technology Officer (CTO) at CMP, believes that it should be the City of Copenhagen that should finance the installation of OPS at Copenhagen's port. Of the same opinion is Mrs Ledgaard[45], Director of By & Havn, that as explained afore is the company owning the port facilities that CMP is leasing. Mrs Ledgaard justifies her stand explaining that even though By & Havn is partially owned by the City of Copenhagen, the company is profit oriented and therefore needs the existence of a profitable business case before investing in OPS equipment. As a matter of fact, a report draft by the Danish Energy Association (Dansk Energi) in 2013 has confirmed that the company financial business case is negative at the given assumptions (Dansk Energi, 2013).

Dansk Energi has been in dialogue with some of the different actors involved in this transition: Copenhagen's municipality, as one of the owners of CMP; By & Havn, as the owner of the port facilities; and two technology providers, ABB and Schneider. As previously said, according to their calculations, which considered two different scenarios of Oceankaj being used for turnaround ships only, or for port of call vessels as well, the economy of cold ironing for Copenhagen would be very weak (Dansk Energi, 2013) for the time being. The Danish Energy Association pinpoints the insecurities related to European legislation as one of the factors that would make the investment uncertain.

According to Mrs Ledgaard, the municipality as well as its politicians were initially reluctant to consider OPS for the port of Copenhagen, mainly because of the high costs that the implementation of this technology entails. Nevertheless, after assessing the possible environmental and societal benefits that might arise from cold ironing, the City of Copenhagen, as confirmed by Mrs Christensen[46], Climate & Energy Coordinator at Copenhagen municipality, is currently actively investigating the opportunity of having OPS at Oceankaj. The municipality is at present looking at previous experiences, like Ystad in order to gain better knowledge on this technique and investigate different financing models (Christensen, 2013).

Dansk Energi has looked into possible ways in which the municipality could actually pay for the investment and has come up with two different suggestions. With the first one, Dansk Energi has come to the conclusion that adapting the financing model previously suggested for the introduction of electric vehicles in Copenhagen, could give fruitful results. According to this model, the owner of the electricity grid, which in Copenhagen is Dong Energy, should take responsibility of establishing the necessary cabling system. In this sense, OPS would represent some sort of extension of Dong Energy's portfolio. The initial costs related to the connection would be thus borne by the utility company, which could re pay its investment through the rental fee paid by the customer, therefore be By & Havn, as the owner of the port facilities. In the other scenario proposed by Dansk Energi, Dong Energy would establish the cabling as well as a shore power plant. In this way, the utility company would be selling electricity directly to the vessels. However, this latest suggestion would require a legislative change in the Electricity Supply Act (Nejsum, 2013).

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[44] Private meeting held at CMP in Malmö on 10.07.2013.

[45] Private meeting held at By & Havn on 26.07.2013.

[46] Private meeting held at the Environmental Center of Copenhagen's municipality on 19.07.2013.

The Local Government Denmark (LGDK) association[47] has also contemplated existing financing possibilities and concluded that a possible model could be a public private partnership (PPP) or ESCO[48] approach, where the municipality of Copenhagen basically outsources the project but sets energy consumption requirements. A private operator will then be in charge of building and operating the facility retaining the consequent profits. LGDK believes that a model like this could be of interest for an OPS technology provider company, like ABB for instance. According to LGDK the application of this model would alleviate the municipality from the burden of such investment (FIVU, 2013). However, Mr Nejsum is of the opinion that this type of approach would not be attractive enough for big companies to invest in it, as they tend to prefer more substantial investments.

At the time of writing, the financing of the OPS project for Copenhagen's harbour is still under discussion and according to Mrs Christensen it constitutes the main obstacle to the OPS practical fulfilment.

4.2 Regulatory Framework for Controlling Air Emissions applying to the Port of Copenhagen

The purpose of this section is to provide the reader with background knowledge on the most important regulations and rules the port of Copenhagen needs to abide by with respect to air emissions deriving from maritime activities. It should be mentioned that both at international and European level, air emissions from shipping activities were left unregulated for many years (EC, 2011; Papoutsoglou, 2012). In fact, when the International Convention for the Prevention of Pollution from Ships (MARPOL), which regulates the prevention and minimisation of pollution of the marine environment cause by shipping activities, was adopted in 1973, it was deliberately decided not to regulate air emissions and consequent pollution (IMO, 2013). Air pollution was included in the Convention more than twenty years later, in 1997.

4.2.1 International IMO Agreements

Regulations for preventing air pollution from ships and shipping activities were first adopted at international level in the 1997 Protocol to the MARPOL Convention and are included in Annex VI of the Convention, which entered into force in May 2005 (IMO, 2013). Annex VI was eventually revised in 2008[49] and the European Commission (2011) has calculated that this revision and the consequent tightening of the rules are having positive effects in the reduction of public health costs in the European context. In fact, according to this assessment, the costs related to a reduced mortality index exceed by far the costs related to the implementation of the revision.

The MARPOL Convention was adopted to control and limit exhaust emissions deriving from shipping activities. With this Convention, limits are set to sulphur dioxide (SO_2) and nitrogen oxide (NO_x) emissions from vessels and deliberate emissions of ozone depleting

[47] Local Government Denmark is an interest group for Danish municipalities that tries to protect their interests offering them consultancy on various matters. For more info, see http://www.kl.dk/English/

[48] ESCO stands for Energy Saving Company as it is an energy service company or energy savings company that provides services to its customers with the ultimate goal of improving their energy efficiency as well. The ESCO company will then be remunerated according to the energy savings achieved. The ESCO company will at the same time provide a guarantee for the level of service provided and the for the savings accomplished (DLA Piper, 2012).

[49] MEPC.176(58) Amendments to the Annex of the Protocol of 1997 to amend the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (Revised MARPOL Annex VI)

substances are prohibited (IMO, 2013). The Convention does not explicitly regulate other types emissions related to vessels, like volatile organic compounds (VOCs), particulate matter (PM) and carbon dioxide (CO2).

With respect to SO_2 emissions, Annex VI of the MARPOL Convention limits the amount of sulphur present in the fuel used by vessels. Limiting the quantity of sulphur in the fuel can help reduce emissions as SO_2 emissions are directly proportional to the how much sulphur is contained in the combusted fuel (Ballini, 2013). Annex VI also defines some special areas, the so called sulphur oxide (SO_x) Emission Control Areas (SECAs) that are subject to more stringent controls on sulphur emissions (IMO, 2013). As it can be seen on table n. 5, the Baltic area is identified as a SECA. As per the most recent adjustments made to Annex VI, the allowed amount of sulphur in marine fuels is 3,5 per cent (as per 1 January 2012) but will have to go down to 0,5 per cent by 1 January 2020[50]. With respect to SECAs, the allowed amount of sulphur in marine fuels is 1 per cent (as per 1 July 2010) but will have to be reduced to 0,1 per cent by January 2015. In order to reach the goals, a wide range of equivalent emission abatement methods, like the implementation of different techniques, alternative fuels, and so on are contemplated. Cold ironing is included in the range of abatement technique suitable for SO_x reduction (Winnes, 2010).

Annex VI: Prevention of air pollution by ships (Emission Control Areas)			
Special Areas	**Adopted**	**Date of entry into force**	**In effect from**
Baltic Sea (SOx)	***26 September 1997***	***19 May 2005***	***19 May 2006***
North Sea (SOx)	22 July 2005	22 November 2006	22 Nov 2007
North American (SOx, and NOx and PM)	26 March 2010	1 August 2011	1 August 2012
United States Caribbean Sea ECA (SOx, NOx and PM)	26 July 2011	1 January 2013	1 January 2014

Table 5: Special areas under Annex VI MARPOL. Adapted from IMO (2013)

NO_x emissions from large marine diesel engines are also regulated by Annex VI, depending on the engine maximum operating speed measured in revolution per minute (n, rpm). The regulation contemplates the existence of three different standards for marine diesel engines installed on ships built after year 2000. As NO_x regulations apply to diesel engines of 130 kW, these limits are binding for most auxiliary engines (AE) used by large vessels, like cruise ships (Ballini, 2013). Three different categories have been identified: the so called tier standards (tier I; tier II; and tier III) that define the permitted emission levels.

Tier	**Date**	**NO_x limit, g/kWh**		
		n < 130	**130 ≤ n < 2000**	**n ≥ 2000**
Tier I	2000	17.0	$45 \cdot n^{-0.2}$	9.8
Tier II	2011	14.4	$44 \cdot n^{-0.23}$	7.7
Tier III	***2016***	***3.4***	$9 \cdot n^{-0.2}$	***1.96***

[50] Those targets will be reviewed in 2018 and the deadline possibly extend to 2015 (IMO, 2013).

Table 6: NOx Emission Limits MARPOL Annex VI. Adapted from IMO (2013)

As it can be seen on table n. 6, tier II and III, which were introduced in 2008, set stricter requirements than tier I and while tier I and II are global, tier III is applicable to the so called emission nitrogen oxide control areas (NECAs), which are areas subject to stricter NO_x emissions control (IMO, 2013).

In 2010, at the Helsinki Convention on the Protection of the Marine Environment of the Baltic Sea Area (HELCOM)[51], the Baltic States decided to work on a proposal to the IMO in order to apply for the creation of a NECA area for the Baltic Sea. As per May 2013, the application is ready for submission, with entrance into force expected for 2016 and applicable to vessels built after the date of designation of the Baltic Sea as NECA (EC, 2013). The European Commission (EC) estimates that in this way NO_x emissions will be reduced of 16 per cent by 2020 and of 46 per cent by 2030. The EC expects all vessels to meet the NECA requirements by 2050.

As for GHG, in 2011 energy efficiency measures were adopted by IMO. In fact, the energy efficiency design index (EEDI) for new ships and the ship energy efficiency management plan (SEEMP) were introduced with binding effect from January 2013 (IMO, 2013).

4.2.2 EU Legislation

The existing EU legislation regarding air emissions from vessels at berth in European ports is generally in line with IMO requirements and in some cases has preceded them.

The European Commission with the communications to the European Parliament and the Council regarding "*An European Union strategy to reduce atmospheric emissions from seagoing ships*" (EC, 2002) and a "*Thematic strategy on Air Pollution*" (EC, 2005) stresses the importance of reducing SO_2, NO_x, VOCs, and PM emissions deriving from ships in port in order to improve the quality of the surrounding environment and public health (ESPO, 2012); more specifically, the aim of these communications is to reduce illnesses and premature deaths caused by air pollution deriving from shipping activities as well as reducing their negative impact con the natural environment (EMSA, 2013).

With respect to SO_x emissions, Directive 1999/32/EC[52] as amended by Directive 2005/33/EC and by Directive 2012/33/EU regulates the maximum amount of sulphur that can be contained in marine fuels. The Directive sets the sulphur limit to 3,5 per cent by 2014 and 0,5 per cent to be reached by 2020[53] in all EU seas and confirms the limit of 1 per cent by 2014 and 0,10 per cent to be achieved by 2015 for SECAs. With this directive the EU has substantially incorporated the requirements set by the Annex VI of MARPOL, but has amplified their spectrum, including additional requisites for the fuel used by ships calling at EU ports. The Directive permits several emission abatement methods or technologies for all

[51] HELCOM is an intergovernmental organisation of the 9 coastal Baltic States (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden and the European Union in charge of marine protection against pollution (HELCOM, 2013).

[52] COUNCIL DIRECTIVE 1999/32/EC of 26 April 1999 relating to a reduction in the sulphur content of certain liquid fuels and amending Directive 93/12/EEC. This Directive replaced Directive 93/12/EC, including limits on the content of sulphur in marine diesel oil (MDO) and marine gas oil (MGO) for vessels in EU territorial waters and inland waterways.

[53] In the IMO Convention a review of fuel availability is scheduled for 2018 and the deadline will possibly be extended to 2025 (see footnote n. 50). On the contrary, the EU Directive sets the limit to 0,5 per cent by 2020 regardless of the results of IMO targets review.

ships sailing in European waters, regardless of their flag, as long as continuous SO_x emission reductions are achieved. Furthermore, the Directive sets a stronger compliance mechanism respect to Annex VI of MARPOL and therefore improves the effectiveness of IMO standards (Airclim, 2012). Member States have to transpose the amended Directive into national law by June 2014.

As for NO_x emissions deriving from vessels at port, for the time being the EU has not issued any binding legislation in order to reduce them (EMSA, 2013). However, it should be noted that the 97/68/EC Directive on emissions from non-road mobile machinery tries to reduce the negative effects to the environment and to human health caused by NO_x, hydrocarbons (HC), and PM inviting Member States to set more stringent emission limits applicable to special areas of inland waterways. However, the Directive appears to cover rivers and canals more than sea waters, and therefore the Baltic Sea does not seem to be included. The Danish authorities could, however, take the emission limits for inland water as the required standard for Danish territorial water (Danish EPA, 2012).

Even though not legally binding, in May 2006 the EC adopted the "*Recommendation on the promotion of shore-side electricity for use by ships at berth in EU ports*". The EC highlights that the results achievable with the use of shore side electricity can be significant especially for reduction of NO_x and PM emissions at local level and thus the use of this abatement technique should be considered especially in ports placed close to urban areas. Likewise, Directive 2003/96/EC also named the Energy Taxation Directive as it aims at restructuring the framework for the taxation of energy products and electricity is intended to push the use of shore side electricity. In fact, Article 14(1) (c) states that Member States shall exempt from taxation electricity produced on board a craft, also while berthing at port. The exemption, when granted, applies for a maximum period of eight years. So far this rule has been applied to Sweden and Germany.

To conclude, it should be noted that in 2009 the EU Strategy for the Baltic Sea was adopted. This represents the first macro-regional strategy with the aim of setting different priority areas in order for the Baltic Sea Region to become a regional model for clean shipping. Among the seven priority areas one is dedicated to the promotion of measure to reduce emissions from vessels and to the development of shore side electricity facilities (DMA, 2013).

4.2.3 National Danish Level

According to a report published by the Danish Environmental Protection Agency in 2012, international legislation represents the greatest limit to what the Danish legislator can regulate in matter of emissions from vessels that navigate in Danish territorial waters. In fact, before introducing specific rules that might relate to the protection of the marine environment, the Danish legislator needs to make sure that they are in line with the principles expressed in the UN Convention of the Law of the Sea (UNCLOS) adopted in 1982 and signed by Denmark on the same year. According to UNCLOS, even though coastal States can adopt individual laws and legislations in order to protect the surrounding marine environment, some channels, like the Øresund, which provide the only passage from one area or country to the other, need to be considered exempt from this option. Moreover, national laws do not normally regulate the innocent passage of foreign ships in their waters (Danish EPA, 2012). Basically, the Danish legislator can only regulate ships that are calling at Danish ports. Furthermore, articles 26 of UNCLOS that regulates charges which may be levied upon foreign ships, declares that a foreign ship passing through territorial sea can only be charged for a specific service rendered to the same. Essentially, a foreign vessel calling at a Danish port cannot be charged for any of the emissions it releases.

For what concerns SO_x emissions, Denmark implemented Council Directive 1999/32/EC as amended by Council Directive 2005/33/EC with Statutory Order No. 372 of 15 April 2011[54] (Retsinformation, 2011). As other State Members, Denmark will have to transpose the new Council Directive 2012/33/EU by 2014 and adapt to the new SECA requirements.

With respect to NO_x emissions, Denmark imposes a levy[55] on nitrogen dioxide (NO_2) and equivalents deriving from fuel combustion and released in Danish territory, including the territorial sea. The NO_x tax is applied also to fuels used in the transport sector, even though rates are maintained at the symbolic levels of € 1,56 per ton fuel or € 0,026 per kg NO_x. However, sea transport is generally excluded from this tax as well as large vessels with emissions above 200 tons NO_x (Danish EPA, 2012).

Because of the afore described exemption, and considering that 70 per cent of NO_x emissions in Danish waters derive from foreign-flagged ships that never call at a Danish port (Danish EPA, 2012), it becomes obvious that voluntary agreements are one of the few options left to the Danish legislator to regulate NO_x emissions.

4.2.4 Municipal Level: City of Copenhagen

Since 2007, the role of municipalities in Denmark has amplified its spectrum, with more and more environmental tasks falling under their umbrella. Since then, Danish municipalities have seen their responsibilities increased within local planning, transportation, construction, urban maintenance, as well as environmental issues (KL, 2009).

In the 2025 Climate Plan (KBH2025) established in 2012 by the City of Copenhagen in order to achieve carbon neutrality by 2025, the municipality of Copenhagen stresses the fact that as a conspicuous part of the legislative framework for green transition takes place at national or European level, the City of Copenhagen does not have many possibilities to exert a direct influence on it. However, the City of Copenhagen aims anyhow at inspiring the legislative framework both at national and international level sharing its experience in adopting climate friendly measures for a sustainable urban development[56] (Municipality of Copenhagen, 2012).

For this reason, the City of Copenhagen has started an initiative running between 2013 and 2016 to improve the legislative framework related to the use of onshore power supply for cruise vessels (KBH2025, 2013). Furthermore, the plan requires that all future port developments related to cruise vessels, should have the infrastructure in place for cold-ironing (Ballini, 2013).

[54] https://www.retsinformation.dk/Forms/R0710.aspx?id=136787

[55] Act. no. 472 of 17/06/2008, *Lov om afgift af kvælstofoxider*.

[56] The Municipality of Copenhagen is member of ICLEI, the global network of local governments for sustainability since 1991. ICLEI, which has over 1200 local governments members, represents the interests of local communities within the UN and at international policy forums (ICLEI; 2013).

5 OPS seen through the Lens of Theory

This section aims at investigating the formulated research question through the prism of the conceptual and analytical framework chosen. On the base of the analysis, some recommendations are drafted. As motivated in chapter 2, Transition Management Theory (TM) was considered suitable to explore the role of municipal governments because it is the level of governance closest to its citizens and therefore they are often core of societal transitions. In fact, especially in the Baltic Sea Area and more specifically in Denmark, where most ports are municipally owned, local governments should have the sufficient power and the necessary capacity to shape and influence the development of a city harbour. TM is thus applied to the current situation that Copenhagen's harbour is facing, as well as to the other Baltic experiences described; the latest, with the purpose of providing a reference on how transition to shore side electricity is taking place in the surrounding harbours, looking into how the main actors are interacting, as well as of how local municipalities are acting in this respect.

5.1 Applying TM to the Baltic Experiences

Looking back at figure n. 1 on page 8 that describes the four different phases involved in a transition: predevelopment; take off; breakthrough; and stabilization, it can be noted that the four described cases (Gothenburg, Oslo, Ystad, and Copenhagen) stand all in different stages. As previously explained, a transition is a slow process that runs on different paths over several decades. For this reason, the goal setting of both the port authorities and of the municipalities in the different cities will follow a very different time frame depending on the phase they are in.

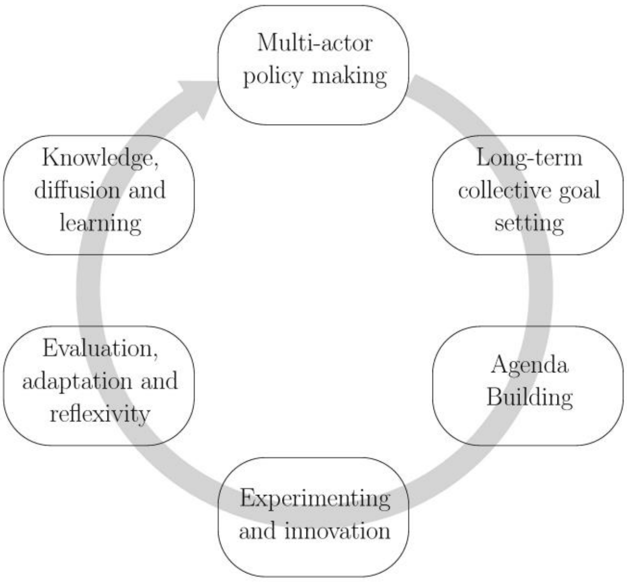

Figure 11: TM process. Adapted from Loorback (2007)

With over ten years of experience, the port of Gothenburg is going through a stabilization phase, with more and more of its terminal as well as of its clients being equipped for OPS. Having such a long tradition of OPS, enough data is available on the environmental and societal benefits deriving from the implementation of this technology, which means that the port of Gothenburg as well as its municipality have tangible figures that enable them to evaluate the efforts so far made. With the vision of having 40 per cent of the vessels berthing at its port switching to OPS by 2015, which would then correspond to not even half of the total, the system cannot be considered stabilized as such. However, setting goals for the short medium term shall be regarded as a good strategy, as it aids the system stabilizing and reaching equilibrium quicker, as new goals are set according to the results achieved. As captured on figure n. 10, transition is an adaptive and reflexive process (Loorback, 2007) and the port of Gothenburg is currently in a stage of reflection upon the outcome of the overall OPS project, which is accompanied by the willingness to share the knowledge acquired. Proud to be often taken as a role model, the port of Gothenburg is indeed very active in spreading information and raising awareness about both the benefits and the challenges related to shore side electricity.

As mentioned before, the port of Ystad introduced OPS only one year ago, which means that it is undergoing a breakthrough stage. In this phase the change becomes visible to the larger public and this is what is exactly happening in Ystad right now. With the Swedish Minister of Environment present at the opening ceremony, the port and the municipality of Ystad clearly wanted to send a message to their residents: things are happening! In fact, what made the system oscillate in first place was society as such, demanding new solutions for air pollution and noise deriving from vessels in the harbour. According to Loorbach (2007), the extrinsic goal of TM is to empower the civil society in order to give the possibility to its citizens to shape sustainability issues according to their actual needs. In this sense, it can thus be argued that this is what has happened in Ystad. However, a more institutional push was decisive, as the decision taken by the Environmental Court was in fact key in making this change happen. As discussed with Mr Boström, Managing Director at the port of Ystad, this transformation has comprised all levels of society: from Ystad's residents that in the past raised their voices to claim their rights to a clean air; through the shipping companies, whose cooperation and willingness to adapt to the new system is indispensable; to the municipality, which took charge of advancing the necessary funding for the OPS investment.

On the other hand, the port of Oslo is at the moment in a take-off phase, where real decisions are yet to be taken. In fact, even though OPS is already on the agenda for the coming years, the port of Oslo is still negotiating with the different actors, among which the municipality, how the installation of this technology should take place. A scratch in the system has been made; however, alliances are not completely formed as the different interests at stake are not aligned yet. In fact, according Mrs Neilson, Environmental Manager at the port of Oslo, issues related to both costs and space are still to be solved and the management of the port of Oslo is to finalise a decision on how to proceed by the end of 2013. When the final decision will be taken, it is reasonable to think that the transition will increase its pace also in order to keep up with the goals previously set.

Both the Swedish cases clearly show how the different societal layers as described by the TM shall interact to make transition possible. In the Gothenburg experience in particular, the interaction among the niche, the landscape and the regime level, as visualised in figure n. 2 on page 10, has been particularly profitable. In fact, stricter environmental requirements set from a private company on own initiative on its clients, pushed the port of Gothenburg to experiment and find an environmental friendly solution that could result in a competitive advantage over the other suppliers. The port of Gothenburg acted essentially as a front runner that managed to climb from the niche level up to the landscape. In fact, the collaboration brought about among the different stakeholders created the necessary pressure on the regime to open up for innovation. Furthermore, the alliance formed among the port authorities and the shipping companies was strong enough to change the existing legislative framework. As a matter of fact, they lobbied for over a year until they managed to shake the Swedish government that promised a change in the legislation that would allow for a tax exemption on electricity supplied at berth. This lobbying activity was so effective that it reached the European level and it culminated with the European Commission allowing Sweden to cut down the taxes on shore side electricity for vessels. In this way a change in the overall the system was reached, which was of utter importance not only because other ports in Sweden, like Ystad for instance, are now able to benefit from this modification, but it has inspired other National Governments in Europe to aim for the same. As a matter of fact, Germany, following the Swedish case, has also been allowed by the EC to apply a reduced rate of electricity tax to the electricity supplied at berth (EC, 2011).

5.2 Applying TM & PAA to the case of Copenhagen

When analysing the case of Copenhagen, it becomes obvious that no real interaction among the micro, meso and macro level has happened yet. However, even though a change in the system could seem very far away, things are anyhow moving as there is an open discussion about the development of OPS for the new cruise terminal. Thus, from a policy perspective, the use of TM can give fruitful results as it helps contextualizing the problem and envisioning it in a broader perspective at the same time.

As opposed to the other Baltic experiences examined, Copenhagen lies in a predevelopment phase, which, as per definition, has a much slower pace than the other stages of TM. At this stage, albeit feasibility studies on OPS and the on-going debate among the different actors on who should be carrying the borne of the investment, nothing is visible to society as a whole. It can be said that Copenhagen is still at a strategic level with action mostly initiated in niches at micro level where experimentation is taking place and the meso level being just scratched. The willingness to change the overall system is evident: the new quay will be suitable for OPS and this change in the physical infrastructure can be regarded as the first crack at meso level. CMP and By & Havn in this respect can be seen as frontrunners, acting so far mainly in their own niches and in their own sphere of influence, envisioning the change that Copenhagen's harbour is going through. However, as it has been stressed several times in this thesis, when planning an OPS system it is important to include as many actors and stakeholders as possible, but, as a matter of fact, only few actors appear to be involved at this stage: the port operator CMP; the owner of the port infrastructure By & Havn; Copenhagen's municipality; and the Danish Energy Association Dansk Energi. They seem to share the same vision, but no communal goals have actually been set.

Looking at the transition process as explained on figure n. 10, Copenhagen lies still at the beginning of it, where the so called transition arena is not built yet and its formation seems difficult. The main actors so far involved, CMP, By & Havn, and the municipality agree on the necessity of having OPS at Oceankaj, but none of them seems eager to make the investment. Both CMP and By & Havn argue that it should be the municipality advancing the costs related to the investment. Considering that both CMP and By & Havn are profit oriented enterprises, it can be understandable that they feel the necessity to have a profitable business case before investing in OPS and that they thus consider the municipality, which is no profit oriented, as the actor that should actually do the first move. On the other hand, the municipality is in the process of seeking a way of financing it, but from the information collected during this thesis it appears obvious that the municipality is reluctant to use public resources for it. Unless responsibilities on the investment are determined, it might be difficult for the different actors to find an agreement.

This highlights the political dimension of OPS, which has actually been clearly pinpointed by Mrs Ledgaard during the interview conducted. Utilizing a policy arrangement approach (PAA) can thus be convenient for digging into the political dimension of this transition and trying to answer the formulated research question that relates to what the municipality could do to incentivize the use of OPS. It should be noted that the objective of this research is neither to assign responsibilities over the planning and the implementation of OPS, nor to investigate possible ways of financing the related investment, but simply to speculate on how the municipality as a key actor could push the use of this technology.

As roughly described in chapter 2 and captured on figure n. 11, four are the dimensions of a policy arrangement: actors, and their coalitions; the resources employed; the so called rules of the game; and the discourse, which is basically the meaning given to a policy. These four dimensions are strictly interdependent, which means that one change occurring in one of them will influence the others as well. Looking into what is happening in every single dimension with respect to the role of Copenhagen's municipality, might be useful in order to explore what measures could be taken to promote the use of shore side electricity.

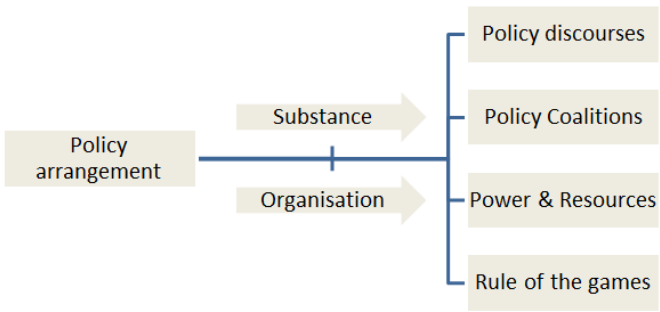

Figure 12: Policy Arrangement Concept. Adapted from Arts & van Tatenthove (2004)

As for the actors and their relationships or coalitions, the municipality of Copenhagen has established a dialogue with the other main actors so far involved: CMP and By & Havn. Some of the other relevant actors do not appear to have been included yet though. The owner of the electricity grid in Copenhagen, Dong Energy, for instance seems to have been engaged very little, mainly for technical details.

The shipping companies that would be the ultimate user of shore side electricity do not seem to have been called for at all. For example, the study conducted by Deltamarin (2011) which has eventually been used by Dansk Energi as well as By & Havn to assess the profitability of the investment, took into account the possibility to connect to OPS for the vessels that were schedule to come to Copenhagen in the last couple of years, but no survey was conducted on their actual willingness to connect. Other experiences in the Baltic area teach us that engaging the shipping companies at an early stage can be key in influencing the outcome of an OPS project. Switching to shore side electricity is a change in paradigm for ship owners as well and the hierarchy typical of the maritime environment does not always allow for flexibility. Even though the technology is mature enough, uncertainties regarding the use of shore side electricity can be easily experienced among the personnel involved. Mr Parlati, for example, Environmental Officer on board Costa Luminosa, a cruise vessel that is already equipped for cold ironing, expressed his concern about emergencies shut downs that could occur if the vessel relied only on the local grid for the production of the energy used on board.

It could be argued that it is CMP as port operator who should initiate the real contact with the shipping companies, being in charge of their berth at Copenhagen's harbour. Nevertheless, the cruise industry that is expanding its traffic in Copenhagen year after year creates job opportunities and revenues for the whole city of Copenhagen, not for the harbour only. Thus, establishing a dialogue with them, making them aware of the benefits that the use of cold ironing could entail for them as well, has to be considered a task that relates to the municipality of Copenhagen as well.

Considering the strong impact that the cruise market has on the economy of the city, the municipality of Copenhagen could contemplate a partnership with the tourism industry, in particular with Visit Denmark, the official tourism organization of Denmark, to try to attract cruise operators that are willing to reduce their negative impact on the natural environment. The port of Copenhagen is the perfect getaway to the Baltic Sea and the short distance and the easy connections between Copenhagen's international airport and the harbour make Copenhagen a very suitable turn around pier; ergo it is very unlikely that putting some pressure on the cruise industry will result in a loss of clients for the city of Copenhagen.

Copenhagen's residents are to be considered as one of the stakeholders in this transition, as they are directly impacted by the pollution created by vessels at berth or along Copenhagen's coastal areas. Thus, the city of Copenhagen should take them into account in the broader picture, engaging them and asking their opinion about the future of the harbour. The municipality of Copenhagen is currently engaging its residents in the development of the recreational side of the harbour. A campaign called "*En Havn af Muligheder*[57]*",* which means an harbour of opportunities, is running between September and October 2013 in order to hear people's opinion on the future of the city harbours. A similar initiative could be taken for what concerns the future of the commercial harbour, whose activities are impacting residents' health conditions. This could help the municipality setting priorities in a way that they can better meet its residents' needs.

When discussing the allocation of resources, it should be kept in mind that the amount of financial and human resources available to an actor directly influences that actor's power. In this respect, a municipality like Copenhagen with a whole department dedicated to Technical and Environmental Administration (*Teknik- og Miljøforvaltningen*) should have enough capacity, at least in the terms of knowledge, authority and networks, to act as a facilitator, helping the other actors involved in this transition to connect to each other and contributing to sharing knowledge. Mrs Dutt stressed the important role that the municipality of Gothenburg played in helping the port authorities to collect sufficient legal knowledge in various matters, for example, as well as in applying for public funding.

In connection with the so called rules of the games that relate to all the norms, the legislation and the practices that influence the policy domain, it should be remembered that municipalities in Denmark since the reform in 2007 have been taking over several environmental tasks, among which the issuance of operational permits. If we connect this dimension to TM, when enough pressure is created at niche level, this might induce a change at regime level and eventually at landscape level. Ergo, going beyond compliance setting

[57] For more info, see http://www.kk.dk/da/om-kommunen/nyhedsliste/2013/3-kvartal/tmf-ny-vision-for-havnen

stricter environmental requirements at municipal level could induce a change at the national one, and maybe at European or even International level, when sufficient pressure is exerted.

The case of Gothenburg provides a good example of how the pressure created through lobbying activities can lead to change at macro level. More pressure on the system is in fact exercised when single actors aggregate. In the case of the municipality of Copenhagen, establishing a network of Danish municipalities that are willing to set stricter environmental obligations related to air pollution, for instance, in order to safeguard their citizens' health could be a good tactic to breach the system. With so many kilometres of coastal line, many other municipalities in Denmark are probably facing the same issues regarding air quality and looking into possibilities to improve it, and OPS is most likely one of the solutions they might be considering. As previously said, the municipality of Copenhagen is a member of ICLEI, which is an international network of local governments sharing experiences of sustainable urban solutions. Nevertheless, being part of a more specific network, with respect to both geographical scope, which could be the Baltic Sea Area, and to thematic, could provide more inspiring solutions for Copenhagen. For example, the municipality could join an association like KIMO[58] that pools local authorities mainly in the Nordic and Baltic Sea regions with the common goal of protecting coastal communities from maritime pollution. In this way, the municipality could gain more knowledge on how to tackle emissions deriving from vessels and at the same time could support other municipalities that aim at changing the landscape level.

As expressed by TM, collaborative learning can positively influence the outcome of a transition. On the same note, almost all of the interviewees of this thesis confirmed the necessity of creating synergies among the Baltic States, especially among the port authorities and the municipalities of the Baltic capitals involved in a cruise itinerary, in order to expand the use of shore side electricity and share experiences, as this helps evaluate the feasibility of OPS in different contexts. In fact, if all ports in the Baltic Area were able to offer shore side electricity for cruise vessels, it would be easier to get the collaboration of shipping companies, as knowing that they could make use of this technology at every port they berth, would probably make them more eager to switch to OPS.

The last dimension that goes under the name of discourse comprises of all the undergoing discussions related to the problem. As said, the municipality of Copenhagen in its 2025 Climate Plan communicates to the public that it is taking initiative to improve the legislative framework related to the use of OPS for cruise vessels. However, no much information was possible to retrieve on this respect during this thesis. As a matter of fact, the municipality is very much aware that if Denmark managed to obtain the same exemption that Sweden and Germany got about the tax applied to the electricity supplied on shore side, this would encourage the development of cold ironing in Copenhagen.

As previously expressed, a transition cannot be controlled as such, but it can be steered and its speed can be influenced. What becomes apparent from this brief analysis is that the political component of this transition is very strong, which enables the municipality of Copenhagen to enact its sphere of authority in many ways that could encourage the development of shore side electricity.

[58] For more info, see http://www.kimointernational.org/Home.aspx

5.3 Final Reflections

The purpose of this brief section is to look at the overall work and at the analysis carried out in a critical perspective, in order to reflect upon the legitimacy of results achieved.

5.3.1 On Theoretical Framework

As explained in chapter 2, this study has mainly made use of the concepts expressed by TM to systematically collect and analyse data. Being a multi-level and multi-phase framework, TM was very useful for dissecting the path that the presented Baltic cases are or have been following and for better grasping who are the main players and how the different actors interact and form alliances. Furthermore, being all of the studied experiences at a different stage of their transition, TM was helpful to capture the role that the respective municipality has played in the development of an OPS culture.

With respect to the main case study, the port of Copenhagen, as anticipated, TM was considered appropriate but too generic to be able to draw conclusions and make suggestions. As properly conceptualised by TM, Copenhagen is still in its early days of this transition. What is mainly happening is a discussion taking place at different levels of governance and even though a decision seems to have been taken neither the municipality nor the other actors seem to have at the current stage the proper means to embark on this journey. For this reason, PAA was also applied to better catch the political dimension of this transition. PAA was beneficial in breaking down the different spheres of influence that the municipality can exert to push the OPS project forward. For example, the use of the four dimensions made possible to capture the different actors the municipality has engaged so far, as well as the different resources that have been employed. However, it was still difficult to crystalize the interaction and the interdependency of the four dimensions, due to the very initial stage Copenhagen is in.

On the contrary, SNM complemented the collection of data rather than the analysis. SNM in fact aligns the technological and social development of a transition, stressing the importance of a coevolution of technology and socio-technical arrangements. For this reason, elements of SNM were used for data collection in order to capture how the existing technology and its users influence each other. However, SNM was not fully exploited in the context of this thesis. In fact, as SNM puts emphasis on the importance of learning, applying SNM for the analysis of the collected data could have resulted in a profitable benchmarking exercise. Comparing in a semi structure way the experience of Copenhagen against the other Baltic cases described would have helped to further dig into the role played by the other municipalities involved. Nevertheless, as previously mentioned, it was difficult to retrieve primary information on the function assumed by the different municipalities of the experiences examined, thus lack of sufficient primary data on this aspect, constrained the use of SNM for this purpose.

5.3.2 On Method

As explained on chapter 2, both qualitative and quantitative methods were employed in this research. However, being OPS a niche phenomenon often of recent adoption, a lack of quantitative data was sometimes experienced. Thus, qualitative data represent the majority of the data collected and analysed for the purpose of this paper.

For what concerns the collection of primary data, interviews were mainly conducted in an informal and semi structure way, which resulted in a very pleasant and fruitful exchange of knowledge. However, most of the interviews were carried out over the phone, which always constitutes a barrier, especially when the communication is conducted in English as a foreign language. Having the chance of meeting in person would have probably enriched the content of the conversation. Nevertheless, as many of the interviewees are not based in the Øresund region it was difficult to meet personally.

As per the selection of the interviewees, the choice was somehow limited by the geographic location as well as by the time constrain that was accompanied by the vacation period. It would have been beneficial to be able to collect more primary data on the role of the Baltic municipalities for example, as well as it would have been extremely useful to make contact with some other actors as well as politicians within the municipality of Copenhagen. This would have provided a better insight on the actions taken at municipal level and could have helped feel the temperature on how the transition in Copenhagen can be steered.

5.3.3 On Findings

The legitimacy of the designed research question was supported by the necessity of having a leading actor that takes responsibility for this harbour transition or at least tries to guide it. Being shore side electricity still at an early stage, the different roles and to some extend responsibilities for the initiative are difficult to generalize. However, the fact that ports in Scandinavia and especially in Denmark are for the most owned by the municipally, justifies the interest of exploring the measure that the municipality of Copenhagen can take in order to promote OPS.

As expressed in the previous section, being able to hear the opinion of more people involved in this project within the municipality would have increased the reliability of the findings. More specifically, the political dimension of the findings lacks a proper political voice, meaning that it could have been interesting and useful to collect the opinion of a political actor as well.

Despite what afore said, it is possible to generalise the recommendations made, at least in a Scandinavian context where harbour are municipally owned and local governments have a wide sphere of influence. Local governments are the level of governance closest to its citizens and therefore more able to meet their needs. For this reason, they are more suitable than other actors for facilitating community participation and inter sectorial collaboration.

6 Conclusive Remarks

The OPS technology and the related market are proven and mature enough to become of wide use and the environmental benefits that can be generated are several. However, the spread of an on shore power supply culture struggles to take off. Thus, there is a need for an actor that takes the lead paving the way of this transition. The role of the municipality was considered crucial in this shift and ergo the range of its intervention was explored in order to discover how it could be amplified. The research looks into the current situation at Copenhagen's harbour, as well on how OPS has developed in some other Baltic Sea ports, with the intention of providing concrete examples to formulate suggestions.

The main findings and conclusions reached through the formulation of the research question will be summarised here underneath. The research question investigated along this paper was:

"How can the Municipality of Copenhagen incentivize the use of on shore power supply?"

The findings of the study put emphasis on the political relevance of this transition. Even though the municipality has shown a strong interest in adopting cold ironing for the new cruise terminal, its action seems constrained by the lack of agreement among the different actors involved with respect to the financing of the operation. Nevertheless, regardless of who takes responsibility for the overall investment, there are several ways in which the municipality can wield its power and authority to accelerate this transition.

The study has revealed that the municipality has so far established a contact with a very limited number and range of actors. The municipality is acting mainly in its own niche, which even though it could be argued that it is the place where innovation takes place it may risk restricting its view. Many are the actors and stakeholders involved in this transition and they all need to be engaged. Ship owners, energy companies and local communities, for instance, have been addressed only marginally, while this type of shift requires the understanding, the participation and the engagement of all parties directly or indirectly involved.

The municipality has an on-going project running through 2013 – 2016 aiming at influencing and consequently changing the legislative framework for the use of shore side electricity. One of the presented experiences has shown that lobby movements can achieve promising results when they rely on the concerted action of different actor groups. The municipality of Copenhagen gives more the impression of acting on its own though, which might result in bigger efforts and fewer results.

Based both on the findings and on the opinions received during the interviews the following recommendations are elaborated:

- The municipality needs to strengthen its role of facilitator. With its strong local contextual rooting, it has the capability to engage the broader public and connect the several actors involved in this transition. As the level of governance closest to its citizens, it has enough capacity in terms of resources, knowledge, connections and authority to catalyse the necessary change.

- The municipality shall also intensify its communication efforts, to make the larger public aware of the transition that the city harbour is going through. Being the connection point among its residents and the surrounding environment, the municipality can outreach all societal levels which will help increase awareness about environmental issues and the related possible solutions. Bottom-up changes often rely on wider public acceptance and making feel the local community that is part of the change will make transition faster and smoother.

- The city of Copenhagen has the opportunity to confirm and consolidate its position of green capital. As previously mentioned, Copenhagen is the leading cruise capital in Scandinavia, being the perfect getaway to the Baltic capitals. Including the tourist operators in this transition, establishing a partnership with them in order to be able to shape and direct the cruise market towards a more sustainable direction, which among other possible options can comprise the use of OPS, could give very positive results both in terms of revenue generation and of environmental protection.

- Copenhagen's municipality needs to work together with other Danish municipalities, as many of them are likely to be facing air pollution problems related to vessels in proximity to urban areas. Therefore they will be looking into possible ways of reducing emissions, and cold ironing is probably among them. However, especially small municipalities might encounter different barriers of legislative, financial or public acceptance nature. Establishing thus a network of municipalities with special focus on environmental and maritime issues could help overcome some of these obstacles. Furthermore, participative learning is a key component of a transition and sharing knowledge can accelerate and positively influence the outcome of it.

- The municipality would benefit from working on a more wide geographical perspective though. Pooling together with the other Baltic capitals, in order make shore side electricity a common phenomenon among the ports hit by a standard Baltic cruise itinerary, would increase the acceptance and the willingness of the shipping companies to be part of this shift. Being able to use OPS at every port they berth, would constitute a big incentive for change for cruise ships and as the other presented Baltic cases confirm, the collaboration with shipping companies can give fruitful results.

- The municipality shall intensify its lobbying activities in order to be able to breach the system and improve the legislative framework for shore side electricity on national and European level. Being able to apply a reduced tax rate on the electricity supplied at berth would probably be what most can encourage the development of shore side electricity in Copenhagen and every actor involved in this transition would benefit from this. The experience of Sweden shows that the concerted action of different players can result in more powerful lobbying activities, which can be able to change the overall system when sufficient pressure is exerted.

The last recommendation formulated is to be considered of utter importance and for this reason requires future research. Most of the suggestions made are strictly interconnected. However, the establishment of a network of Danish and Baltic municipalities is to be seen as prerequisite for more effective lobbying activities that can provoke a change at macro level.

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List of the persons contacted and interviewed

Böstrom Björn, *Managing Director at Port of Ystad,* email correspondence and telephone conversation on 06.09.13, 30 minutes

Christensen Hanne, *Climate & Energy Coordinator at Copenhagen Municipality,* email correspondence and private meeting held in Copenhagen on 19.07.13, 45 minutes

Dutt Susann, *Quality Manager & Specialist Sustainability at Port of Gothenburg*, email correspondence and telephone conversation on 05.09.13, 30 minutes

Ejlertsson Cecilia, *Environmental Officer at the Port of Ystad,* telephone conversation on 05.09.13, 30 minutes, 30 minutes

Jansson Bengt Olof, *Chief Technology Officer at Copenhagen Malmö Port,* email correspondence and private meeting held in Malmö on 10.07.13, 70 minutes

Klingström Anders*, Safety & Environment at Ports of Sweden,* telephone conversation on 06.09.13, 10 minutes

Ledgaard Kirsten, *Senior head of Planning at Udviklingsselskabet By & Havn,* private meeting held in Copenhagen on 19.07.13, 60 minutes

Neilson Heidi, *Head of Environment at Port of Oslo,* email correspondence and telephone conversation on 30.08.13, 25 minutes

Nejsum Thorbjørn, *Energy Consultant at Dansk Energi*, telephone conversation on 11.09.13, 35 minutes

Parlati Gennaro, *Environmental Officer on Costa Luminosa,* private meeting held on board Costa Luminosa berthing in Copenhagen on 03.08.13, 20 minutes

Schmidt Jim, *Cruise Manager at Copenhagen Malmö Port,* guided tour of the new cruise terminal in Copenhagen, held on 08.09.13, 45 minutes

Appendix I – IIIE/ISO/IEEE 80005-standard for OPS

Quality of supply	• Voltage and frequency limits
Electrical requirements	• Voltage system 6.6 kV and/or 11 kV • Range of power • Short circuit withstand capacity • Neutral earthing system
Environmental and mechanical requirements	• Compliance with IEC 60092-101 and 60092-503 • Temperature, humidity, wind, snow, salt, atmosphere • Combination of weather conditions • Protection against moisture and condensation
Safety	• Protection against electrical shocks • Equipotential system • HV plug safety during handling • Interlocking system • Protection against electrical faults • Requirements for hazardous areas • Emergency shutdown • Operating rules
Electrical equipment requirements	• Switchboards • Circuit breakers • Transformers • Inverters • Cooling system
Compatibility between shore connection and ship equipment	• Compatibility assessments to be performed prior to ship connection
Ship to shore connection and interface	• Cable system • Types of cables • Monitoring of cable tension • Monitoring of cable length • Cable unbalance monitoring
Plugs and sockets	• Operator safety • Main contacts • Pilot contacts • Earth contacts • Contact connection sequence

Ship requirements	• Shore connection switchboard • Circuit-breaker, disconnector, earth switch • Transformer • Protection against electrical faults • Ship connection procedure • Ship power restoration • Load transfer
Verification and testing	• Visual inspection • Power frequency test for HV switchgear 62271-200 and 60502-2 • Insulation resistance measurement • Functional test of the protection devices • Functional test of the interlocking system • Functional test of the control equipment • Equipotential bond monitoring test • Phase-sequence test • Functional test of the cable management system • Integration tests • Periodic testing and maintenance

Table 7: IEC/ISO/IEEE 80005-1 standard. Adapted from Radu & Grandidier, 2012