Cost-effective integration of LNG medium and small-scale bunkering facilities within marine bunker fuel markets

Bunkering LNG powered vessels in Baltic SECA

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SUMMARY

This research explores the deployment of Liquefied Natural Gas (LNG) as marine fuel infrastructure.

In the context of the sulphur limit imposed by the International Maritime Organization from January, 2015, LNG represents one of the compliant choices for vessels trading in Sulphur Emission Control Areas. Short sea shipping (ferries, coastal trading vessels) represents the segment mostly impacted by the regulation in question.

LNG as marine fuel, currently, faces the issue of a deficient infrastructure. As a consequence the distribution towards bunkering location is not sustainable.

Implicitly, the LNG bunker market undergoes an incipient phase of evolution.

SUMMARY (contin.)

For this reason, the study has regarded the LNG distribution system that requires support by means of infrastructure planning, market analysis, logistics, supply chain perspectives and a proper analytical framework to support decision making.

Findings of previous studies and theoretical positions from infrastructure planning area, logistics, supply chain, market forces, competitive environments and the analytical framework of cost-effectiveness have constituted the ground for this study.

A qualitative approach of an exploratory nature has been deemed to suit the study. Several semi-structured interviews have been conducted with purposively selected candidates. Analysis of data presupposed primary data, inductive reasoning based on interviews, qualitative content analysis, secondary data and own observations.

In order for the LNG market to outrun the incipiency stage, the findings of the study indicated that more LNG infrastructure that is able to capture more of the capacities has to be established. For the purpose of increasing availability for maritime customers, the patterns to be followed suggest complementing/meshing up the LNG distribution network with more facilities that operate smaller-scale capacities. The respective facilities can generate proper bunkering environments that would allow ship-owners to adequately plan the bunker sources in advance. The medium and small-scale LNG facilities in focus regard the establishment of Baltic SECA.

Because most of the LNG infrastructure initiatives imply, on one hand policy decisions, budgetary constraints, subsidies schemes, and on the other hand potential private partnerships among various stakeholders characterized by still a non-definitive structure and an uncertain level of motivation in relation to funds to be committed, the author has proposed the cost-effectiveness analytical framework to facilitate decisions. The benefits manifest by means of facilitating a better sight on the outcomes of chosen courses of action meant to achieve specific objectives as contrasted to the associated costs.

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Thesis title: Cost-effective integration of LNG medium and small-scale bunkering facilities within marine bunker fuel markets

Bunkering LNG powered vessels in Baltic SECA

Student name: Ludmila Patrascu

Supervisor name: Halvor Schøyen

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Being part of the Master Program in Maritime Management at Buskerud and Vesfold University College has been both edifying and challenging. The expertise of local maritime professionals encountered across the last two years of studies, but also the potentiality of the domain knowledge to transcend local borders have purveyed valuable and up to date insights. Hence, I consider the accumulated knowledge and experience -fairly gratifying.

The theoretical framework and practical issues emerging from the program courses have proved inspirational when choosing the master thesis topic.

I, also deem that my previous work experience as a logistics provider and freight forwarder along with my keen interest for greener and more sustainable shipping, have enticed me into giving thorough consideration towards exploring certain aspects related to Liquefied Natural Gas (LNG) - marine fuel bunkering infrastructure. Given that LNG as marine fuel provides for environmental and climatic advantages in comparison to oil-based fuels and given the context of the new sulphur limits applicable from 1^{st} January, 2015, in Emission Control Areas, numerous stakeholders have performed studies and expressed opinions regarding the LNG option as marine fuel. Therefore, my main challenge has been to distinguish among the most eligible issues for research and to reasonably handle the extensiveness devolving from the spin-off sub-themes.

Firstly, I wish to thank my supervisor, Halvor Schøyen, who has assisted my efforts with fairly constructive criticism and courteous encouragement. And, secondly, I wish to express my sincere contentment in conjunction with the experience of participating at the ‘LNG in Baltic Sea Ports Stakeholders Platform Seminar’ on March 27^{th}, 2014, in Helsingborg, Sweden. Meeting and discussing with parties that are directly and in a practical manner implicated in various LNG infrastructure projects have proved to be both instructive and insightful for my research.

Buskerud and Vesfold University College, Norway

May 15^{th}, 2014

Ludmila Patrascu

Abstract

Although, shipping is deemed to be the most environmental-friendly means of transportation, improvements of ship’s emissions are solicited in line with measures to be undertaken in meeting climate change mitigation policies. The sulphur limits imposed by International Maritime Organization from January, 2015 for Emission Control Areas have created a challenge to the ship-owners that have to choose between compliant marine fuels and technologies.

Liquefied Natural Gas as marine fuel represents a competitive choice among alternatives. Nevertheless, it faces the issue of a deficient infrastructure to support a proper distribution towards bunkering locations. As a consequence, this bunker market undergoes an incipient phase of evolution.

For this reason, this study aimed to explore conditions that allow Liquefied Natural Gas bunker market to outrun the incipiency phase. A qualitative research of an exploratory nature has been deemed to suit the intents. Several semi-structured interviews have been conducted with purposively selected candidates. Analysis of data implicated primary data, inductive reasoning based on interviews, qualitative content, secondary data and own observations.

Findings revealed that more Liquefied Natural Gas infrastructure that is able to capture more of the capacities has to be established. For maritime customers, availability can be built by complementing the Liquefied Natural Gas distribution network with facilities that operate smaller-scale capacities. These facilities have to generate a proper bunkering environment that would allow ship-owners to adequately plan the bunker sources in advance. For this reason, the Liquefied Natural Gas distribution network requires support by means of infrastructure planning, market analysis, logistics, supply chain perspectives and a proper analytical framework for decision making.

List of Terms and Abbreviations:

Bunkering facilities: physical system of terminals, storage, bunker ships, tank trucks that serve the end users to refuel;

Bunkering facilities layout: a schematic arrangement of parts or areas comprised by the physical system of terminals, storage terminals, bunker ships, tanker trucks;

Business model: describes the rationale of how an organization creates, delivers, and captures value in economic, social or other contexts;

Cost-effectiveness: used as an analytical approach in this study and supposes the combination of cost information with appropriate measures of effectiveness, which contributes to more productive uses of resources;

Distribution network: An interrelated arrangement of individuals, storage facilities and transportation systems that moves LNG from liquefaction sites to ultimate consumers;

ECA: Emission Control Area;

Gas off-grid areas: areas that lack pipeline for transport of natural gas**;**

IMO: International Maritime Organization;

LNG: Liquefied natural gas- natural gas condensed into liquid by cooling to approximately − 162 °C, takes up about 1/600th the volume of natural gas and consists predominantly of methane;

LNG bunkering environment: the combination of conditions created to support LNG bunkering;

LNG establishment: an arranged order/system to support LNG distribution for bunkering purposes;

LNG Hub: physical and virtual gas trading means to accommodate the different structures of the LNG industry;

LNG refuelling network: an interrelated arrangement of individuals, storage facilities and transportation systems to supply LNG fuel

LNG supply chain: is a system of organizations, people, activities, information, and resources involved in moving LNG from suppliers to customers;

LNG value chain: a chain of activities operated in the LNG industry in order to deliver the LNG product to the market;

Market liquidity: a market's ability to facilitate quick sales of an asset without affecting its price too much;

Marine bunker market: operations of fuels trading, such as: fossil fuels, used to power ships;

Marine Conventional fuels: in this study conventional fuels refer to traditional fossil fuels for marine propulsion: residual fuel of different sulphur contents (Heavy Fuel Oil) and marine distillates (Marine Gas Oil);

Medium and small-scale bunkering facilities (100,000 cbm-40 cbm): intermediary terminals, storage facilities, bunker barges, feeder vessels and trucks that operate on a different level of magnitude / capacities and hold a significant role in increasing LNG availability;

NOx: generic term for mono-nitrogen oxides;

SECA: Sulphur Emission Control Area;

SOx: generic term for sulphur oxides (ex. Sulphur monoxide, Sulphur dioxide, Sulphur trioxide);

SPA: Sales and Purchase Agreement, refers to LNG bunker sales and purchase contracts;

TTF LNG price: Title Transfer Facility-virtual trading point operated by Gasunie Transport Services the transmission system operator in the Netherlands. It offers market parties the opportunity to transfer gas that is already present in the system (‘entry-paid gas’) to another party. In this study it serves as a European Gas Hub Pricing reference;

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1. Introduction

Marine fuel accounts for approximately 60% of the voyage costs, the fact that makes decisions taken in relation to it crucial to the shipping businesses (Bunker World, 2012).
Major costs implications represent inherent and inevitable changes to derive from the implementation of Directive on the Sulphur Content for Marine Fuels (EU Commission, 2008).
The harmful emissions limitation is imposed on ships sailing in Emission Control Areas (covering the Baltic, the North Sea and the English Channel) from the 1st of January, 2015 with a foreseeable expanded enforcement in other trading areas, as well (Danish Maritime Authority, 2012). Primarily, harmful emissions such as sulphur dioxide but also nitrogen oxides, particulate matters and carbon dioxide are invoked when the choice for compliant on-board propulsive systems is to be made (European Commission, 2014). Short sea shipping segment (ferries, coastal trading vessels) is mostly exposed to the impact of the regulations in question.
As a consequence of the environmental regulations, the bunker industry is to undergo transformations (Bunker World, 2014).
The changes herald for alertness in planning ahead the bunker sources, irrespective of the alternative chosen: low sulphur fuels, MGO or LNG.
This study has given consideration to LNG as marine fuel with the focus placed on bunkering infrastructure of Baltic SECA.
Intrinsically, the highest share of vessels that spend 100% in a SECA are found in Baltic Sea, their trades counting for 25% of SECA in terms of fuel use (Danish Maritime Authority, 2012). This constituted one of the main reasons to regard this specific geographical parameter, in addition to the fact that multiple LNG infrastructure projects are currently in process.
Every type of fuel from the compliant spectrum is confronted with a particular challenge. Thus, MGO is too expensive and scarce and any projection on refineries increasing capacities is unjustified due to non-remunerative margins in this business (Danish Maritime Authority, 2012). HFO with scrubber faces the issue of product availability, stability and design challenges for some types of vessels, as well as lack of procedures to settle for sulphur sludge handling in harbours. And ultimately, LNG is confronted with a persistently precarious distribution and, hence, low availability (Semolinos, 2013). The reasoning to mention these issues within the introduction, herein, is the fact that ship-owners/operators follow these alternatives in line with the competitive edges rendered and in line with the degree of suitability to their business models, before adopting a definitive decision. Consequently, the market segmentation, in terms of

portions acquired by each of the fuels, depends on how convincingly participants mitigate the existing issues.

LNG is a legitimate solution for vessels trading in ECAs, fully compliant from 2015 but also compliant to NOx Tier III standards, in 2016 (European Commission, 2014). But, LNG has to remain a leading candidate in order to secure a substantial share of the world bunker markets (Tri-Zen International, 2013).

From a pure economic point of view, new investments, long term commitments, aggregated volumes and long term vision of all the stakeholders involved have to be intercalated concordantly within the value chain, in order to achieve functionality for the LNG distribution network (Semolinos, 2013).

A functional distribution network, thus, implies an effective interaction among the components and a holistic overview comprising collaborative and coordinated efforts to handle the goods and information flow (Coyle, Bardi & Langley, 2003). For a properly proportioned LNG supply, logistical implications and supply chain perspectives have been deemed applicable in order to tackle the dissonance of LNG flow among facilities.

Further, an LNG bunker market resembling the simple distribution patterns of the conventional marine fuels would generate more certainty and, thus, a higher demand. Therefore, drawing upon the functional conventional bunkering patterns represents a pertinent means to seize the bunker industry opportunities.

And still, the lack of necessary components and processes in the distribution network, non-transparent pricing of LNG, unfavourable contract terms and poor stakeholders' engagement, throw a spanner into the works of having more LNG powered vessels trading along the coasts.

1.1 Context for research questions emergence

Liquefied Natural Gas as marine fuel has been addressed by various studies, e.g. LNG as bunker fuel: Challenges to be overcome (Semolinos, 2013), North European Infrastructure Project (Danish Maritime Authority, 2012), LNG-fuelled deep sea shipping; The outlook for LNG bunker and LNG-fuelled new-build demand up to 2025 (Lloyd's Register, 2012), most notable of them emerging from class societies. But the emphasis was usually placed on technological feasibility, normative framework and commercial soundness addressing capital and operating costs. Previous studies, nevertheless, preponderantly hinted to the lack of infrastructure for LNG distribution that would not develop and function properly until sufficient LNG fuelled vessels would determine a higher and more predictable demand (Semolinos, 2013).

Although, LNG technology, operational on LNG carriers as well as on non-carrier vessels had to breed familiarity and prove functionality across a considerable span of time, in order for the vicious circle to be broken, an infrastructure initiative shall be imposed (Van Renssen, 2014).

The desired commitment of customers for LNG marine fuel can be stimulated by a more functional and predictable distribution through the requisite bunkering facilities. This can be further achieved in a cooperative manner and by coordinating the efforts by means of a coherent infrastructure initiative. The concept of interaction, interrelation among the elements in accordance with the type of bunkering, supply structure with inherent volumes and frequencies of refuelling, presumes designing the most appropriate layout of an efficient bunkering environment (Danish Maritime Authority, 2012).

The aforementioned, explicitly address a context for which the underlying characteristics require exploration and analysis. The context of this study relates to the geographical dimension: Baltic SECA.

1.2 Research questions

After conducting an extensive literature review which consisted of published studies addressing the LNG infrastructure topic and upholding actuality with daily peers of speciality journals, the author proceeded with setting inquiries to precisely and rigorously regard the area of interest. The respective issues have constituted a framework of reference for further elaboration throughout this research.

The following exploratory and open-ended research questions have been shaped up to address the research area of interest:

Research question 1:

How should the LNG bunkering infrastructure develop in Baltic SECA, in order to effectively meet the small and medium scale demand?

In order to answer this question, a secondary data analysis on Baltic SECA LNG establishment has been conducted, followed by the analysis of 5 interviews administered to purposively selected domain professionals with in depth knowledge of LNG bunkering infrastructure. The exploratory and open-ended nature of the research questions permitted for early elaboration on theories and generation of own concepts.

Research question 2:

What are the main enablers/barriers towards the Baltic SECA LNG bunkering infrastructure's expansion?

This question was answered by conducting a qualitative content analysis on presentations held within 'LNG in Baltic Sea Ports Stakeholders Platform Seminar' on March 27th, 2014, in Helsingborg, Sweden.

Research question 3:

What are the essential logistical implications and supply chain perspectives to be considered for effectively integrating Baltic SECA, LNG medium and small-scale bunkering facilities within marine bunker fuel markets?

This question has considered the analysis of secondary data pertaining to different perspectives on logistics systems integral to a LNG supply chain. The theoretical reasoning related to interactional effects and interchange of claims between relevant stakeholders has weighted relevant. This research question, also, made use of data collected from the implemented interviews.

2. Theoretical Framework

The research method and the area of interest have supported the need to enclose a fairly wide range of research topics. The respective have been congregated to regard 3 sections:

1) Infrastructure literature regarding the physical systems of arrangement. Logistics as a support function for bunker fuel distribution through the infrastructure. Supply chain perspectives
2) Market forces and competitive environments theories
3) Cost-effectiveness approach providing an analytical framework to support decision making

The rationale behind the selected framework is to provide key areas around the topic of interest. The intrinsic concepts of the key areas purvey the possibility to reflect and organize the data collected. Due to the exploratory nature of this study, the existing theoretical positions are scrutinized in terms of insights evoked on the main issues but also in terms of their limitations.

In order to shed light on the evolution of the LNG infrastructure, the first section displays the physical arrangement of bunkering facilities as a matter of identification of the components in a network. In line with the concept of condition assessment information (Elmer &Leigland, 2014) components that are not performing adequately or determine the cause of the deficiency are to be identified and remedies shall be prescribed. Intrinsically, the physical components are viewed as means to support the LNG distribution. Schematic representation is later provided for exemplification within this section (see figure 1).
For further exploration of the issues pertaining to precarious LNG distribution, logistics systems are implied in line with their support function. And at last, the holistic view on different logistics systems addresses a harmonized summing-up of all elements within a given context and implies a longer term vision on the matters.

The second section regards the LNG bunker market dynamics, implying competitive arenas and market forces determined by economic mechanisms. It addresses themes as supply and demand relationship, third parties access, LNG commoditization process, pricing dynamics, dissensions relating to LNG purchase and sale agreements, bargaining power of suppliers and customers. The afore-stated concepts are essential as they provide key areas for consideration in an incipient LNG bunker market.

Moreover, in an internal market that is highly dependent on LNG imports, the marine usage turns to be of secondary importance (Danish Maritime Authority, 2012). This determines the adjacency and synergetic link of LNG supply to the industrial and energy sector, as a matter of meshing up the network and ensuring LNG distribution continuity.

The third section of the theoretical framework addresses the concept of cost-effectiveness, broadly applied in social programs, transportation, infrastructure and other fields (Levin & McEwan, 2001). The reasoning this approach may create some positive precedent for LNG bunkering infrastructure is the fact that development projects imply considerable implication of policy decisions. Incontestably, policy decisions are particularly subject to both costs and effects considerations as they are often validated in relation to budgetary constraints and should be a result of both cost and improved outcomes review for the given resources (Levin & McEwan, 2001). The analytical framework of cost-effectiveness, thus, can favourably support decision making. Further, the incipient stage in establishing the layout of a distribution network may advantageously give consideration for as many courses of action as reasonably possible to reach the best outcome.

2.1 LNG infrastructure-physical arrangements for LNG bunkering

The definition of LNG bunkering infrastructure evokes an interrelated arrangement of facilities ranging from production, liquefaction, storage and transportation to ultimate consumers (Danish Maritime Authority, 2012). Maritime usage represents an inherent component in the arrangement, the scale being determined by the infrastructure providers' interests as contrasted to the existing demand. The stakeholders' interests will be dealt with ulteriorly, as in focus hereby are the physical layout and the support functions for effective LNG distribution.

The incipiency of LNG infrastructure brought along various studies, conducted relatively in a disparate manner, as consideration was accorded to the concept of 'functional infrastructure bits'. Functional infrastructure bits suppose displacing proven technology to a more reduced level of capacities to suit a specific context. As infrastructure development for LNG bunkering does not require a technological breakthrough and uses a variety of solutions to allow for a flexible and scalable value chain (Sund Energy, 2014) a broader picture of the bunkering system can purvey a better sight on the most feasible and balanced distribution patterns.

The inference of requisite planning for the bunkering infrastructure development has manifested for the tangency with infrastructure planning theories.

Elmer &Leigland (2014) address the concept of condition assessment information involving the analysis of the baseline conditions as the first substantive step in infrastructure planning. Therefore, the undertaking to map the bunkering facilities in a given context has been deemed essential to the condition assessment.

A sample of assets structure performing supply is reflected as follows:

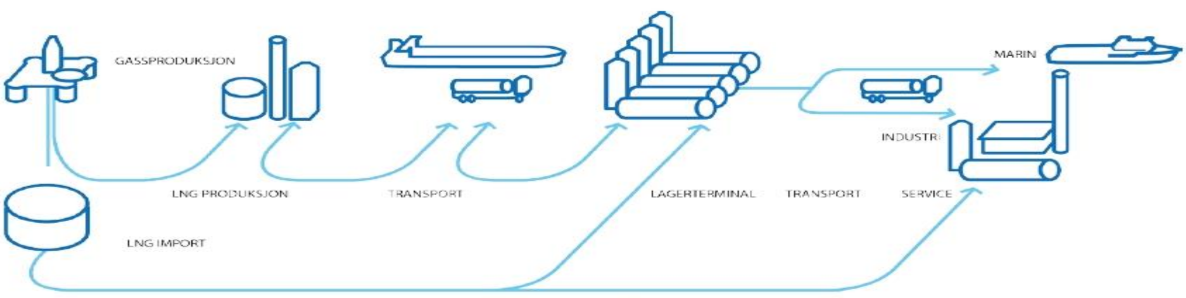

Figure 1: LNG bunker chain supply (Skangass, 2014).

The schematic representation above consists of the following elements (from left to right): Gas production facility, LNG import terminal, LNG production plant/ liquefaction, LNG transportation facilities (LNG tanker truck and LNG barge), LNG large storage terminal, LNG tanker truck, LNG demanding industrial customer and LNG fuelled vessel in need for refill.

The representation veritably provides for a complete LNG supply chain, with all requisite assets endowment and presumably various logistics systems to support functions in different phases of the distribution. Distinguishable also in the representation herein is the delivery for marine usage which in fact can intervene at various stages in conformity with the scale required and the agreements between parties involved.

Elmer & Leigland (2014) also nominate the predictive models of structures when systems lack certain components, further prescribing for the application of asset management. The concept of asset management encompasses a broad number of variables such as: systems, elements, location, quantities, capacities, size, detailed description, etc. As for the LNG infrastructure the aforementioned provisions suppose inventorizing the existing assets, modes of bunkering in demand, number of vessels calling at the specific locations for the marine use, volumes and frequencies of refuelling (Danish Maritime Authority, 2012). The rationale is for the planned or existing assets to serve the distribution in an effective and profitable way.

Molitar (2011) sustains that the effective LNG infrastructure shall presume adequate terminal layouts, efficient port operations, risk analysis, bunkering operations and prompt development provisions if LNG is to become a realistic, cleaner alternative to diesel power.

By drawing a parallel to the predictive models of structures, a possible layout of bunkering facilities in large ports, as envisaged by Semonolinos (2013) is illustrated bellow:

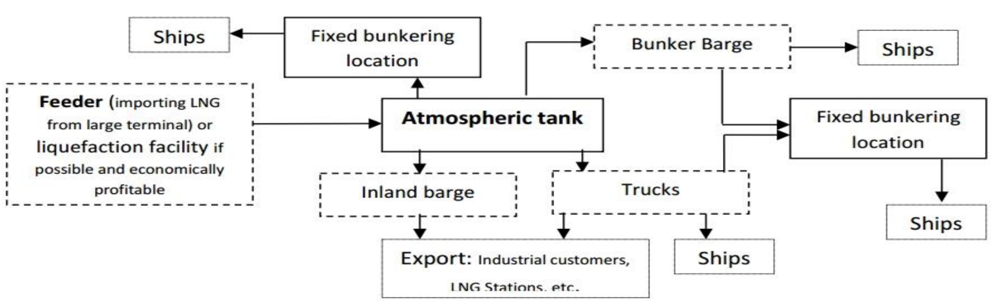

Figure 2: Predictive models of structures-a possible layout of bunkering facilities in large ports (Semonolinos, 2013).

The Danish Maritime Authority (2012) reckons that good availability of requisite elements in a distribution network shall consider interim strategies to counteract transient changes carrying potential disturbances.

In line with the afore-stated stipulation, a possible layout of a first phase of development is represented below:

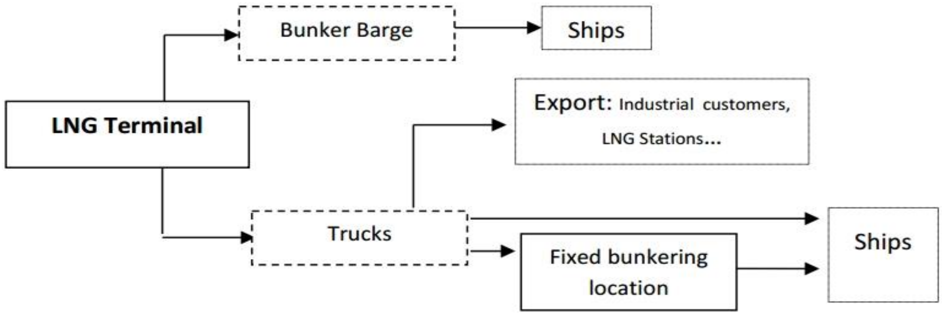

Figure 3: Predictive models of structures-an intermediary layout to allow for future changes (Semonolinos, 2013).

The reasoning out, in this respect, is that intermediary layouts render more flexibility and ensure conditions for better coping with uncertainties or conversely for better grasping the potential opportunities.
Further, by virtue of port's size, a sample of assets' structure performing distribution in a small port is displayed as follows:

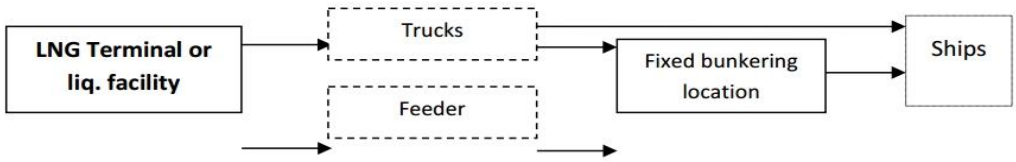

Figure 4: Predictive models of structures-a possible layout of bunkering facilities in small ports (Semonolinos, 2013).

Underlying features devolve from the positions taken by previous studies regarding LNG bunkering infrastructure. The respective pertain to the choice of location, capacities, terminal design to reach reasonable levels of safety, land based synergetic links to industrial and energy customers, interaction with other port activities and optimization of the layout and surrounding, amount of suitable and interested traffic in the port, as well as possibilities for quick and customized bunkering solutions to all types of traffic (Molitar, 2011). The aforementioned strongly relate to the concept of effectiveness further developed in this study.

2.1.1 The 'soft' dimension of the LNG bunkering infrastructure

As LNG bunkering moves from the niche market stage to an established, growing market (Sund Energy, 2014) new logistical challenges emerge. Nowadays, evidence displays 50 LNG-fuelled ships in traffic, besides LNG carriers, and a global potential of fleet expansion up to 700 by 2025.

The demand model is reflected below:

The Demand Model – Ship Demand Forecast 2012-25

Ship type	Newb. (cum.)	LNG-fuelled newb (cum.)	LNG-fuelled newb. per ship type	Share of LNG-fuelled newb.
Container	1,898	110	6 %	17 %
Bulk	7,305	275	4 %	42 %
Oil tankers	1,977	146	7 %	22 %
Cruise	230	25	11 %	4 %
Chem. tankers	1,614	14	1 %	2 %
LPG tankers	522	4	1 %	1 %
General cargo	1,313	49	4 %	8 %
Car carriers	711	30	4 %	5 %
Total	15,570	653	4 %	100%

Figure 5: The ship demand forecast 2012 - 2025 (Lloyd's Register, 2013).

The 'hard' dimension of the LNG infrastructure (terminals, bunker ships, tank trucks) regarded in the previous section had in focus the physical system, which basically exhibits the same algorithm of establishment that the oil based fuel bunker facilities had implemented (Danish Maritime Authority 2012). The other standpoint- the 'soft' dimension, refers to the industry standards regulatory framework and various support functions.

2.1.2 Safety implications for the LNG bunkering infrastructure

According to Gahnstrom (2011), maintaining a safe handling record is crucial for LNG bunker operations. And an acceptable level of safety can be achieved through risk awareness, rigorous operational training, keeping safe distances during bunkering process and well prepared contingency plans on all levels.

Further, Mark Bell from Gas Fuel Society (Trade Winds, 2014) sustains that producing a key publication comprising safety guidelines and proper reference is of high relevance as many new entrants within the sector are used to perform business differently and they tend to start from varying levels of competence and training. Therefore, we may infer the 'learning curve' concept which befittingly applies to the safety concerns with further reference to the effects

and large cost disadvantages to new entrants (Besanko, Dranove, Shanley & Schaefer, 2013) of the LNG business arena.
Experience and know-how are relatively unsettled for LNG bunker operations and this may negatively affect the fluidity and reliability of handling.

2.2 Logistics function to support LNG distribution

As the LNG fuel associated infrastructure has been discussed, the further proceedings will consider the storage and distribution.
When addressing the distribution of other bunker fuels we discover that they are currently supplied to ship-owners through a cost-efficient infrastructure of bunker tanks in ports, bunker ships and barges, and direct filling when the ship is lying alongside a quay. In addition to the physical assets, good availability is supported by various functions transposing logistical implications and supply chain perspectives. And these exact dimensions, applicable to LNG distribution may provide for functional patters in a similar way.
(Coyle et al., 2003) define logistics as the processes of anticipating customers' needs and wants, acquiring the capital materials, human resources, technologies and necessary information to fulfil their needs and concomitantly carries out optimization of those goods/services/processes that produce the network, serving the customers' requirements.
Therefore, the logistics systems, logistics management and supply chain theories have been considered suitable to address the issue of building availability and functionality for the LNG distribution.
But also valid for the LNG distribution is the fact that infrastructure investors /project partners such as states, ports, gas and LNG terminals, transmission system operators, suppliers and other various companies from the maritime cluster, hereby representing the LNG supply chain (Danish Maritime authority, 2012) shall consider a strategic approach to the commercial viability of the segment within which they operate.
As a matter of addressing logistical implications, (Coyle et al., 2003) infer the concept of engineering dimensions of logistics which provide for reliability, maintainability, configuration management and continuity for supply support. The authors also, depict the concept of logistics management which encompasses a variety of sources, as supply items and personnel and implicates somewhat different perspectives on the physical distribution of goods.

2.3 Medium and small-scale facilities' role in complementing LNG distribution

To better address the needs of marine customers, a system of small-scale and medium-scale terminals with feeder ships bringing LNG from the import terminal to the respective smaller terminals and bunker ships, etc., must be established (Danish Maritime Authority, 2012).

Further, the Danish Maritime Authority report claims that an adequate number of large LNG terminals are important in bringing down the associated costs from the import terminals. The operations of medium and small-scale bunkering relate to a different level of magnitude/capacities and hold a significant role in increasing LNG availability.

And precisely, medium and small-scale bunkering facilities presuppose intermediary capacities ranging from 100,000 cbm-40 cbm, handled by terminals, storage facilities, bunker barges, feeder vessels and trucks. Therefore, these facilities set for complementing the storage solutions as a matter of meshing up the required bunker network to supposedly serve better the maritime needs (Danish Maritime Authority, 2012).

2.3.1 Logistical implications for medium and small-scale bunkering facilities

Setting for complementarity determines numerous logistical implications supposedly with resultant efficiencies.

In line with the former argumentation, we may explore the role of logistics with respect to the concept of value-added logistics (Coyle et al., 2003), which presumes types of economic utility that contribute to the enhancement of value of a product or service. It's relevant to refer to the form utility concept as, the inference is drawn upon breaking-bulk at distribution points, changing the shipment sizes and implicitly adding value to the final delivery parcels. The concept of form utility may unravel patterns of adding value to the processes of LNG distribution. The concept is further validated by the structure of the small-scale LNG value chain, as outlined by Sund Energy (2014):

- break-bulk and small-scale-liquefaction facilities (examples: GATE terminal, break-bulk facilities projects of Gasum Oy and Gasnor AS);
- LNG transport to own or clients' facilities-via ships, trucks, rail (examples: Anthony Veder, Liquiline, Gasnor);
- receiving terminals-at end-user site or further break-bulk (examples: Skangass);
- bunkering infrastructure-LNG as marine/truck fuel (providers: AGA Gas AB, LNG Europe);
- distributor-integrated or trading-only (examples: LNG Europe, Skagerak Energi).

The concept of 'logistics processes place utility' (Coyle et al., 2003) implies moving goods from production or storage surplus points to points where demand exists. Therefore, in an environment with uncertain demand, logistics can extend the physical boundaries of the market area and effectively add economic value to the goods.

The place utility value furnished by logistical efforts may be substantiated through the illustration of the example of an LNG terminal offering new LNG service (Gas Infrastructure Europe, 2014):

- reloading: transfer of LNG from the LNG reservoirs of the terminal into a vessel;
- trans-shipment: direct transfer of LNG from one vessel into another;
- loading of bunker ships: LNG is loaded on bunkering ships which supply to LNG-fuelled ships or LNG bunkering facilities for vessels;
- truck loading: LNG is loaded on tank trucks which transport LNG in smaller quantities to other locations;
- rail loading: LNG is loaded on rail tanks which transport LNG in smaller quantities to demanding sites;
- LNG small-scale liquefaction plants: LNG is produced in small-scale liquefaction plants to respond to peak shaving demand or make available natural gas to regions where it is not economically or technically feasible to build new pipelines.

And ultimately we make reference to time utility concept evoking proper inventory maintenance and strategic location (Coyle et al., 2003). An example of time utility concept validation is the LNG satellite storage modality, which enables to store LNG in small quantities in areas where there is no high pressure pipeline. LNG is delivered mainly by trucks (but also by small LNG ships) to these satellite plants where it becomes stored and re-gasified into the natural gas distribution networks or used by an end user (Gas Infrastructure Europe, 2014).

Furthermore, it is a fact that European LNG terminals face a low capacity utilization, which presumably may lead to a low return on the capital employed.

The figure below uncovers some evidence on the capacity utilization:

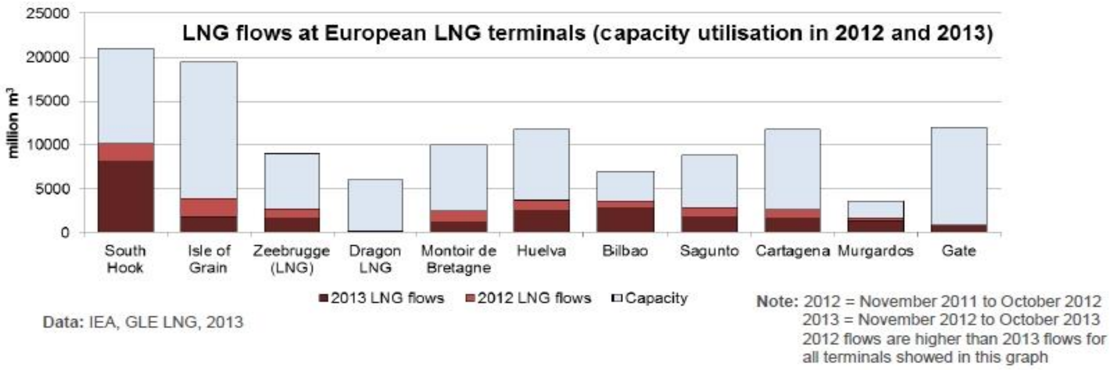

Figure 6: Capacity utilization at European LNG terminals (International Energy Agency, 2013).

Business logistics might provide solutions to mitigate certain risks in a setting as indicated above as it is set to confront that part of the supply chain process that plans, implements and controls efficient and effective flow or storage of goods and adjacent information (Coyle et al., 2003).

Logistical implications intervene also with respect to differences in patterns for wholesales versus retail sales (Coyle et al., 2003). Thus, large import terminals, on the average would purchase larger quantities than retailers and would therefore be confronted with fewer logistics management incongruities by managing their inventory in a more predictable and consistent manner.

Retailing establishments, as medium and small-scale LNG refuelling facilities would have to be more precautious with the replenishment scheduling and allow sufficient lead time before stock-outs. Various undertakings as forecasting, scheduling and transportation are to be scrutinized from the point of origin to the point of use to meet customers' requirements and the respective processes shall be analysed in line with their primary purposes differences. (Coyle et al., 2003).

2.4 Supply Chain perspectives on the LNG distribution

According to Coyle et al. (2003), viewing logistics in the context of a supply chain or demand chain that links all the organizations from vendor's vendor to the customer's customer ensues distinguishing various indigenous logistics systems with their particular coordination processes for goods and information.

Simchi-Levi, Chen & Bramel (2014) summon for similar reasoning and emphasize the potentiality for leverage in following demand, setting the supply sources, maintaining the adequate flow of goods and information.

In practice, the leverage can manifest through proper coordination of LNG flow among the bunkering facilities, capacities adjustments, settlement for appropriate transportation modes between facilities, safety and technical adequacy assurance, etc.

Further, finding the adequate configuration for each component in the distribution network, in accordance with the underlying parameters provides for shaping up the correct patterns to facilitate integrating the respective components into a functional network.

The argumentation manifestly provides for development of bunkering points in line with the associated logistics and the holistic approach to a functional supply chain.

Consequently, the prerequisite for a successful management of the supply chain presupposes the integration of the inherent logistic systems (Coyle et al., 2003).

Sunil Chopra & Peter Meindl (2013) argue that a supply chain growth and profitability is driven by a proper design, planning and a proper operating profile.

In practice, many logistics decision makers often engage in what is called satisficing as opposed to maximizing decision-making behaviour, highlighting not the optimality but rather contentment with the solution (Mangan & Lalwani, 2012).

Nevertheless, extended collaborative efforts across the supply chain are highly rewarding if carried out prudently and may render higher predictability, efficiency and harmonized interaction among stakeholders.

Mangan & Lalwani (2012) describe the collaborative partnerships among supply chain participants as determining better results and leveraging capabilities. The mutual efforts improve product/process development and logistics efficiency through sharing information on forecasts, sales, supply requirements, problem alerts in advance.

The authors also suggest that in practice collaboration among supply chain partners takes a great deal of time. And this is due to the fact that the settlement for the course of actions is not solely confined to the logistics functions but instead involves a cross-functional, process-based perspective.

Elmer &Leigland (2014) address the concept of collaborative planning process which involves developing information platforms that can be trusted by all the stakeholders. The best cases display decisions that reflect a shared vision and an innovative solution based on the group's shared knowledge.

Thus, partnerships among local energy companies-importers and traders, LNG suppliers, transmission companies (that could add value to the grid), LNG consumers/bunkering companies, infrastructure investment companies may take advantage of collaborative planning processes meant to tap improvement and efficiency. The shared vision and commitment to mutual performance is easier achieved when participants' drivers/interests are fairly decipherable.

In line with the long term vision, Sunil Chopra & Peter Meindl (2013) set out on the significance of adopting a supply strategy or design which allows for the company to decide on how to structure the supply chain over the next several years. In this case consideration is given towards chain's configuration, how will resources be allocated and what processes will be performed at each step.

Achievement of the proper design supposes rigorous analysis of market signals, alignment of demand planning in accordance with the specific context and ensuring consistent forecasts and optimal resource allocation (Anderson, Britt & Havre, 2007).

Furthermore, the development of a supply chain-wide strategy supporting multiple layers of decision making provides for a clearer view on the flow of products, services and information (Anderson, Britt & Havre, 2007).

The application of supply chain holistic view within LNG distribution envisages proper inventory handling and inventory policies, setting dates for replenishment orders, generating pick lists to further retailers or final consumers and may allow for flexibility in areas where modifications may be effectuated with the intent to optimize performance.

2.5 LNG Market

Introduction

Before exploring how the LNG market functions, a few underlying characteristics are presented to shed light on LNG supply structure and supply drivers.

The world is highly dependent on fossil fuels for most of the energy supply and will remain so in the foreseeable future (Forbes, 2014). Diversification of energy supply sources within a market increases the energy security and provides for enhanced bargaining power when negotiating prices with potential suppliers (Van Renssen, 2014).

More bargaining power on the buyer's side renders more value capturing in terms of favourable conditions and discounted sales prices (Porter, 2008).

Naturally, gas supply is viewed as an energy source, in competition with coal, oil, bio gas (bio-methane), nuclear energy and renewables (geothermal and solar thermal systems, Aeolian and Hydro power). Thus, gas is a resource with strong ties to energy policies as it ensures supply diversity and flexibility, provides for renewal of energy infrastructure in close connection with systems reliance to supply/demand shocks, and plays a significant role in stimulating investments and rejuvenating economies (Gatermann, 2014).

The social imperative of economic growth and de-carbonization of industrial and transportation sector dictates for displacement of coal by natural gas. Maritime sector, thereupon, is to address the stipulations on SOx and NOx limits by means of choosing the compliant fuels in SECAs.

The role of natural gas within the world's energy mix will grow up from 21% in 2010 to 25% in 2035, natural gas being the only fossil fuel which share expands (International Energy Agency, 2012). Natural gas is liquefied to become LNG and serve specific demands (example: maritime bunkering) or to allow transportation in liquid state in areas where there are no pipes to support the distribution in gaseous state. Also, in this respect, vessel based imports may improve distribution to the extent that synergic effects can materialise by means of an effective land based distribution network.

The aforementioned reasoning relating to natural gas as energy resource is relevant when addressing the matter of LNG importing to specific internal markets as shipping is only a secondary factor for consideration (Danish Maritime Authority, 2012).

A continual distribution of LNG is paramount to maintain the development of LNG markets, this contributing to competitive pricing at bunkering points (Danish Maritime Authority, 2012).

Further, LNG is a global commodity that can connect regional natural gas market and enhance global gas price competition, regardless of source of supply (Sund Energy, 2014).

2.5.1 Pricing dynamics and competitive forces in the LNG market

In order to understand how the LNG market works, an analysis framework is further developed to devise and explore underlying contextual characteristics. As LNG represents natural gas in liquefied state, the pricing mechanisms relate to natural gas market forces.

Firstly, the gas pricing dynamics is addressed for the European hubs, as Baltic SECA regarded by this study is part of the European geographical context shaping up an internal market with specific traits.

The concept of market structure has been consistently depicted by Michael Porter (2008) in his article on competitive forces. The author argues that competition for profits goes beyond established market rivals to include four other competitive forces as well: customers, suppliers, potential entrants and substitute products.

The competitive environment of a market as envisaged by Porter (2008) is displayed as follows:

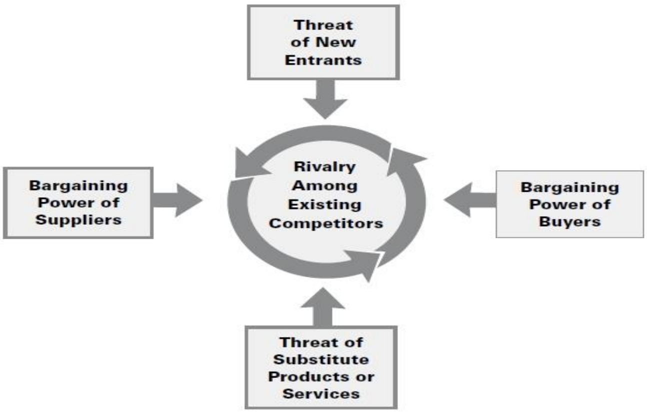

Figure 7: Competitive forces and competitive environments (Porter, 2008)

Porter (2008) further claims that the protracted rivalry that results from all five forces defines the market structure and shapes the nature of competitive interaction. Understanding competitive forces and the underlying causes within a specific market reveals current profitability sources as well as provide a framework for anticipating and influencing competition over time. In addition, it provides for an effective strategic positioning and for identification of defences against the competitive forces, shaping them in company's favour.

Distribution of LNG is impacted by the gas market forces, therefore, the theoretical framework furnished by Porter (2008) has been deemed relevant.

Firstly, the attempt is to make sense of the European supply structure and underlying features. Noteworthy, herein are the supplies on long term contracts, oil indexation, LNG flows, Russian supply, interconnection and storage (Timera Energy, 2014).
Thus, pricing dynamics is assessed by investors, traders, risk managers and asset owners by means of grouping sources of supply with similar pricing and flow dynamics and by focusing on flexibility of gas volumes that drive hub pricing at the margin.
The traditional approach to analyse gas market pricing 'bottom up' view, presupposing a detailed display of fields, pipelines, projects and contracts can degenerate into unmanageable complexity and consequently erode validity in a market that is not dependable on production costs but rather on long term contractual pricing and contractual flexibility (Timera Energy, 2014).
Storage capacity is another key supply dynamic factor, weighting prominently within hub pricing dynamics. Nevertheless, storage capacity enables movements of gas between periods rather than

representing an outright source of supply. Seasonal storage acts to move gas from lower priced summer periods to higher priced winter periods.

Geographical groupings of supply sources are, thus, defined primarily on contractual terms rather than physical characteristics. This enables a focus on commercial decisions that drive the pricing and flow of gas, rather than trying to capture the physical complexity and infrastructure.

Hub prices fluctuate based on changing intersection of supply and demand. Given the demand is relatively insensitive to price it is the supply flexibility that preponderantly determines how prices evolve at the margin (Timera Energy, 2014).

So, for a solid understanding of how hub price dynamics works, the reference imposed is to comprehend how different sources of flexible supply (contracted or even captured un-contracted sources) interact to determine the marginal pricing. Flexibility supply sources vary, ranging from pipeline contract swing volumes to spot and divertible LNG supply or even storage capacity.

The clearness intervenes when each individual supply is scrutinized with respect to its geographical grouping as it is characterized by the same structure and transposes the commercial sense driving the hub pricing mechanism. The price band is to some extend flexible but also resistive. It can be stretched by predominant supply and demand dynamics and as further prices deviate from oil indexed levels the stronger is the force acting to pull prices back (Timera Energy, 2014).

As hub prices fall below oil-indexed contract prices, contract owners make use of ‘swing’ to pull back on contract volumes which supports hub prices. And, conversely, as hub prices rise above oil indexed prices, swing gas flows increase the volumes to act as price resistance.

Norwegian un-contracted production flexibility plays a significant role, representing a key source for equalising forces across hubs (given multiple delivery points across North West Europe). Further, Norway holds a strategic position in being able to pull back on production to support prices during oversupply periods. Spot and divertible LNG supply does not impact significantly European hub pricing, as prevailing structural Asian spot price premiums determine diversion of cargoes to the East.

The concept of competitive forces and competitive environments reasoned out by Porter (2008) permits to uncover patters on how different market participants can make use of their bargaining power and capture more of the profitability in a market. More bargaining power on the suppliers’ part would render more value capturing for them, detrimental to the other contacting party’s profitability. Transposing the rationale to the LNG retailing facilities for

marine usage, much interaction between flexible tranches of supply would drive marginal pricing with the presumable opportunity of value capturing for the retailing facilities. Traditionally in a setting confronted with fierce competition, significant portions of value are transferred to the customers (Porter, 2008).
Although, bunker LNG retailing facilities still enjoy reduced competition among themselves, this does not guarantee value capturing in relation to the final consumers due to the actual low demand and high threat of substitution deriving from the other compliant fuels. The internal rate of return on the capital invested in LNG bunkering facilities is, thus, squeezed to the level that allows for competitiveness of LNG fuel as opposed to the alternative fuels.

Porter (2008) claims that new entrants to an industry bring new capacity and a desire to gain market share, which sets pressure on prices, costs, and the rate of investment necessary to compete.
In line with this reflection, attestable becomes the fact that the increase of the supply base for LNG, determines upward pressures on development costs and downward pressures on natural gas prices.
It is perceptible that increasing LNG supply tends to lower natural gas prices in the North West European spot markets (Sund Energy, 2014).
Nevertheless, it is crucial to maintain a positive long-term outlook in order to achieve buyers' willingness to sign long term contracts and sellers' willingness to commit capital to develop the required infrastructure projects. As a consequence, sellers must adapt to rising development costs, competition and shifting demand to more price-sensitive customers.

2.5.2 Transient and current features of the LNG market

In order to get a better sight on the evolution of the LNG market, a few transient matters have been deemed noteworthy.
LNG is a global commodity, connecting regional gas market and making gas available in regions without pipeline infrastructure (Sund Energy, 2014).
Traditionally, gas prices were indexed to oil product prices, as oil products were often the alternative in both heating and electricity generation. Thus, the first small-scale LNG contracts were a build-up of an oil-indexed gas/ LNG price, and a cost element associated with the small-scale LNG value chain. Currently, gas prices are set by supply and demand, on spot markets, and this is increasingly reflected in small-scale LNG transactions (Sund Energy, 2014).

2.5.3 Subsidies in the LNG market

Another important aspect for the LNG market is reflected by subsidies intended to develop this specific market, implying committed efforts towards aligning the investments and port authorities 'endeavours to fully develop the requisite infrastructure of hubs and break-bulk terminals (Port of Rotterdam Authority, 2013). Subsidies represent a substantial boost for LNG hubs, from which the whole LNG logistics can profit. But the respective assets need policy and regulation support and investment in cooperation with relevant partners. Joint ventures between ports authorities as well as private participation of different parties are deemed to contribute to a better LNG supply for bunkering purposes (Port of Rotterdam Authority, 2013).

2.5.4 Bargaining power in LNG market

The analysis of the market conducted in line with the theoretical positions on market forces has provided for the opportunity to explore underlying structure of the supply and demand, as well as, it has helped to identify transient and cyclical changes. Distinguishing the potential for profitability for various market participants, such as: suppliers, infrastructure investors /project partners, ports, policy makers, LNG terminals, transmission system operators, ship-owners/operators, unravels the logic of their positioning, the magnitude of their bargaining power and the directions intended. Although, the incipiency of the bunker LNG market still implies considerable uncertainty, the state of the underlying structure combined with certain perceptible attributes contribute to a better sight in conjunction with future projections.

2.5.5 LNG competitiveness

LNG as marine fuel is highly competitive against conventional bunker fuels and as availability increases with more mature infrastructure/ logistics, ship-owners will find it easier to commit to dual fuel or pure LNG technology (Sund Energy, 2014).

The choice faced by ship owners, due to the upcoming emissions regulations in SECAs is to run their ships on LNG, on HFO with desulphurisation scrubbers (and de-NOx-ing at a later stage), or on MGO (with de-NOx-ing at a later stage). Apart from the CAPEX cost of LNG vs. HFO/ MGO/ dual-fuel engines and other implications on cost of operations, a key strategic factor is the expectation of future LNG, HFO and MGO retail prices (Sund Energy, 2014).

Some ship-owners expect higher gas market liquidity and independent price formation, opting for spot price indexation in their LNG supply contracts, whereas others stick to the oil market fundamentals and choose LNG supply contracts indexed to oil products, typically MGO (Sund Energy, 2014).

Shipping companies increasingly prefer LNG prices indexed to the spot gas price, which has now been significantly lower than oil product alternatives for several years, and expected to remain so. They also require the same sort of flexibility as in oil-based bunkers sourcing, i.e. short negotiations for standardised contracts with short duration (Sund Energy, 2014).
Long-term contracts sound unreasonable to ship-owners/ operators, who are used to short-term, spot-based bunker contracts, adapted to the volatility and uncertainty of the shipping sector (Sund Energy, 2014).
Gas for transport being often priced against oil based alternatives, the LNG delivered at retail filling stations are: 3xTTF priced (continental Europe's most important gas market, the Dutch Title Transfer Facility) and LNG to large ships 2xTTF (see appendix 3) (ICIS, 2014).
As small-scale LNG distribution networks mature, retail prices will come down closer to wholesale gas price levels (Sund Energy, 2014).

A forecast on the forward prices for SECA compliant fuels positions the TTF priced LNG fairly advantageous:

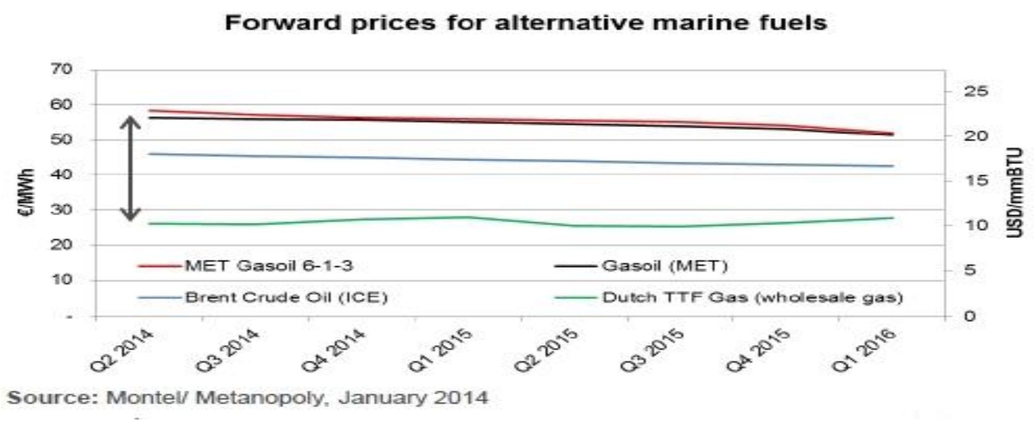

Figure 8: TTF priced LNG in comparison with alternatives (Montel, 2014).

Nevertheless, high costs of the value chain will persist with reference to costs for liquefaction, storage under transportation, break-bulking and bunkering, even though the infrastructure will be considerably established.

The typical contract for LNG bunkering will add up to the hub/ liquefaction plant FOB price several cost elements (Sund Energy, 2014):

- Port fees to pick up LNG from the receiving terminal or liquefaction plant;
- LNG storage in the port/cost of bunkering;
- LNG tank-ship fees for transportation to small-scale receiving terminal;

- Further transportation costs on trucks, onwards by local pipelines to final consumers when necessary.

With more third parties access increasing competition, the cumulative costs congruent to each value chain element will decrease, reducing the distance between wholesale and retail sale prices.

Although, value chain costs of LNG are higher than oil based products, it could, however, maintain a comfortable edge as compared to IMO-compliant HFO and MGO. On the long run, increased competition will provide for shorter lead times, increased optionality, more affordability, predictability and supposedly overall better terms for the ship-owners (Sund, Energy, 2014).

The assumption on LNG competitiveness as envisaged by DNV (2012) favourably positions LNG in comparison to the other alternatives:

Source: DNV, Shipping 2020

Figure 9: LNG competitiveness prediction (DNV, 2012).

2.6 Cost-effectiveness analytical framework

The following last section of the theoretical framework regards the approach to cost-effectiveness, pivotal to this research as it interposes an analytical tool to support decision making in relation to LNG bunkering infrastructure establishment.

Levin & McEwan (2001) define the cost-effectiveness analysis as a technique of combining cost information with appropriate measures of effectiveness which contributes to more productive uses of resources.

The reason for which it has been accredited to regard the LNG bunkering infrastructure establishment pertains to the rationale that various incipient infrastructure projects imply policy decisions and particularly assert subject to both costs and effects considerations as they are often validated in relation to budgetary constraints and should be a result of both cost and improved outcomes review for the given resources. It presumes an alternative approach to the traditional cost-benefit analysis and suits better the need to compare the relative costs to the outcomes/effects of two or more courses of action.

In contrast, quantitative models evaluating capital investments such as: Internal Rate of Return (IRR) or Net Present Value and cost benefit ratios are designed to consider the time value of money comparing alternative projects within a particular area. These types of models rank several prospective projects and are optimally utilized in areas where funding is more predictable and supposedly underlying factors or alternatives are more alike (Elmer &Leigland, 2014).

Transposing the quantitative models' potential of evaluation to the incipient LNG bunkering infrastructure affirms rather incongruous due to the uncertainty in relation to funding sources and partnership structure for the LNG projects.

Whilst, cost-effectiveness provides for an analytical tool that facilitates the choice among alternatives in the way that it accomplishes a given result in the most parsimonious manner. It is widely accepted that projects that show the largest positive effects are chosen over those showing the lowest, notwithstanding costs might be fairly higher (Levin & McEwan, 2001).

Although, it might seem reasonable to render a specific set of principles in carrying out the cost-effectiveness analysis, the actual application in a particular setting would require the judgements on the part of the administrator or evaluator (Levin & McEwan, 2001).

According to Elmer &Leigland (2014) generating alternatives in an iterative process from which devolves a set of viable alternatives furnishes for further in depth analysis of impact. This is the case of pre-investment phase for the LNG infrastructure projects within which the most effective and less costly alternative may be considered for further impact assessment. The strength provided by the cost-effectiveness approach is that it simply requires combining cost data with the effectiveness data that are ordinarily available from projects evaluation. The crucial characteristic is that alternatives are to attain the same goal so that effectiveness would be deemed for the same indicators and be compared within the same cost-effectiveness framework. Furthermore, the analysis wouldn't provide for overall determination of worthiness in absolute terms but rather relatively (Levin & McEwan, 2001).

So, a first step is to delineate a range of possibilities/provisions, secondly we may proceed with determining costs, sometimes exhaustively listed items. The next step is to estimate effectiveness of each possibility/provision. A non-experimental method may be used, namely a statistical technique called multiple regression analysis that compares the relative achievements (examples: LNG availability, completing energy sector needs in off-grid areas, increase in LNG potential investors' interest) when using greater or lesser quantities of intervention (establishment size, capacity, investment). Final step purveys data as a result of combining costs and effectiveness by calculating a cost-effectiveness ratio. The ratio would indicate the cost required to attain a 1 point increase in achievement. It practically provides the costs per unit of effect (Levin & McEwan, 2001).

3. Research Method

The research methods employed in a study are not neutral but rather linked to the point of view of the researcher (Bryman, 2012). The approach in performing the sampling, choosing methods of data collection and data analysis shall suit the process of answering the research questions in the best way possible. According to Bryman (2012) a research method could be defined simply as a technique of collecting data. In line with this prerogative, this research deemed adequate to analyse 5 semi-structured personal interviews of purposively selected LNG domain professionals and also makes use of a single specific case study' LNG Stakeholders Seminar' for which the author deemed tenable to conduct a qualitative content analysis.

The methods option allowed to systematize the data and to increase transparency without being constricted by rigid procedures.

The literature review constituted an extensive process of discerning the most relevant materials addressing the topic. The potentiality of the literature to associate to the discussion on the subject matters and to the findings conferred assurance towards the possibility to contribute to the stock of knowledge.

The figure below illustrates the steps followed in the research process:

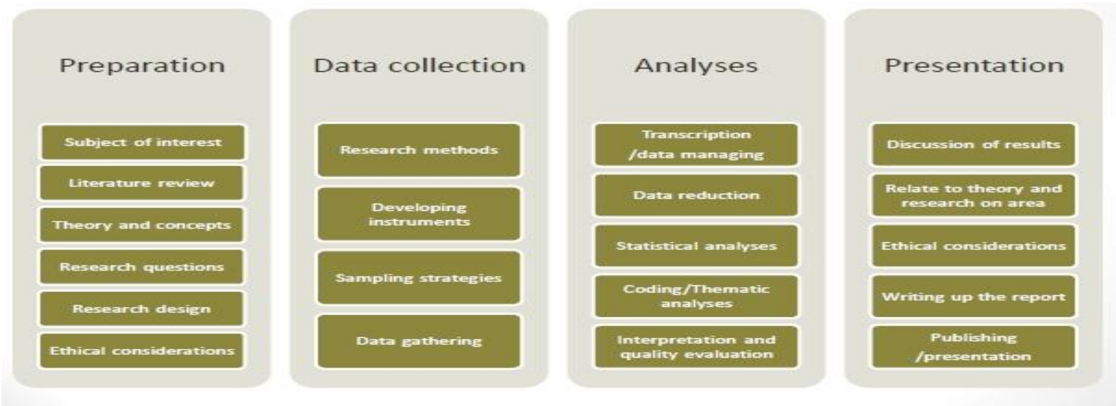

Figure 10: Elements of the research process (Johannessen, 2010).

3.1 Research strategy

The author has deemed the qualitative approach as being the most suitable strategy for this research.

Qualitative strategy is defined as an approach that emphasises words rather than quantification in the collection and analysis of data (Bryman, 2012).

In conjunction with qualitative studies, Denzin and Lincoln (2000) affirm that there are various academic and disciplinary resistances, as the emphasis in a study as such is placed on the qualities of entities and on processes and meanings that are not experimentally examined or measured.

Splinder and Splinder (1992), on the other hand, display an insightful observation upon their qualitative approach to quantitative materials suggesting that instrumentation and quantification are solely procedures that expand and reinforce interpretations, hypotheses and data. These very allegiances are further strengthened by Bryman and Burgess (1999) whilst addressing the wrong tactics of distinguishing qualitative research as an opposing term for the quantitative research.

Among the most relevant characteristics of qualitative studies, we mention the flexibility and lack of structure, and the potentiality of concepts/theories generation (Bryman, 2012).

Further, Blumer (1954) implies a distinction between the definite concepts in quantitative studies that become fixed through the elaboration of indicators and the 'sensitizing concepts' of qualitative studies that capture different perspectives.

In line with Bryman and Bell (2011) precepts on qualitative research this study considers generating theories, the relationship between theory and research being of an inductive nature.

The figure below displays the process of drawing up new theory/concepts as a matter of potential generalizable inferences devolving out of own observations:

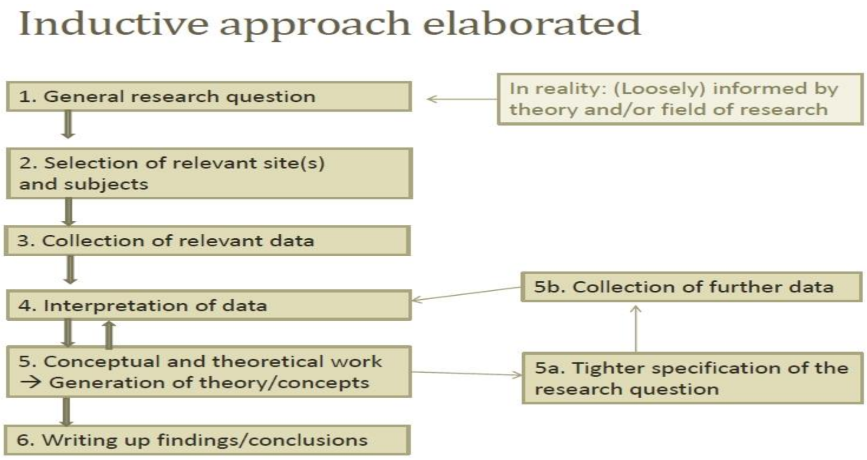

Figure 11: Main steps of qualitative research (Bryman, 2012).

3.2 Research Design

A research design provides a framework for the collection and analysis of data (Bryman, 2012). It reflects the decisions the author has taken in relation to the priorities accorded to a range of dimensions in the research process. It presupposes the expression of causal connections between variables and understanding behaviours and their meanings within a specific context. But, also allows for a temporal assessment of phenomena and their interconnections (Bryman, 2012).

In order to answer the stated research questions, the author has focused on a single Sulphur Emission Control Area- Baltic Sea, on which an exploratory case study has been built. Exploratory case studies are used to explore situations in which the outcome of the study is uncertain (Yin, 2003). The case study design addresses the complexity and particular nature of the case in question (Stake, 1995). The author has proceeded with exploring the state of bunkering infrastructure in Baltic SECA by making use of various sources which conferred the possibility of exploration. This further signifies that the issues are not explored solely through one frame but rather viewed and better understood through multiple frames (Baxter and Jack, 2008).

The figure below displays the schematic framework for the collection and analysis of data:

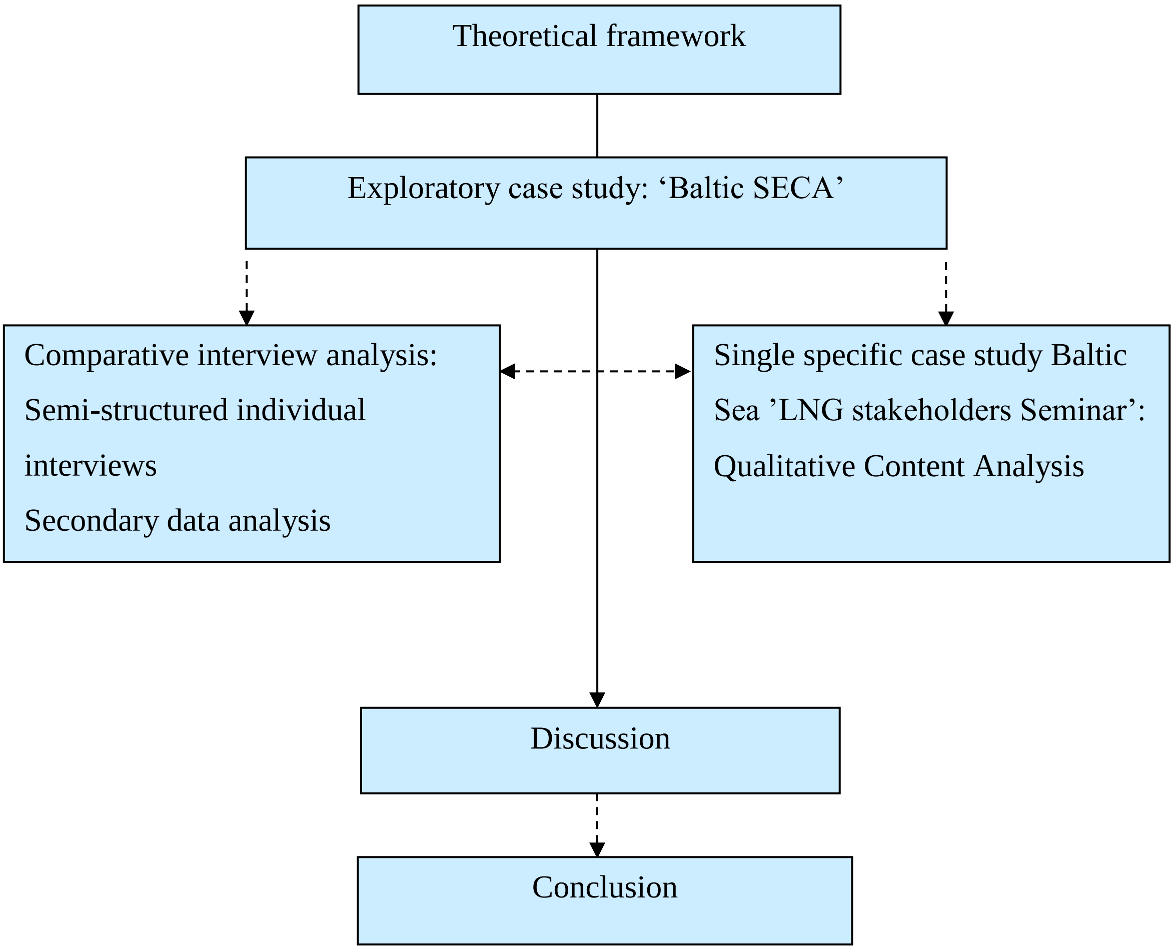

Figure 12: Schematic framework for the collection and analysis of data (author's own elaboration).

The first phase of this study was to collect secondary data, leading to the settlement of theoretical framework. This part has been confronted with the abstractness of grand theories operating at a more general level (Merton, 1967) and which necessitated the inference of middle range theories in order to connect to the reality. Primary data from the interviews provided for new perspectives and determined further grounds to extend the theoretical framework. The exploratory nature of the thesis has emerged incontestable at this stage. Second step consisted of collecting information by interviewing the candidates. The exploratory strategy fairly prescribed for semi-structured interviewing as to allow for considerable leeway. Nevertheless, an interview guide has been utilized to ensure a proper coverage of inquiries (Bryman, 2012). The author has perceived each interview as a particular case study in order to further conduct a comparative cross-case analysis. The rationale behind it implies the very logic of comparison and precisely that it's easier to understand phenomena when more contrasting cases are being compared (Bryman and Bell, 2011). The cross-sectional design format acts as a springboard for theoretical reflections upon contrasting findings, as well (Bryman, 2012).

The single specific case study' LNG Stakeholders Seminar' represents the format of a single event, representative for the Baltic SECA, that allows for intensive examination of the setting. The approach to the analysis of this setting has considered the qualitative content analysis sometimes called ethnographic content analysis (Bryman, 2012). It comprises a searching out of underlying themes in the materials analysed. Altheide (1996) has outlined this type of approach to the analysis, describing it as a constant revising of themes or categories distilled from the examination of documents.

> ‘’ Ethnographic content analysis follows a recursive and reflexive movement between concept development-sampling-data, collection-data, coding-data, and analysis and interpretation’. The aim is to be systematic and analytic but not rigid ‘’ (Altheide 1996:16).

This approach is relevant to this study as categories and variables initially devised for the LNG infrastructure development have guided the study, and further allowed for emergence of other categories and variables in line with constant discovery and constant comparison of situations, settings, and meanings (Altheide, 1996).

The author's expectation from the specific case study' LNG Stakeholders Seminar' is to grasp the categories and topics that posit relevant for the Baltic SECA with respect to LNG bunkering infrastructure. The dynamics of the setting and rapid pace changes in the industry and the specificity of regional development justify this type of analysis deployment.

3.3 Data collection

The collected data is substantially qualitative. As specified earlier it consisted of semi-structured interviews, qualitative content analysis, own observations and existing materials. The primary data has been collected by the author and secondary data represents published existing materials (Bryman, 2012).

The theoretical framework displays secondary data in its essence and has been constituted of gathered published literature addressing logistics systems, supply chain management, cost-effectiveness analysis, market forces, infrastructure planning. Some of the literature has been part of the master program curriculum.

Subsequently, the topic investigated has been profoundly influenced by the available theoretical positions (Bryman, 2012). Furthermore, this research has been informed and influenced by previous substantive studies regarding LNG infrastructure as not to risk covering the same grounds (Bryman, 2012).

Previous studies also purveyed a foundation for the research and the possibility to address the deficiencies in knowledge. Industry insights have been maintained up to date by use of on-line daily peers such as: LNG in Baltic Sea Ports, Society for Gas as Marine fuel, Bunkerworld - Petromedia Group, European Spot Gas Markets Report, European Energy Review Journal, Trade Winds, Riviera Maritime Media, European Policy Framework and Directives. The reviewing of literature has been iterative throughout the entire process in line with its exploratory design.

The interviewing has been administered at a considerable time after literature review has commenced, which conferred a better sight over the issues pertaining to LNG distribution through bunkering facilities. The concept of integrating the respective facilities in the conventional bunkers market represents a link the author has identified as being relevant in facilitating the functionality of marine LNG market.

As regards the single specific case study' LNG Stakeholders Seminar' for which the author has conducted a qualitative content analysis, the presentations published by Baltic Ports Organization with respect to the on-going project' LNG in Baltic Sea Ports' have been utilized. Although, the author has participated at the LNG Stakeholders Seminar and has engaged in conversations to probe specific issues of interest, the field notes have been considered of no value to any generalization. The time was insufficient to strike the right note in the relationships established (Sarsby, 1984) and any hint towards participant observation would be fairly frustrated. In broad terms, and in accordance with pure technicality of this research, the author has concluded that the participation had only provided familiarization with the context the documents were generated. Therefore, further gathering of data emerged from the collection of Seminar's presentations.

3.3.1 Semi-structured interviews

Qualitative interviewing provides for a less structured approach and stresses a greater generality in the formulation of initial research ideas and interviewees' own perspectives (Bryman, 2012).

The term in depth interviewing and qualitative interviewing refers to both semi-structured and unstructured interviews (Bryman, 2012). The author has opted for the semi-structured format consisting of a list of questions-the interview guide that has been deemed to cover the topics of interest. It ascertains the following of the script by interviewees to a certain extent, simultaneously allowing for some flexibility (Bryman and Bell, 2011). Flexibility in the interview process has proved fruitful in terms of the qualitative data it has furnished,

interviewees being given some freedom with respect to framing the understanding and explaining the issues in accordance with their own perspectives and their particular availability for elaboration on the matters. Nevertheless, the guide questions represent a mix of pre-coded and open end questions, this technique ensuring for a proper coverage of the topics and a higher degree of validity emerging from cross-case comparability.
The interview guide (see appendix 1) consists of 4 questions, pre-coded and open. For the pre-coded questions the respondents were accorded the possibility to tick the appropriate answers while for the open questions respondents were given the freedom to answer on their own terms. The open-ended responses have been recorded.

3.3.2 Qualitative content analysis

The second technique of data collection which has been applied to the single specific case study 'LNG Stakeholders Seminar'-the qualitative content analysis, has involved a few specific steps: assuring the correct formulation of the research questions that the qualitative data analysis would answer, proper familiarization with the presentations, increase familiarization with some specific presentations, precisely 6 of them, generate categories that would guide collecting data, coding and finally analysis (Bryman, 2012).

3.3.3 Observations

An experience of knowledge sharing through a platform like 'LNG Stakeholders Seminar' has proved insightful. Hearing the real concerns of ship-owners, policy makers, port authorities and LNG suppliers has constituted an authentic sample of different perspectives, counterbalancing interests of the relevant stakeholders.

3.3.4 Documents

The author has been provided with secondary literature from Danish Maritime Authority, European Commissions' Directorate-General for Mobility and Transport (DG MOVE), TEN-T Executive Agency and Sund Energy AS -a specialised energy consulting company based in Oslo, Norway. Reviewing these documents has contributed to the enrichment of author's knowledge.

3.4 Sampling of interview candidates

As empirical/statistical generalization is not the aim of this study, the sample is not probabilistic. The criteria implied for the selection rather regards the potentiality of units/cases to provide, in the best way possible, information about the research questions (Bryman, 2012). Thus, guided by the research questions, the generic purposive sampling has constituted the technique to be used, in line with strategic considerations for the selection. The approach for the purposive sampling is sequential. Teddlie and Yu (2007) refer to the distinction between non-sequential and sequential purposive sampling implying fixed sampling strategies versus less established strategies at the outset of the research. The sampling has evolved along the process, gradually adding to befit the research questions. The dimension of the research interest, though, indicated for the benefit of variation sampling. Therefore, candidates derive from differing areas of the LNG infrastructure, their professionalism being the most relevant criteria.

The single specific case study ’LNG Stakeholders Seminar’ has been chosen as the best alternative among the events of this nature. The range of event possibilities comprised: LNG Bunkering Summit, Amsterdam 27 - 29 January, 2014, Gas Technology Seminars 25-27 March 2014, Korea, ’LNG Stakeholders Seminar, Helsingborg, 27th March, 2014 and Seminar: LNG as fuel, St. Petersburg, 13 May 2014. In terms of regional representativeness, ’LNG Stakeholders Seminar, Helsingborg proved to be the right option, concomitantly suiting with the time confinement for this study’s submission. Thus, the author has justifiably opted for the contextual level of sampling in line with the geographical area considered and also due to the time constraint the sampling can be deemed slightly convenient.

The events of this kind provide for dialogue and actuality and, thus, build propitious settings For LNG industry’s issues tackling.

3.4.1 The sample size

One of the challenges that the author has faced at the outset of sampling was the size/number of units to be considered once theoretical considerations guide the selection (Bryman, 2012). The criteria applicable herein, and in line with Onwuegbuzie and Collins (2007) opinion on the matter, relate to data saturation, theoretical saturation or informational redundancy. Although, the author kept in mind the minimum level of acceptability propagated by the research methodology, what posited definitive for the sampling size option was for the material to be fruitful. As Gerson and Horowitz (2002:211) observe, some qualitative interviews are ‘uninspiring and uninteresting’. So, at the point of transcribing material, the author has identified significant portions of collected data that couldn’t be of any use. Therefore, the blend of the conclusive material has frugally deemed only the relevant data as a matter of consideration for research quality.

3.5 Qualitative data analysis

The operationalization techniques have implied developing codes right from the commencement of the process. Thus, in accordance with Lofland and Lofland (1995) considerations, the author has conceived the following matters for reference along the process of developing codes:

- general categories representative for the specific items of data
- what do the specific items of data signify
- what do these data propagate
- to which topics do these data items relate
- what questions and answers about the topic suggest the item of data

After reviewing the codes, the author reflected upon the general theoretical ideas in relation to the codes. Even though, the mechanism of codes generation has been fairly comprehensive and to some extent fatiguing, it has shed light on the meaning of data collected and helped to reduce the vast amount of it (Huberman and Miles, 1994).

Transcript of the interviews presupposed taking notes and refining them into codes. Even though, the pre-coded questions would normally prescribe for quantification, the aim of these questions was to render fixed codes (acting as background facts) to which respondents could associate their qualitative reflections. As mentioned before, generalization is not the aim of this study, therefore, the ordinal and nominal variables emerging from the questions are designated to shape up a somewhat structured context within which the responds could furnish valuable qualitative insights. And hence, Bryman and Bell (2011) sustain that it's not the case that there is complete absence of quantification in qualitative research. And, indeed this very matter coffers the opportunity of cross-case comparability given the outcomes are similitudes or either dissonance.

The operationalization of the qualitative content analysis, firstly presumed being utterly conversant with the context of content generation. As suggested before, this state has been reached due to the participation at the LNG Stakeholders Seminar, and subsequently due to thorough familiarization with the documents in question. Once codes were generated from the notes, they've served further as basis for the theoretical understanding of the data and constituted a valuable input for the research focus (Bryman, 2012).

3.6 Reliability and Validity

Qualitative reliability emphasizes that the approach of the researcher shall be consistent across different researchers and projects (Gibbs, 2007). Undoubtedly, it represents a criterion of quality assessment of the social research, preponderantly addressing the consistency of the measurement. Mason (1997:21) argues that qualities as reliability, validity and generalizability have achieved a significant degree of rigor in quantitative studies in accordance with certain methodological and disciplinary conventions. Bryman (2012) supports the same argumentation stating that the mere definition of reliability with connotation of measurement seems to contradict with qualitative studies. Therefore, the terms shall be adopted to match assessment needs in qualitative research.

In line with this prerequisite, in qualitative studies, the essence of reliability would regard the need for astute coding and diligent documentation in order to avoid mistakes (Gibbs, 2007). Therefore, the author has applied the formerly mentioned precautions within the process of coding, results interpretation and comparative cross-case analysis.

With respect to external validity, Lecompte and Goentz (1982) sustain that it’s a difficult criterion to be met in qualitative studies, as it’s impossible to freeze social settings and the circumstances of the initial study.

Qualitative validity describes how the researcher checks for accuracy of the findings by making use of specific procedures (Gibbs, 2007). Further, Hammersley (1992), suggests that plausibility and credibility of the researcher’s ‘truth claims’ are to be given consideration in evaluating the qualitative research. In line with this argument, the validity of the claims in this study is judged on the basis of the adequacy of the evidence offered in support of them.

The internal validity in qualitative studies addresses the matter of credibility of the findings. And, thus the following question arises: Do the associations discerned between the variables constitute sense and acceptability to others? Starting at this vantage point the author could strengthen position by ensuring more variation within the sampling units, and by increasing awareness in conjunction with the interviewees’ specific task and role influencing their perspectives.

The quality of external validity and transferability, evaluates how the findings of the study can be applied to other contexts (Bryman and Bell, 2011). As for this specific study, there might be some external validity in conformity with the principle that markets may reach functionality when following certain proved patterns.

Ecological validity focuses on the significance of a natural context. As indicated by Cicourel (1982), the need to ensure that the chosen method captures real conditions, values and knowledge in their natural settings is to be imposed. According to the aforementioned, it’s justifiable to consider that this study has immersed in a natural setting to a reasonable degree, as it transposes an actual state of the LNG bunker market, existing issues and tendencies.

In order to keep the quality assessment at an adequate level the author made use of checklists of criteria for appraisal (ex. coherence of assumptions, the adequacy for documentation, accurate data context portraying and ethical considerations).

3.7 Limitations and challenges

The main limitation of this study pertains to the possibly subjective view deriving from analysing the LNG infrastructure of a single particular SECA-Baltic Sea. As a matter of confirmability, the author has attempted to a degree reasonably possible not to overtly allow personal values and theoretical inclinations sway the conduct of the research (Bryman, 2012). Although, the author's background in logistics and freight forwarding might have influenced the area of interest, previously acquired convictions were not taken for granted but rather have been submitted to self-reflection.

Another challenge has related to certain affinities with the interviewed candidates, which imposed for disentangling the stance as a researcher in contrast with subjects' perspectives (Bryman, 2012). As interview candidates are not representative to a specific population the author, by no means, claims generalizability in relation to it. Instead, the author considers for the research findings to generalize to theory. J.C. Mitchell (1983:207) argues that it is 'the cogency of the theoretical reasoning' rather than statistical criteria, that is decisive in considering the generalizability of the findings of qualitative research. Therefore, the challenge has pertained to being critical towards the quality of the theoretical inferences in the attempt to assess generalizability.

Finally, ethical considerations have been of main concern at every stage of the research. Therefore, participants have been assured of full anonymity and confidentiality. Precautions have been taken in relation to data deriving from responses not to trace back to the identities of the respondents. In order to counteract any possible concern the author has provided the respondents with a written consent statement to substantiate the ethical conduct (see appendix 2). Furthermore, no personal data subject to reporting to Norwegian Data Protection Authority has been collected in this study.

4. Case study 'Baltic SECA' Data Analysis

As it has been indicated in the schematic representation of the research design, the framework for the collection and analysis of data addresses the complexity and particular nature of Baltic SECA LNG infrastructure. The various sources used in exploration of this case conferred the possibility to view and understand the existing issues by means of using multiple frames for reflection.

Case study 'Baltic SECA' encompasses three main section of data analysis: the first regards the LNG infrastructure establishment in Baltic SECA and makes use of secondary data deriving from European Commissions' Directorate-General for Mobility and Transport (DG MOVE), TEN-T Executive Agency (2013), the second addresses the comparative interview analysis and the third section deals with 'LNG stakeholders Seminar' content analysis.

4.1 Introduction

For Baltic SECA LNG Infrastructure, the secondary data deriving from European Commissions' Directorate-General for Mobility and Transport (DG MOVE), TEN-T Executive Agency (2013) exhibits the project 'LNG in Baltic Seaports', which has been active for more than a year.
The project 'LNG in Baltic Seaports' further constitutes a relevant item of data to provide perspectives on the Baltic SECA LNG infrastructure assessment.
EU institutions closely monitor the LNG development in the Baltic Sea area as a long term perspective to ensure environmentally friendly ship bunkering. According to the representatives of EU Commissions' Directorate-General for Mobility and Transport and the TEN-T Executive Agency (2013), the strategy to promote and contribute to the development of LNG availability as an alternative fuel is fully active and prone to serve as a touchstone for future sulphur emission control areas.

4.2 LNG infrastructure establishment in Baltic SECA

The operationalization of the data deriving from European Commissions' Directorate-General for Mobility and Transport (DG MOVE), TEN-T Executive Agency (2013) has provided for certain categories representative for the respective data:

A) *Condition assessment – a substantive step prior to infrastructure planning processes,* represents a category which has emerged in relation to the analysis of Helsinki area LNG establishment.

The port of Helsinki has accomplished its part of feasibility studies for bunkering facilities at the port, along with the bunkering from other vessels/barges and bunkering from trucks. Hence, the condition assessment for this LNG project indicates a good starting point to initiate planning processes and investments in assets. Precisely, the diligent work of conditions assessment with reference to the theoretical concept of analysis of baseline conditions has proved to posit substantive prior to infrastructure planning processes' commencement. The consideration for bunkering modes to serve the potential demand for bunker LNG in accordance with context's specificities provides for an adequate planning of assets to serve the distribution in an effective way.

B) *Predictive models of structures for layout configuration*, evokes a category which has emerged from the data analysis for LNG establishment of port of Aarhus, Denmark (Aarhus Havn).

The identification of a fairly serious constriction in case of LNG establishment for port of Aarhus, Denmark (Aarhus Havn,), conduces to reflections upon ‘predictive models of structures’ considered within the theoretical framework. Aarhus Havn faces considerable challenges with respect to costs, dimension and localization for the LNG establishment which makes the possible layout questionable.
The lack of clear signals of ship-owners’ commitment and precarious demand prospects for LNG have determined the hesitance of project management department towards any undertaking. In addition to the afore-stated arguments, there would be some loose ends pertaining to handling boil-off gas for this project.
Relational to this data is the interposition of asset management, prescribable for application when the predictive model of possible structure lacks conclusiveness on variables such as location, LNG volumes in demand, frequencies in refuelling, etc.

C) *Interim strategies to counteract transient changes* expresses a category devised in relation to the need for flexibility in setting the LNG infrastructure for the port of Aarhus.

In line with the general theoretical idea that good availability of requisite elements in the distribution network shall consider interim strategies to counteract transient changes carrying potential disturbances, pertinent inference may be drawn to the predictive modelling of the Aarhus port. The LNG bunker layout indicates preliminary potential range for capacities, spotted around 5 000-15 000 thousand cbm and an arrangement consisting of flat bottom type or several cylindrical; thermos tanks of approx. 1 thousand cbm each connected through pipes. This arrangement allows for more flexibility as it can be established segment by segment while following the market developments. Under circumstances of expressed concerns in connection to future prospects for the bunker LNG demand and handling boil-off gas procedures emerge, also, categories such as *project commercial viability and lack of handling guidelines* to be developed further in the thesis.

D) *Cross-functional, process based perspective on collaboration between project partners*, portrays a category arisen in conjunction with LNG bunker establishment is the Port of Turku, Finland, LNG project.

This project rigorously proceeds without delays. The undertakings hint towards LNG bunkering with the use of trucks in the port area. Investigations are performed to devise pros and cons of LNG bunkering across every quay. In the meanwhile a local detailed plan for the Pansio LNG terminal (capacity: 30,000 cbm, investment: €60 million) was accepted by the Board of Environment and City planning. Gasum, the operator of the facility has commenced on technical planning of the LNG terminal, whereas Turku port focuses on planning of the area around the terminal. In terms of safety, Port of Turku has completed a draft of the 'Safety Manual', which was sent to the regional rescue services for further annotations.
In focus, in this respect becomes the outline of distinguishing various coordination processes within the planning phase. The LNG establishment layout for the port of Turku has been conceived, in point of fact, in accordance with cross functional, process based perspective, proactively engaging the stakeholders towards a joint vision upon efficiency and commercial viability.

E) *LNG infrastructure synergetic linking to industrial and energy customers* represents a category deriving from the Port of Turku's intents to expand supply beyond maritime customers.

Thus, the optimization of the layout and the surroundings is considered in line with prospectively land based synergetic linking to industrial and energy customers by means of a pipeline construction network, in which case LNG can be delivered from the terminal to the users in gaseous state.
Diversification of customers' base concept emerges from the aforementioned argumentation, explaining the potential of increase in lucrative revenues and advantageous market positioning in relation to other participants.

F) *Commercially viable and functional distribution network to build LNG availability* displays a category deriving from the analysis of LNG establishment processes for the port of Copenhagen-Malmo, Denmark/Sweden.

Prompt development provisions have commenced for Copenhagen-Malmo Port, Denmark/Sweden, encompassing cost and market analyses for the investment under consideration. Two main courses of action have been deemed towards accomplishing the goal of LNG availability in the area. Firstly, the analysis relates to atmospheric tanks built onsite and the second one focuses on the cost analysis for a 10,000 cbm facility. The consultancy company Liquiline, designated to conduct the analyses has opted for quantitative evaluations for the capital investment as funding is relatively predictable and the alternatives accede more or less to a particular area of arrangements.

Findings of the data analysis for this setting reflect that pre-investment planning of assets presume the potential of the respective assets to support adequately the LNG distribution, ensuring availability, in addition to which thorough consideration was given to the type of resources' allocation in line with the extent of commercial viability it provides.

G) *Location choice effectiveness* represents a category derived from the analysis of data on Port of Helsingborg LNG establishment.

Location choice effectiveness proceeds from LNG settlement optioning in case of Helsingborg area. Port of Helsingborg together with Kemira Kemi AB, Oresundskraft AB and NSR AB collaborate on the project called Helga (Helsingborg Liquified Gas Association) to settle for the LNG infrastructure in the Helsingborg area. The report has concluded that there is potential for LNG demand and that shipping segment is crucial for securing critical volumes. Helsingborg has been identified as the most appropriate location on the western Swedish coastal area from Halmstad in the North to Vellinge in the South. Thus, Kemira Kemi AB- industrial park, in the southern part of Helsingborg proved to be the adequate choice of localization.

The inference drawn upon infrastructure planning theoretical positions evokes adequacy in layout settlement in line with strategic positioning and optimization of the surroundings to facilitate the development of a proper bunkering environment.

H) *Proactive dialogue with implicated stakeholders* provides for a category discerned through data analysis conducted on the LNG establishment of Stockholm port, Sweden.

Port of Stockholm, Sweden has proceeded with ship to ship bunkering operations since the arrival of Viking Grace, 14th January, 2013. The operations are performed 5-6 times a week at Stadsgården, Stockholm. The dialogue with relevant stakeholders: gas supplier AGA, Viking Line, the Swedish Transport Agency, has been proactively carried out, mutual efforts concerning certain shortcomings proving proficient. A noteworthy instance relates to the mutual efforts invested towards alleviating public concerns with respect to safety. Theoretical positions discussed within the theoretical framework depict collaborative partnerships as rendering leverage capabilities. Sharing information, alerting problems in advance developing a common vision upon the issues by means of mutual efforts improve performance of processes/services. Collaborative efforts among stakeholders, though, shall *accredit the matter of prudent alliances in planning and executing* processes whilst striving for standardization and consensus in order to reduce potential redundancies.

I) *Cost-effectiveness of LNG infrastructure establishment* represents a category emerging as a result of analysing the LNG establishment in port of Helsinki.

The concept of cost-effectiveness entirely substantiates in case of LNG bunkering facilities' establishment in port of Helsinki.
By virtue of examining all possibilities, the results indicated that the most effective bunkering solution is ship-to-ship because it provides for flexibility in an area like Helsinki characterized by separate harbours with varying structures and functions. The matters concerning offshore bunkering method in Helsinki area, describe that ship to ship bunkering method dispenses with the need to invest in port's dock structures. Options, in this situation might suggest for modification of bunkering vessels (e.g. Seagas) –with a fixed container structure or a vessel with replaceable cryo-containers as the example of bulk AT/B type provides. Flexibility may be furnished by separating propulsion (tug) from cargo (barge) and enabling a "swap and drop" arrangement.
The intermodal AT/B baseline configuration provides for another solution with reference to LNG offshore supply with a capacity of 5,300 m^3 comprising approximately 144 ISO standardized Type C containers. These LNG-rated containers, also called "tank-tainers," can be configured to standard 20 ft., 40 ft., or 45 ft. sizes. Although, some of the offshore solutions are still concepts, technical feasibility confirms the potentiality of complementing LNG availability with the respective offshore facilities.
Furthermore, a bunkering environment installed anywhere on the Gulf of Finland shores would not be a disadvantage to the offshore option in Helsinki. Herewith, considerations have supposed to establish a LNG terminal.

Port of Helsinki also cooperates with the Finnish Border Guard on bunkering options in the Vuosaari Harbour. The respective area permits for quays and slots establishments for tank trucks use.
The afore-stated facts provide for the vindication of cost-effectiveness approach to the LNG infrastructure project in question, as the best use of the given resources embodies consideration for different ways to achieve LNG availability in Helsinki area.

J) *Extension of physical boundaries for LNG distribution by means of logistics support functions* is a category emerged from a final extrapolative analysis on the Baltic SECA LNG establishment, namely- port of Tallinn, Estonia.

Projections, herein, indicated that bunker tankers would be the most effective bunkering service to be provided in line with the presumable low and irregular demand.
The regional infrastructure planning considers, also, the prospect of an LNG import terminal, envisaging cost-effective logistics solutions of bringing LNG to the Northern Baltic Sea region.
The reasonable deduction devolving from analysing this specific context relates to the concept of extension of physical boundaries of a regional market confronted with low demand, by making use of logistics place utility processes which add value to the cargo by moving it to venues in demand.

4.3 Comparative Interview Analysis

As mentioned within the research methods chapter, the rationale for interview candidates' variation sampling has been determined by the dimension of the research interest and has gradually evolved to befit the research questions. The candidates derive from different sections of the LNG infrastructure which inherently has provided specific perspectives on the existing issues. The outlook of particular cases inferred to the interviews purveyed the possibility to perform the comparative cross- case comparability.
The codes generated in relation to the data of each interview have been related to various existing theoretical positions. Subsequently, the exploration on how the respective codes associated to the theory has furnished distinct constructs. The potentiality for validation of these respective constructs has been provided by means of confronting the findings back to the collected data.

4.3.1 Introduction

Several interviews have been conducted with the aim to complement knowledge in relation to LNG bunkering infrastructure of Baltic SECA. The exploration of propitious LNG distribution trends towards a functional bunker market was intended to answer the research question 1: How should the LNG bunkering infrastructure develop in Baltic SECA, in order to effectively meet the small and medium scale demand?

Although, the exploration of issues through interviewing is distinctly enframed to address the case study 'Baltic SECA', the potentiality of the conceptual categories and associations derived from data analysis to transcend the case study's confines has been deemed noteworthy.

Interview candidates represent purposively selected LNG professionals deriving from various sectors of the LNG infrastructure. As respondents have been assured of full anonymity, the distinguishability of their answers is provided by means of referring to their specialization area. Thus, the conclusive interviews considered for analysis have been conducted with the following candidates:

1. Port authority representative
2. LNG business developer
3. LNG project developer
4. LNG supply & research manager
5. LNG fleet manager

The interviews have been conducted in the period between 05th of March and 27th of March, 2014, in three locations: Oslo (Norway), Helsingborg (Sweden) and Copenhagen (Denmark).

The interview analysis encompasses five sections:

1. The first section regards factors facilitating LNG establishment in Baltic SECA in line with the requisiteness to meet the medium and small-scale demand for marine use;
2. The second section addresses LNG distribution logistical implications, in line with the endeavours to scale up the LNG bunkering infrastructure in Baltic SECA. This section, concomitantly, provides insights for answering research question 3: What are the essential logistical implications and supply chain perspectives to be considered for effectively integrating Baltic SECA, LNG medium and small-scale bunkering facilities within marine bunker fuel markets? ;
3. The third section deals with LNG bunker sales and purchase contracts;

4. The fourth section regards the medium and small-scale facilities as an emergence of a better new solution to complement the LNG distribution network;
5. The fifth section considers measures of effectiveness for marine LNG bunkering;

4.3.2 Factors facilitating LNG establishment in Baltic SECA

In accordance with the interview guide (see appendix 1, question 1), the respondents were asked to address the facilitating factors for the transition towards LNG bunkering in the Baltic SECA. Answering options encompassed reference to several predefined categories provided by the pre-coded questions and the possibility to explain the choice by commenting on free terms. The pre-conceived categories have been developed in relation to the existing perspectives devolving from various studies, as well as from the existing theoretical positions advanced within the theoretical framework.

The aim was to ensure satisfactory coverage for the categories while exploring the way the respective categories are given consideration by the respondents.

The illustration of respondents' answers for question 1 (scale of 1-6, where 1 is 'the most important'):

Respondent	A	B	C	D	E	F
	SOx limit regulation	**Wholesale LNG price vs.MGO vs HFO**	**CAPEX of LNG vs. MGO and NOx catalyst vs. HFO, SOx scrubber and NOx catalyst**	**Support schemes for choosing LNG instead of other fuels**	**Safety regulations and standards for LNG bunkering in ports**	**Difference between retail and wholesale LNG prices**
Port authority representative	1	2	5	4	3	6
LNG business developer	1	2	6	5	4	3
LNG project developer	3	1	2	6	4	5
LNG supply & research manager	1	2	5	6	4	3
LNG fleet manager	1	2	3	6	4	5

Figure 13: Factors in facilitating the transition towards LNG in Baltic SECA, ranked by degree of importance (author's own work).

The cross-cases analysis of the findings reveals that the context of the amended Annex VI of IMO MARPOL Convention under which auspices Sulphur Emission Control Areas have been enacted, represents the highest ranked facilitating factor. Thus, reasoning sets forth the *strict enforcement on SOx* limits as the primal impetus in stimulating settings for the different compliant technologies.

The price of LNG vs. MGO vs. HFO is regarded as the next facilitating factor with the emphasis on the competitive edges rendered.

Safety regulations and standards for LNG bunkering in ports is the next highly important factor. Respondents have argued that consistent, unequivocal safety regulations/industry standards for LNG bunkering procedures are crucial in setting a safe and reliable bunkering environment.

Next factor in ranking is *CAPEX for LNG powered ships vs. MGO and NOx catalyst vs. HFO, SOx scrubber and NOx catalyst.* The discernible common perspective indicated for the case dependable parameters to weight more relevant, with reference to age of the ship for retrofits and expected payback time, financing terms, net present value, fleet structure for companies owning/operating more ships, trading patterns, exposure to SECA, suitability to the ship-owner/operator's business model.

In relation to the *difference between retail and wholesale LNG prices* as a facilitating factor for the transition towards LNG bunkering, the LNG supply & research manager affirmed that LNG's competitiveness as a marine fuel in comparison with the alternatives is among the main prerogatives to secure a viable share of the bunker market.

Whilst, the LNG business developer argued that the trend to reduce the LNG distribution costs and value chain costs sets much pressure on investors as too much competition erodes the potential lucrative revenues. He further suggests that as a matter of bargaining power consolidation, LNG distributors are highly incentivized to lock in customers by means of pooling several in a port on long term contracts.

The category *difference between retail and whole LNG prices* relates to the theoretical concepts on competitive forces. It allows for the explanation of competition for profits among the participants in the LNG distribution. Costs inherent to every element in the LNG distribution would reflect, thus, the magnitude of bargaining power of the participants in relation to each other.

With respect to *support schemes* respondents expressed the necessity to distinguish between the support schemes applicable to ship-owners and the ones applicable to infrastructure developers. Thus, the perspective on support schemes acting as facilitators is judged in accordance with the terms for subsidies and grants. The common practice shows the investment risks are shared among the grantor and the grantee. Furthermore, in conjunction with the schemes applicable to the infrastructure developers, the port authority representative suggests that the willingness of port authorities and established bunkering players is significant in assuming either the first mover advantages or conversely the risk of sunk costs and stranded assets in case of low LNG penetration for the marine traffic. For Baltic SECA, LNG establishment is supported through funding from the EU Trans-European Transport Network, Motorways of the Sea.

4.3.3 LNG distribution logistical implications. Endeavours to scale up the LNG bunkering infrastructure in Baltic SECA

As a result of EU's Impact Assessment Study for the proposed directive on the deployment of alternative fuels infrastructure -COM (2013) 18/2, the need of swift implementation of the LNG refuelling network has been identified.

According to all the respondents, under these circumstances, the implication of logistics is inevitable as different perspectives on the LNG supply are required in line with the need for congruence in processes such as planning, procurement, scheduling and transportation from the original manufacturer/distributor to the final consumers.

The logistical implications for the LNG distribution is addressed by question 2 from the interview guide (see appendix 1, question 2).

The illustration of respondents' answers for question 2 depicts the following (scale of 1-5, where 1 is 'the most relevant'):

Respondent	A	B	C	D	E
	Availability and cost of break-bulk facility at large terminals	**Availability and cost of LNG capacity at break-bulk facilities**	**Availability and cost of small-scale LNG tanker ships/trucks to distribute LNG to smaller facilities**	**Availability and cost of small-scale LNG receiving terminals in main ports of Baltic**	**Regulations for LNG bunkering and the associated additional cost**
Port authority representative	1	3	4	2	5
LNG business developer	2	3	4	1	5
LNG project developer	2	3	4	1	5
LNG supply & research manager	1	5	3	2	4
LNG fleet manager	1	3	4	2	5

Figure 14: LNG distribution chain bottlenecks, ranked by degree of relevancy (author's own work).

Moving LNG from large capacity export/import terminals to the bunkering location necessitates breaking-bulk by means of medium and small-scale facilities. As a matter of complementarity, these facilities are crucial in scaling up the LNG bunkering infrastructure. This imposes for proper configuration of all medium and small-scale elements in an area of reference in line with necessary capacities' adjustments and settlement for adequate transportation modes to reach the bunkering location.

Cross-case analysis of the answers to question 2 reveals that within a LNG distribution chain, from a large export/import terminal to the bunkering locations, the main bottleneck is represented by the category *availability and cost of break-bulk facility at large terminals.* Maritime customers' needs for LNG refuel are better served by a system of medium and small-scale facilities. Also, an improved distribution of LNG presupposes more of the infrastructure to capture more of the capacities which is made possible by meshing up/complementing the LNG infrastructure with facilities that operate smaller scale capacities. Therefore, from the starting point of distribution would be advantageous to break-bulk in an affordable manner in order to increase fluidity in distribution to the bunkering location.
The rationale also relates to the leverage provided by better coordination of LNG flow when early adjustments of capacities can be effectuated.
The category *availability and cost of small-scale LNG receiving terminals* in main ports of Baltic SECA has been devised as the second main bottleneck for LNG bunkering of ships. Lack of smaller receiving facilities to serve the maritime demand for LNG represents a major impediment in building availability and a proper bunkering environment.
Availability and cost of LNG capacity at break-bulk facilities category has been addressed as the third potential bottleneck for LNG bunkering, inherently referring to the possibility of these facilities to supply LNG in right volumes and in an affordable manner.
Availability and cost of small-scale LNG tanker ships/trucks to distribute LNG to smaller facilities represents the next potential bottleneck according to the respondents due to the need of these assets to complement the distribution network in order to make the required capacities available at the bunkering location. And, lastly*, regulations for LNG bunkering and the associated additional cost* have been ranked as the least important bottleneck. The respondents argued, though the relevance of bunkering standards, claiming that the ranking resulted due to other categories weighting more basic to the problems.

Following, the operationalization of qualitative portions of data supplement insights relating to logistical implication within the LNG distribution.

The relevance of cooperation among stakeholders deriving from different parts of the supply chain is accentuated within the LNG supply & research manager's assertion:

'*We expect incentivized communities of investors to come on-board LNG businesses. Along with entrenched participants such as ports, gas providers and energy traders, advantageous joint ventures can be settled. All these parties can contribute with their distinct competence to the overall efficiency of the LNG distribution. However, it's a matter of adequate particular processes coordination for the LNG flow and the intrinsic information to finally and collaboratively build up an efficient bunkering network'*.

The concept of various indigenous logistics systems with particular processes of coordination articulated within a broader context of a supply chain stands out in relation to the frame of reference set by the LNG supply & research manager. A LNG distribution network with various types of complementary bunkering points might generate considerable fragmentation to an operational supply chain if the product and information flows are not adequately supported through logistics systems.

Consequently, these support functions may be opportunely furnished by means of logistics systems.
According to the LNG business developer, the logistical implications require a professional approach, associative with competent engineering of logistical systems in order to properly support the breaking bulk processes.
LNG refuelling facilities capacities, either referring to offshore facilities, mobile trucks or onshore facilities have to be correlated to conform to the specific context demand.

A unanimous point of view has been expressed in relation to high value chain costs generated by intensive/recurrent break-bulking and coordination of the associated processes.

Communicatory in this sense is the LNG business developer's allegation:

'Undoubtedly, the LNG availability will increase once we get all the necessary medium and small-scale facilities set in motion. Competition between them would be a good signal for the market as ship-owners would trust more the price level as being a correct one. Of course you can't beat all the costs and fees at once, as we speak about a bunker market in formation. It's rather a matter of long term adjustments between parties set to fight it out on the level playing field'.

Prominent, in this section, emerges the fact that logistical implications should consider *certain standards for efficiency* and strive to keep costs down as not to affect the competitiveness of LNG as a marine fuel. Albeit, the perspective on intensive competition and low margins posits demotivating to the potential investors, given the circumstances of highly uncertain demand, it provides for overall better terms for the ship-owners.

4.3.4 LNG bunker sales and purchase contracts

LNG bunker sales and purchase contracts represents another preponderant factor to support/undermine the scaling up of LNG infrastructure of Baltic SECA. As an underlying feature for the LNG market mentioned within the theoretical framework, gas supplies are usually contracted on long terms and indexed to oil.

In light of question 3 from the interview guide (see appendix 1, question 3), respondents have provided the following answers (scale of 1-5, where 1 is 'the most important'):

Respondent	A	B	C	D	E
	Price level for LNG, too high and close to the alternatives	**Price indexation mechanisms for the LNG**	**Difference between retail and wholesale price for LNG**	**Contract duration and flexibility in making adjustments**	**Lead time needed to negotiate and sign an LNG SPA**
Port authority representative	2	1	4	3	5
LNG business developer	1	2	4	3	5
LNG project developer	1	3	5	2	4
LNG supply & research manager	1	2	5	3	4
LNG fleet manager	1	2	4	3	5

Figure 15: Elements of LNG bunker sales and purchase contracts, ranked by degree of importance (author's own work).

The cross-case analysis of the respondents' answers indicated *that price level for LNG, too high and close to the alternatives* represents an element in the bunker sales and purchase contracts to weight most relevant. The argumentation related to the competitive edges rendered in comparison to the conventional fuels. Further, respondents claimed that ship-owners' commitment to LNG bunker fuel is determined in a predominant way by purely more reasonably satisfactory pricing. Second in ranking displays *price indexation mechanisms* for the LNG to count mostly among elements in the sales and purchase contracts. The rationale herein pertains to LNG customers demanding the indexation either to HFO, MGO or Gas Hub in accordance with the optioning best suiting their operational profile. The next ranked element displays *contract duration and flexibility in making adjustments.* The LNG business developer has drawn a parallel to the conventional fuel bunker contracts terms suggesting for the necessity to interpose the spot link as a matter of providing a level of liquidity corresponding to the conventional fuels.

The following excerpt poses valuable insights upon contracting issues:

'Market participants mostly express concerns in relation to the price level. And they always associate the price of LNG with the price for the alternatives, reckoning the competitive edges. The reasoning to do so is self-explanatory, even though the evolution of other fuels prices is not of any doubtless assurance. The real concern here is the long commitment for the LNG bunker contracts. Understandably, LNG business is expensive, pricing mechanisms are different, infrastructure establishment implies considerable financial risks, but despite of that and it's the role of negotiating here, the contracting parties shall settle for competitiveness and proper risk mitigation. And most of all, agreements should presume simplified settlements, easy to follow and comply with' (LNG business developer).

The analysis plausibly suggests for the concept of bargaining power of the market participants. The price and terms settlement is unquestionably related to the actual market forces providing for the price setting mechanisms. Therefore, desirable flexibility in making adjustments along the way in line with more value capturing may be secured by means of capitalizing upon favourable conjuncture through astute negotiating.
Difference between retail and wholesale price for LNG is the next category to which respondents have referred. Comments also suggested that LNG wholesale vs. retail pricing is further analysed in comparison with HFO, MGO and de-NOx solutions to comply with the upcoming regulations. Another relevant observation regarded the increase in competitiveness of LNG under circumstances of third parties access which will shorten the distance between wholesale pricing compared to retail levels.
Lead time needed to negotiate and sign an LNG SPA has been referred as the last element to count among the stated ones. Argumentation related to the need of a more competitive environment that would allow for shortening lead time, increase optionality for supply

sources and increase affordability for the respective sources. The reasoning out associates once more to the concept of bargaining power of market participants elaborated earlier.

4.3.5 Medium and small-scale facilities as an emergence of a better new solution to complement the LNG distribution network

The following two sections regard the analysis of qualitative data furnished in connection to the 4th question from the interview guide (see appendix 1, question 4) in light of which respondents were asked about their opinion on how should LNG bunkering infrastructure develop from its infancy stage to an intermediary stage and up to maturity in order to reach a similar structure as compared to the oil products bunkering environments.

According to the LNG project developer, medium and small-scale facilities represent a solution to develop the LNG bunkering environments. He further described that it's a change to the established approach that implicates efforts to displace proven technology from large scale to a more reduced level of capacities. It also presumes shifting from dedicated parties with integrated distribution networks to third parties access which allows for complementing the distribution network providing for more availability and affordability of bunker LNG.

A distinct interpretation of the medium and small-scale facilities fundamentals is provided by the LNG project developer which sustains the following:

'The medium and small-scale facilities constitute the appropriate solution to complement the bunker network and serve the maritime needs in a sustainable way. What is quite clear at this moment is the fact that since the first implementation of the sulphur emission limit the industry has not utilized effectively the time to prepare for the thresholds. In the area of LNG project development, currently, the ambitions relate to the establishment of more medium and small-scale LNG infrastructure to be assigned in capturing more of the capacities as a matter of self-strengthening growth'.

The LNG business developer elaborates on the commercial sense perspective implying that medium and small-scale LNG businesses could develop fairly rapid and furnish good margins with participants collaborating at different levels. Criteria as logistical efforts, assets upgrading through innovations, operational improvement could veritably be better addressed in an environment as such. The possibility to loosely trade LNG and invite miscellaneous partners creates a more straightforward medium to access knowledge, private partners and local

authorities. In line with the same reasoning, joint ventures would provide for better risks mitigation, given the individual agendas are adequately matched.
Furthermore, the LNG business developer invokes the contractual provisions that would be confronted with major changes. Long term contracts implying binding volumes would become more standardized, shorter term based and will presume quicker negotiations, under the circumstances of prompt third parties penetration. The traditional view of LNG terminals being also the investor with locked in customers on long term deals will gradually accredit less, opportunities for business rising for novel participants to the arena such as LNG buyers/sellers (as investors), bunkering service companies.
Various theoretical positions can be associated to the findings resulted from exploring the category devised to set out *medium and small-scale facilities as an emergence of a better new solution to complement the LNG distribution network.*
The concept of increased bargaining power rendering more value capturing, more favourable conditions and discounted sales prices fully ascribes to the setting of LNG distribution third party access.

4.3.6 Measures of effectiveness for marine LNG bunkering

Establishing an effective LNG bunkering environment is a prerequisite in tapping the bunker markets. Therefore, availability and standards setting for bunkering processes are further addressed as essential in providing the adequate bunkering environment.

In this respect, the LNG fleet manager has addressed the ship types and trading patterns when referring to the need for availability of bunker LNG. He, further argues that gas fuelled shipping has acquired substantial interest in the marine markets, short sea shipping being the segment clearly manifesting for a greater potential in adoption due to SECAs implementation. According to his opinion the most promising sectors are ‘A to B and back to A’ operators, trading along the coasts as bunker fuel supply can be easily guaranteed at a mutually convened price in the ports of call.

Nonetheless, the industry is still to tackle standards setting issue for bunkering processes. The assignment for standards setting has been the responsibility of class societies, port authorities and countries’ regulators until now, albeit international standards coverage is required in order to create a safe and reliant bunkering environment.

Elucidative in addressing the standard setting issue is the following excerpt:

'LNG availability at the right price is crucial but in addition to it, ship-owners have to be ensured in connection with the bunkering compatibility and compliance to safety guidelines. We've all witnessed the Lloyd's Register classed Viking Grace as the first grand application of a LNG fuelled shipping project. But there are more standards to be developed and thoroughly addressed for widespread reliable LNG technology application. And here we talk about high calibre standards, recognizable by IMO and IACS that could be adopted and operated at global level.'(LNG fleet manager)

By the virtue of the afore-stated argumentation, availability of LNG for marine shall presume sufficient, commercially viable, strategically positioned, compliant to standards of safety bunkering facilities to serve specific trading patterns.
In light of the Directive provisions on mandatory LNG bunkering infrastructure, the intents have explicitly addressed the need to enable ships to access new fuels across the network in a safe and affordable manner. In line with this desired outcome, the Maritime Safety Agency in cooperation with relevant stakeholders, support standards for deployment of alternative fuels infrastructure. The 'European Sustainable Shipping Forum' and its planned sub-group on LNG also address further technical standardisation aspects.

Another perspective on development of LNG bunkering market towards oil-based markets similar structure relates to the demand prospects for LNG as marine fuel.
The respective prospects posit an invariable threat to the LNG bunker businesses. In this respect, respondents have unanimously claimed that even though, LNG infrastructure developers/investors are striving to build up availability in the way that it manifests a similar structure as compared to the oil product bunkering market, the risk of over-establishment is quite considerable due to the current low demand.

Eloquent in this sense is the argumentation of the LNG fleet manager:

'We are not to see any massive shift of fleet to gas power. Retrofitting existing ships is not a realistic solution according to a large number of ship-owners, due to economic non-viability and technical non-suitability of the required layout for adaptation/outfitting, which implies too voluminous gas tanks and complex associated piping. In addition to it, a considerable majority of the ship-owners are reticent towards changing the way of doing business. It's mostly the need to comply with the upcoming sulphur cap that drags them out of the

abnegation. Conversely, new LNG builds show a different perspective. Preparedness to operate in accordance with a different business model, assumed financing terms and pay off time frame and firm conviction in relation to the commercial sense, work well towards favouring the LNG propulsion and implicitly increase the LNG fuel demand'

The competency in the area of LNG technology and LNG bunkering processes has emerged as another relevant issue to be reflected upon, as indicated by the perspectives generated throughout the process of coding data.

The growing number of individuals involved in handling LNG technology raises issues of training and safety. According to the LNG fleet manager, proper training and safety guidelines can be achieved through cross-training provided by reputable gas operators and ports joined working groups to address LNG bunker technicalities.

4.4 Case study: 'LNG stakeholders Seminar'

4.4.1 Introduction

The case study 'LNG Stakeholders Seminar' is intended to tap actuality-based practical insights, which concomitantly provide for the benefits of sharing expert knowledge in a cross-domain context. It embodies a qualitative content analysis conducted on 6 presentations of the 'LNG Stakeholders Seminar' (Baltic Ports Organization, 2014) with the aim to explore and explain the enablers and barriers for Baltic SECA LNG bunkering infrastructure expansion. The criteria for presentations' selection pertain to the potentiality of conclusiveness of the qualitative material in answering the proposed inquiries enunciated within research question 2.

The LNG knowledge sharing platform constitutes a real life context of knowledge sharing among relevant stakeholders. The addressing of current shortcomings of the LNG fuelled shipping in a circularized manner across a various span of domains, allows for the development of a shared among stakeholders' vision and also renders the potential of best solutions' generation based on the groups' diversified knowledge.

4.4.2 LNG stakeholders Seminar-Overview

The LNG Stakeholders Platform event was organised by the Baltic Ports Organization with the assistance of the Cronström Olander AB, and was held on 27th of March 2014 in Helsingborg, Sweden. The seminar was attended by approx. 55 stakeholders representing a wide variety of interests within the LNG field. The event encompassed two parts. Firstly, a number of insightful presentations were given from well initiated domain professionals.

Secondly, a panel debate has regarded the evolution and expansion prospects for the LNG bunkering establishment in Baltic SECA. The stakeholders profile indicated areas such as LNG supply, LNG bunker trading, infrastructure development, port authorities, ship-owners, engine manufacturing, LNG fuelled trucking, energy importing and trading.
The content analysis has been structured in two main parts. The first part explores the enablers for Baltic SECA LNG bunkering infrastructure expansion and the second deals with the barriers for Baltic SECA LNG bunkering infrastructure expansion.

4.4.3 Enablers for Baltic SECA LNG bunkering infrastructure expansion

Baltic Ports Organization initiative to support LNG bunkering infrastructure

Baltic Ports Organization has initiated the development of LNG bunkering infrastructure in 7 ports of the Baltic Region as a result of a positive decision of TEN-T Financial Assistance Committee to grant support. The project called' LNG in Baltic Sea Ports' implicates many industry organisations: national ports, ship-owners, European Ports Organisation.
With a budget set around 3.5 million euro, the project focuses on pre-investment studies, environment impact assessments, feasibility analyses for LNG terminals or bunkering vessels, project designs, regional market studies, safety manuals, etc.

Figure 16: The geographical dimension of the Baltic Sea LNG bunkering infrastructure project (Baltic Ports Organization, 2014).

The main objectives to be accomplished display: jointly developed operational ships bunkering installations in ports, benefits addressing innovation and deployment of necessary infrastructure for LNG bunkering facilities and increase in implementation of the new technical developments in the maritime sector of the Baltic Sea Region.
The project '*LNG in Baltic Sea Ports'* justifiably provides for a main enabler of Baltic SECA LNG bunkering infrastructure expansion.

Pilot LNG Action part of the Joint Industry Project (JIP)

The Pilot Action part of the Joint Industry Project (JIP) is intended to facilitate the transition phase for the compliant alternative fuels deployment through the associated infrastructure.

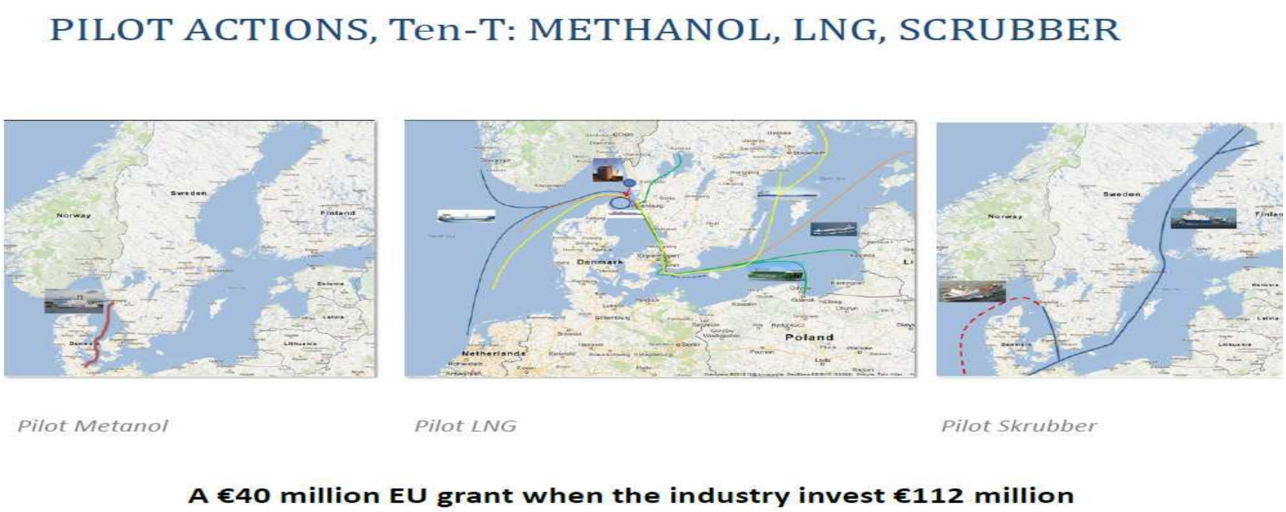

Figure 17**:** LNG in the Pilot Action part of the Joint Industry Project (Swedish Ship-owners association, 2014).

The objectives for the LNG Pilot Action display:

A. *The development for a LNG bunkering hub in Scandinavia*. Through a connection from the LNG terminal to the jetty in Port of Brofjorden, bunker vessels and in some cases, LNG fuelled vessels will be able to refill LNG from the respective terminal. Participants enumerate Skangass, currently involved in LNG production in Risavika (Norway) and also involved in the construction of a LNG terminal in Brofjorden and PREEM, Sweden’s largest oil company, running a refinery business in Brofjorden.

B. *FLEXI Bunker vessel*, *Sirius*, presupposes developing a vessel with a fast, efficient and safe bunkering system for LNG bunkering on-land and offshore. The projections for bunkering operations for the Sirius vessel address Skagerrak/Kattegat area in cooperation with Brofjorden Terminal. Participants enumerate: Sirius, Skangass, Chalmers Univ. of Technology.

FLEXI Bunker vessel, Sirius representation:

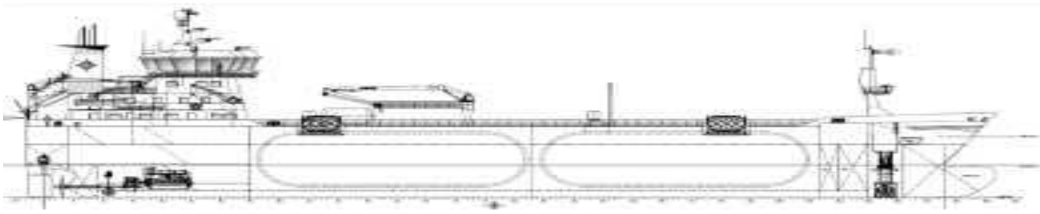

Figure 18: LNG Pilot Action facilities-FLEXI Bunker vessel, Sirius (Swedish Ship-owners association, 2014).

C. *SSD&B Feeder vessel, Donsötank*, representing a LNG feeder vessel with a new integrated tank design. Participants enumerate: Donsötank, Rolls-Royce/Torgy LNG, Det Norske Veritas class society.

D. *EVOlution LNG fuelled tanker, Sirius,* which is a 2-stroke Dual Fuel engine vessel to serve as a showcase of highly innovative technical and operational features. Participants enumerate: Sirius, PREEM Time charter operator of the vessel, Chalmers Univ. of Technology.

E. *LSR LNG fuelled Dry Cargo vessel, Thun***,** supposes an efficient design of a small bulk/dry cargo vessel LNG fuelled, without affecting the cargo space. It provides for training of crew on a 'non-carrier' and encompasses various innovative technical operational features as well. Participants enumerate: Thun Ship-owner and operator, Ferus Smit Shipyard, Lloyds Register class society.

F. *LNG CONV conversion to LNG, Furetank* represents a cost efficient system for converting vessel for LNG operation, with emphasis on reducing the cost of fuel tanks. Participants enumerate: Furetank Ship-owner, Bureau Veritas class society, Öresund Drydock Repair Yard, Fartygskonstruktioner Ship Design Consultant.

Figure 19: LNG Pilot Action facilities-LNG CONV conversion to LNG, Furetank (Swedish Ship-owners association, 2014).

The aforementioned projects provide for physical assets to serve the distribution of LNG in Baltic SECA. Building availability for LNG in accordance with the concept of requisite elements congregated towards a functional distribution network confirms valid when the respective concept is confronted to the Baltic SECA LNG establishment on-going projects. Also, *the safety concerns and bunkering procedures standards* have been rigorously addressed throughout the implementation of all the enumerated facilities, by means of proactive involvement of class societies, port authorities, regulators.

In conjunction with the perspective on asset endowment (see also appendix 4), the following commentary is deemed relevant:

'We, obviously don't face the 'chicken and egg dilemma' anymore, numerous assets are in place, and a lot more will be soon implemented. Performing physical supply of LNG to maritime clients in a safe and efficient manner is a reality today. Either, we talk about STS bunkering in ports, coastal areas/protected waters or offshore, the possibility is there.'(LNG supplier)

Concepts as *comprehensive planning, satisfactory availability and reasonably priced bunker LNG* have emerged from content data coding, the respective concepts genuinely associating to the existing theoretical positions. These exact concepts have come into sight within the interview data processing as well, which provides for pertinent claiming of findings' validation. Comprehensive planning, satisfactory availability and reasonably priced bunker LNG represent enablers for LNG infrastructure expansion.

In relation to the reasonably priced bunker LNG, noteworthy is the following portion of qualitative data:

'Today, we are able to quote FOB prices of LNG, indexed in accordance to what customers demand, either, the indexation optioning is for HFO, MGO, or Gas Hub (TTF, NBP). Also, supplies to the marine market can be provided on long term contracts or spot terms with no limitation to the capacities required.' (LNG supplier)

The distribution of LNG in the Baltic region significantly relates to the need to increase *diversification of energy sources supplies*. Land-based synergetic links to industrial and energy customers or either the potential to complement energy sector needs in off-grid areas are incontestable.

LNG can suitably be used to decrease dependency on certain suppliers (e.g. Gazprom) and provide for gaining bargaining power in negotiating contract prices with the respective.

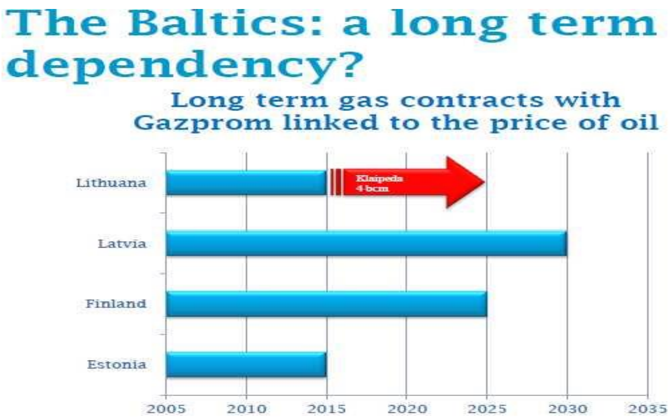

Figure 20: Baltic region-long term dependency on Gazprom supplier (International Energy Agency, 2014).

Thus, the potential of more LNG capturing by the existing facilities can render lucrative revenues and commercial sense to expand LNG infrastructure.

4.4.4 Barriers for Baltic SECA LNG bunkering infrastructure expansion

Obstacles in relation to LNG infrastructure development are fairly numerous, the fact that considerably tergiversated the adoption of LNG technology.

Although, LNG represents a competitive compliant fuel with consistent climatic advantages, a large number of potential adaptors prefer to buy some time to watch the evolution of all the compliant solutions, such as pricing and functionality of sulphur oxides scrubbers, MGO pricing, LNG pricing.

Thus, the *price evolution of LNG marine fuel* weights crucial to the ship-owners and to the LNG infrastructure developers, in line with the commercial opportunities it may furnish.

In this respect, port of Helsinki expects hectic price development after LNG introduction as marine fuel, as much dynamics will be generated by the tendency of compliant fuels/technologies to posit as cost efficient as possible and secure more of the bunker market.

Another barrier addresses the phenomenon of ballooned *construction costs for new supply projects.* A new trend in the area of LNG project development encourages FLNG to reduce new supply projects.

The solution seems to gain acceptance amongst the sponsors of major new gas developments, communicatory in this sense being the following qualitative excerpt:

'The offshore solution to produce, liquefy, store and transfer LNG with 50% less investment in the raw materials as compared to onshore plant seems to be a strikingly viable business opportunity for many potential gas infrastructure developers' (LNG Consultant)

Nevertheless, the vehemence in promoting it has been counteracted by the fact that the technology has neither been sufficiently tested nor has it demonstrated yet the economics aspect.

Under circumstances of high market uncertainty, *the risk of investing in bunkering infrastructure* emerges as another significant barrier. The investors' efforts to mitigate various risks or the optionality of 'outsourcing' the administration of the claims and risks processing represent a few choices to counteract the effects.

Content analysis has provided for the emergence of another significant barrier for Baltic SECA LNG bunkering infrastructure expansion, namely *the safety regulations and industry standards for bunkering.* The concerns were expressed in connection to the requirements imposed on bunkering procedures for vessels with passengers on board, access regulations, requirements for fuelling speed.

The 'soft' dimension of the LNG infrastructure, embodying the safety standards has been nominated throughout the interviewees' responses, as well, providing for the validation of the linkages generated by this category.

5. Discussion

Chapter 5 comprises a discussion on the subject matters addressed within the theoretical framework, case study 'Baltic SECA' secondary data analysis, interviews analysis and within the specific case study 'LNG stakeholders Seminar' content analysis.

Firstly, a few insights are to be imposed in relation to the findings of this study.

Namely, that the intent of this study was to explore how LNG bunkering facilities should be settled and operated in order to create a proper bunkering environment in Baltic SECA. In focus are the medium and small-scale LNG facilities that prove to be the appropriate solution in serving the bunkering needs of the maritime customers.

Further, the exploration regarded patterns to be followed in order for these facilities to pass the incipiency stage of LNG bunker market and evolve to a functional bunker market with a similar structure as compared to the conventional marine fuels.

The exploratory nature has been purposively selected to suit the need of exploration of a precarious distribution network that needs:

a) *Infrastructure planning*
b) *Market analysis*
c) *Logistics support functions*
d) *Supply chain perspectives on the distribution*
e) *A proper analytical framework to support decision making*

Other insights to be imposed relate to the findings possibly confining to Baltic SECA (further to be addressed as limitations of this study) and to the exploratory studies' collateral facet implying uncertainty upon the outcome.

An interesting aspect of this study relates to the actual context of SOx limit enforcement which brought the determination of various stakeholders in tackling the issues by acting on different fronts of the industry. This has provided the possibility to understand shortcomings through multiple frames.

The structure of the discussion encompasses 4 sections:

1. An analytical framework of the Baltic SECA LNG bunkering environment that answers the open-ended exploratory research question 1;
2. Defining enablers and barriers for Baltic SECA bunkering infrastructure expansion, that answers the open-ended exploratory research question 2;
3. Defining logistical implications and supply chain perspectives for LNG distribution among medium and small-scale facilities to support transition from incipiency stage of LNG bunker market to maturity stage, an answer to the open-ended exploratory question 3;
4. Cost effective integration of LNG medium and small-scale bunkering facilities within marine bunker fuel markets. A framework for the concepts emerged.

5.1 An analytical framework of the Baltic SECA LNG bunkering environment

In order to answer research question 1, the main LNG establishments of Baltic SECA have been regarded, along with the pre-investment planning processes. The findings have provided an analytical framework to facilitate understanding of the fundamentals related to the settlement of LNG bunkering environments in Baltic SECA.

Thus, the analysis has provided *key activities that support the development of LNG bunkering infrastructure* in line with the prerequisite of meeting the small and medium demand:

Condition assessment- a substantive step prior to infrastructure planning processes, represents an important contribution in depicting baseline conditions for a potential LNG bunkering location. Confirmed by infrastructure planning theories addressed in the theoretical framework, the condition assessment displays a potential input for consideration in mapping the contextual conditions in accordance with their potential to support the bunkering environment.
Location choice effectiveness **-**identifies as a key activity to set for strategic positioning and optimization of the surroundings of a LNG establishment. The analysis of this activity indicated a few parameters to ascertain effectiveness: *interaction with other activities in the vicinity* which discerns significant when for example the chosen location is a maritime port performing various activities; *potential for optimization of the surroundings* relates to the specific advantages rendered by the location with reference to the potentiality of bunkering modes customization to serve a larger maritime customer base, possibility to attract more marine traffic, etc.

*Predictive models of structures for layout configuration***,** represents another relevant input for an appropriate development of a LNG bunkering environment. It serves in an opportune manner the settlement of a right layout for the bunkering facilities by means of advance planning for physical arrangement of the assets. Variables such as existing assets, appropriate size and capacities, location of every component in the layout, description of the component, identification of lacking components provide input to the layout configuration phase. The specific application in LNG bunkering layouts imposes for physical arrangement and adjustments in line with the number of vessels calling at the respective location, volumes and frequencies of refuelling, modes of bunkering in demand, etc.

Another key activity towards LNG bunkering infrastructure development is reflected *by interim strategies to counteract transient changes***,** which confirms findings from the previous study**-** North European Infrastructure Project (Danish Maritime Authority, 2012). It outlines the need for flexibility within LNG establishments that face high level of uncertainty.
The concept of 'intermediary layouts' that may be implemented in the first phase of LNG infrastructure development in order to allow future changes confirms the findings of the study 'LNG as bunker fuel: Challenges to be overcome' (Semolinos, 2013). The practical application can be exemplified through the analysis of data derived from Aarhus port LNG project, which opted for an arrangement that can be established segment by segment while following the market evolution.

Cost- effectiveness of LNG infrastructure establishment can serve as an input for development of LNG infrastructure by virtue of examining all possibilities towards choosing one that serves the main objective in the best way. The analytical framework of cost-effectiveness in this case encompasses cost information (listing of costs by category) combined with the measures of effectiveness attributable to the specific context. Because, numerous LNG infrastructure projects are subject to budgetary constraints, the cost-effectiveness analytical tool can evaluate the most cost-effective LNG establishment worth to be validated in relation to the budget constraint.
LNG infrastructure synergetic linking to industrial and energy customer, constitutes a potential input to the LNG bunkering infrastructure development that has emerged from the findings in relation to Port of Turku's attempts to optimize the surroundings by means of synergetic linking to industrial and energy sector customers. Inductive reasoning has provided for the emergence of a new concept - *diversification of customer base* by means of capitalizing upon synergies created by links to areas beyond maritime sector.
Another key activity to support the development of LNG bunkering infrastructure derived from findings related to *commercial viability and functionality of the LNG distribution network. Commercial viability* can be reckoned by means of quantitative evaluations for the capital committed to the infrastructure and implies consideration for LNG market evolution with reference to market structure and competitive forces depicted in the theoretical framework of this study. Commercial viability of the infrastructure project is to be associated with the potentiality of the respective project to serve adequately the LNG distribution. Therefore, planning the establishment of LNG facilities shall presume an appropriate LNG flow in the sense that it, also, provides the required availability.
LNG bunkering infrastructure development is supported by the activity of *cross-functional, process-based collaboration between project partners.* The reasoning relates to the findings upon port of Turku planning phase coordination processes among implicated parties and confirms the theoretical position on collaborative partnerships leveraging capabilities.
Associative to the afore-stated topic is another key activity displaying *proactive dialogue with implicated stakeholders* apt to support the LNG infrastructure development. It relates to sub-activities such as sharing information, alerting problems, striving to improve performance.

Extension of physical boundaries for LNG distribution has emerged as an option for alternative use of a projected LNG establishment and is deemed to support the LNG infrastructure development. The activity relates to the concept of diversification of customer base by extending physical boundaries of a regional market confronted with low demand. Confirmatory in this sense is the LNG import terminal to be established in Tallinn, Estonia area.

In order for this project to succeed in extending physical boundaries for LNG distribution, it shall consider logistics support functions, with reference to logistics place utility processes confirmed by theoretical positions discussed in the theoretical framework.

As a matter of supporting the LNG infrastructure development in Baltic SECA, findings in relation to facilitating factors for the transition to LNG bunkering are further addressed in accordance with results derived from interview data analysis.

Facilitating factors for the transition to LNG bunkering in Baltic SECA	**Key topics/areas identified**
Strict enforcement on SOx limits	Establishment of settings for the different compliant technologies.
The price of LNG vs. MGO vs. HFO	Competitive edges rendered
Safety regulations and standards for LNG bunkering in ports	Settlement of safe and reliable bunkering environment
CAPEX for LNG powered ships vs. MGO and NOx catalyst vs. HFO, SOx scrubber and NOx catalyst.	Reference to: *-Age of the vessel; - Net present value-Financing Terms; -Expected payback time; -Rate of exposure to SECAs; -Trading patters; -Fleet structure for companies owning/operating more ships; -Suitability to the ship-owner/operator's business model*
Difference between retail and wholesale LNG prices	LNG distribution costs and Value chain costs
Support Schemes	Schemes applicable to ship-owners Schemes applicable to infrastructure developers

Figure 21: Facilitating factors for the transition to LNG bunkering. Key topics/areas identified (author's own work).

In accordance with the data analysis results, we may build *the profile of Baltic SECA LNG infrastructure potential maritime customers*: ship-owner /operator trading mostly in SECA, thus subject to SOx regulation, adopts the compliant LNG fuel convinced in connection with the competitive edge rendered, operational safe handling standards, and in connection with the availability of bunker LNG and uses a business model that allows changing bunkering patterns. The segment of shipping fitting the above depicted profile may refer to *ferries and coastal trading vessels of Baltic Sea with a trading pattern 'A to B and back to A'*.

5.2 Defining enablers and barriers for Baltic SECA bunkering infrastructure expansion

Findings devolved from the case study 'LNG stakeholders Seminar' represent a high potential of validation due to the fact that they are grounded in actual and expert knowledge evolved in a cross-domain context.

The devised enablers for Baltic SECA bunkering infrastructure expansion are further presented and explained:

Enabler for Baltic SECA bunkering infrastructure expansion	Explanation
Baltic Port Organization initiative to support LNG bunkering infrastructure	A measure to develop operational ships bunkering installations in ports. Addresses innovation and deployment of necessary infrastructure for LNG bunkering facilities
LNG Pilot Action, part of the Joint Industry Project, to facilitate the transition phase for deployment through the associated infrastructure	An initiative to provide physical assets necessary to operate an effective bunkering environment in Baltic SECA
Comprehensive planning for bunkering facilities	Building LNG availability in line with the required elements to serve effectively the distribution
Satisfactory availability	Building a level of LNG availability by means of necessary facilities to guarantee bunkering services to ship-owners. Shifting from dedicated parties with integrated distribution networks to third parties access allows for complementing the distribution network and provides for more availability and affordability of bunker LNG.
Reasonably priced bunker LNG	Affordability and competitiveness in relation to alternative fuels

Safety and bunkering procedures standards	Rigorous development of necessary standards to guarantee safe and efficient handling
Expanding customer base beyond maritime sector	Synergetic link to industrial and energy sector to increase revenues for bunkering facilities

Figure 22: Defining enablers for Baltic SECA bunkering infrastructure expansion (author's own work).

The stated enablers associate and validate by means of infrastructure planning theories, market competition theories discussed in the theoretical framework and confirm the findings of the study North European Infrastructure Project (Danish Maritime Authority, 2012).
Findings deriving from the analysis of barriers for Baltic SECA LNG bunkering infrastructure expansion encompass the following identified elements:

Barriers for Baltic SECA bunkering infrastructure expansion	**Explanation**
Price Evolution for LNG marine fuel	The uncertainty in relation to price levels
Financial risks associated to investments in bunkering facilities	The incipiency of LNG bunker market bears considerable financial risks. In addition to that, the Internal Rate of Return for the Capital Employed is squeezed to the level that allows LNG marine fuel to be competitive in relation to the alternatives
Lack of bunkering compatibility and compliance to safety guidelines	Insufficient standards for bunkering procedures causing ship-owners' non reliance on the LNG bunkering environment

Figure 23: Defining barriers for Baltic SECA bunkering infrastructure expansion (author's own work).

5.3 Defining logistical implications and supply chain perspectives for LNG distribution

Findings deriving from interview data analysis outlined that in a context of a rapid implementation of a LNG refuelling network to support deployment of the LNG compliant fuel, *logistics is a necessary function to uphold the efforts.*

Medium and small-scale facilities represent a solution to develop the LNG bunkering environments to effectively serve the maritime customers. As mentioned before in the study, medium and small-scale facilities complement the distribution network of LNG and therefore increase the fuel availability.

But, due to the fact that operations of medium and small-scale bunkering relate to a different level of magnitude/capacities, *break-bulking* is a necessity in order to refill these facilities. Therefore, medium and small-scale facilities act as retailing establishments.

As a consequence, undertakings as replenishment scheduling to allow sufficient lead time before stock-outs, forecasting of demand and transportation are processes to be implemented in accordance with their primary purposes.

Theoretical positions discussed in the theoretical framework display that viewing logistics in the context of a supply chain or demand chain linking all the participants (from vendor's vendor to customer's customer) presupposes distinguishing all the logistics systems with their particular coordination processes.

With reference to the former argumentation the *holistic, supply chain view upon various logistics systems* provides for a better sight on areas to be optimized towards a better flow of goods and information.

For LNG stakeholders operating entire LNG supply chains, the former arguments set out the possibility to structure the supply chain in accordance with market signals and perform strategic planning over the next several years.

Findings derived from the interview data analysis display that *availability of break-bulk facilities at the large terminals* is an important factor to support a proper LNG flow towards bunkering locations. Early breaking-bulk allows for more fluidity and flexibility in the distribution of LNG. *Availability of LNG medium and small-scale receiving facilities in ports* provide for settlement of proper bunkering environments to serve the maritime use.

Logistical implications, herein, may create utility by means of capacities adjustments, settlement for appropriate transportation modes between facilities and appropriate flow of information.

Nevertheless, in connection with intensive/recurrent break-bulking, the analysis of data has identified *the risk of increase in value chain costs*. Coordination processes would also be more demanding as a consequence.

An important recommendation has emerged from data analysis to regard break-bulking processes. It claims the need for a professional approach to the logistical implications, in the sense that, it implies competent engineering of logistical systems to properly support break-bulking processes.

As a conclusive reasoning at this stage, complementing the LNG infrastructure network with more medium and small LNG facilities, by means of displacing proven technology from large scale to a more reduced level of capacities, supports the distribution of LNG towards the bunkering locations. Therefore, a properly meshed up distribution network with appropriate logistics support may provide for means to facilitate transition from incipiency stage of LNG bunker market to an intermediary stage.

5.4 Cost-effective integration of LNG medium and small-scale bunkering facilities within marine bunker fuel markets. A framework for the concepts emerged

Affirmable at this point in the study becomes the fact that in order for the LNG market to outrun the incipiency stage, more LNG infrastructure that is able to capture more of the capacities has to be established. For the purpose of increasing availability for maritime customers, the patterns to be followed suggest complementing/meshing up the LNG distribution network with more facilities that operate smaller-scale capacities.

Thus, the respective facilities can generate proper bunkering environments that would allow ship-owners to plan the bunker sources in advance.

The inference of 'Integrating' the bunkering environments within marine bunker markets has been pointed out by the title of this study. For a better conceptual distinction 'Integrating' medium and small-scale LNG bunkering facilities manifest for the inclusion of the respective facilities and their environments in the marine bunker markets.

Reference to the patterns of functionality of the conventional fuels market has been made throughout the study. The rationale is for these patterns to serve as a model to be followed. The mentioned model, once combined with the specificities of the LNG technology, may potentially facilitate joining the marine bunker industry.

The findings, so far, indicated that precariousness of the LNG distribution may be solved by proper infrastructure planning, market analysis, logistics support and a supply chain perspective.

Most of the LNG infrastructure initiatives imply, on one hand policy decisions, budgetary constraints, subsidies schemes, and on the other hand potential private partnerships among various stakeholders characterized by still a non-definitive structure and uncertain levels of motivation in relation to funds to be committed.

The afore-stated circumstances proved insightful to the author of this study. Consequently, consideration has been given to the application of the cost-effectiveness analytical tool, which potentially provides for an analytical framework to support decision making in relation to the LNG bunkering infrastructure settlement. The benefits manifest by means of facilitating a better sight on the outcomes of chosen courses of action meant to achieve specific objectives as contrasted to the associated costs. An important observation is that the worthiness of the decision is not to be expressed in absolute terms.

Also, this study has not considered any specific LNG facility establishment evaluation, therefore, the comprehensiveness of the associated costs has been deemed outside the scope of exploration.

The emphasis being on how the LNG market can develop from incipiency stage and solve the issue of distribution precariousness, the analytical framework is proposed because it gives freedom in choosing the course of action that reaches the objective in the most parsimonious manner.

The illustration of several cost effective measures in accordance with predetermined objectives for LNG infrastructure establishments:

Objectives:	Proposals to measure effectiveness:	
Increase LNG-fuel availability	Freedom to choose actions that allows reaching the objective in the most parsimonious manner	Increase in ship-owners interest for bunker LNG
Create a competitive environment for LNG as marine fuel		Increase in LNG affordability
Increase accessibility to the bunkering infrastructure for LNG powered vessels		Decrease in Time and Complexity for Bunkering procedures
Provide Bunkering Safety Standards		Increase in Ship-owners/operators' reliance on technical compliance and safe bunkering environment
Use logistics as a function to support LNG distribution		Increase in economic value and utility (by means of moving production/storage surplus to higher demand locations)
Create synergies with industrial and energy sector clients		Increase in customer base and Increase of lucrative revenues
Decrease of LNG Value Chain Costs		Increase of LNG competiveness as a result of reducing the distance between wholesale vs. retail price
Contract terms similar to the conventional fuel bunker contracts		Increase of liquidity in the LNG bunker market

Figure 24: Objectives and effectiveness measures for LNG infrastructure establishments (author's own work).

Essential considerations, herein, prescribe for addressing the same indicators for the effectiveness framework, and the same predetermined objectives, concomitantly enjoying the freedom of choice for the courses of actions.

This technique is deemed to envisage more of the magnitude of the relative effects as opposed to the associated costs.

For exemplification 2 objectives from the figure above (see figure 24) will be considered.

1. The objective: '*Create a competitive environment for LNG as marine fuel'*, implies considerable policy decision. In order to meet this objective, the course of action towards validation will have to consider the budgetary constraints and the measures of effectiveness.

   The author suggests a scenario to meet the above stated objective as a matter of reference for the proposed analytical framework.

   Thus for the objective: 'Create a competitive environment for LNG as marine fuel', the indicator for effectiveness is deemed to be 'Increase in LNG affordability'. A possible course of action would be: 'Third party access to LNG' terminals.
2. For the objective: *'Contract terms similar to the conventional fuel bunker contracts'***,** the indicator for effectiveness is deemed to be **'**Increase of liquidity in the LNG bunker market'.

   In terms of possible courses for action, the author has considered to apply 'Gap analysis' an adaption from Operations Management (2007):

Gap	**Actions to reach similar terms for LNG bunker contracts as compared to conventional fuel bunker contracts**	**Action by:**
Gap 1	More transparent pricing	LNG suppliers/distributors
Gap 2	Allow for flexibility in making adjustments to the contract	LNG Terminals/Bunkering facilities
Gap 3	Negotiate duration to fit ship-owners needs	LNG suppliers/distributors and ship-owners' mutual efforts
Gap 4	Decrease lead time needed to negotiate and sign an LNG SPA	LNG suppliers/distributors and ship-owners' mutual efforts
Gap 5	Offer price levels reflecting spot market link	LNG suppliers/distributors

Figure 25: Gap analysis for LNG bunker commercial contracts (adaption from Operations Management, 2007).

6. General conclusions

Although this research had initially intended to explore the conditions that allow the LNG bunker market to outrun the incipiency stage of evolution, the current issues of the LNG bunker industry have quickly indicated the comprehensiveness one shall address in order to correctly grasp the shortcomings.
Therefore, in order for the findings to substantiate in a research of this nature, the context of a SECA seemed to be a reasonable choice.
The exploration of deployment of LNG bunker infrastructure, thus, has confined to Baltic SECA, with a frame of reference built by means of addressing three research questions. The research questions have demonstrated the potential to tackle various aspects relating to the LNG deficient bunkering infrastructure of Baltic SECA.

6.1 Theoretical implications

Existing theoretical positions encompass a fairly large base for possible reference nevertheless the choice has deemed the potentiality of the findings to generalize to the theory (Mitchell, 1983). Due to the qualitative nature of this research, the theoretical reasoning proved relevant in relation to the possibility of generalizability.
In order for the LNG infrastructure to support a proper distribution towards bunkering locations, the inference of knowledge from infrastructure planning, market forces/competitive environments, logistics and supply chain has proved to allow the findings to confirm in relation to the deemed theoretical framework.
The findings have confirmed and also expanded the limits of theoretical positions.
Thus, in terms of infrastructure planning, the contribution relates to the key activities identified that may opportunely serve as an input for LNG establishment projects. The findings confirming logistics theories may provide for increase in utility for processes as LNG break-bulking and extension of physical boundaries of a market facing a low demand.

Findings in relation to third party access to the LNG facilities validate through market theories explaining competition and shifts in bargaining power among participants and display the contribution towards a better understanding of the LNG market.
The supply chain theories are confirmed in relation to the findings that adequate coordination processes among stakeholders in a LNG supply chain provide for leverage of capabilities.
The cost-effectiveness analytical framework emerged within this study displayed the potential to support decision making in relation to LNG bunkering infrastructure

establishment. The application of this identified tool may support various other decisions with reference to follow prescriptions in setting objectives and in addressing indicators for effectiveness.

6.2 Practical implications

The study can contribute to a more conscious decision in choosing the inputs for LNG settlements in order to properly support the LNG distribution network and create adequate bunkering environments.

It brings insights on how to complement the bunkering environment with the requisite elements in order to increase availability of LNG as marine fuel.

It also furnishes explanations on how to handle medium and small-scale LNG capacities in order to avoid bottlenecks in LNG distribution by means of considering the logistical implications.

The findings also may provide insights to the investors in LNG facilities on how to capitalize upon synergetic links to customers outside maritime domain. By increasing customer base, a more profitable utilization of the assets to which considerable capital has been committed becomes possible.

The study also purveyed insights in connection with the level of liquidity in the LNG bunker market that can be increased by means of contract terms modifications.

It, also, has interposed the cost-effectiveness analytical tool that can be used in relation to LNG bunkering infrastructure settlement, in the way that it helps setting and prioritizing objectives, evaluate the relative costs and give proper consideration for the measures of effectiveness.

And, at last, it provides an understanding of the conditions that allow Liquefied Natural Gas bunker market to outrun the incipiency phase.

6.3 Limitations and suggestions for future studies

Limitations of this study regard the eventuality that some of the findings confine only to Baltic SECA.

Also, the findings in connection with the inputs to the LNG establishment might not be satisfyingly comprehensive and some other inputs may be further identified.

In relation to the cost-effectiveness analytical framework, the study has not considered a specific example of a LNG establishment project for which to perform the extensive listing of associated costs. Therefore the analytical tool is displayed and explained rather as a conceptual construct. Also, the study has not considered to calculate exact margins for investments in bunkering facilities to explain the commercial viability of particular cases, as in focus was the issue of infrastructure's incipiency that causes LNG distribution precariousness.

As for future research, the author recommends more focus on industry safety standards settlement and the practical application, more focus on how the spot link of the LNG prices evolves and manifests in the LNG bunker markets.
Another recommendation would emphasize the competency in the area of LNG technology and LNG bunkering processes, as the growing number of individuals involved in handling LNG technology raises issues of training and safety.
With respect to adjacent areas for research, worthwhile might prove to thoroughly consider the alliances and partnerships among LNG stakeholders and the topic of diversification of LNG facilities customer base.

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APPENDICES:

Appendix 1: Interview guide

Integral to the completion of studies program -Master in Maritime Management, at University College Buskerud and Vestfold, I will conduct a research project with the topic: **’Cost effective integration of LNG medium and small-scale bunkering facilities within marine bunker fuel markets’. The focus area is Baltic SECA’.**

The main question this project aims to answer is: **How should the LNG marine bunkering infrastructure develop in order to effectively meet the small and medium scale demand in Baltic SECA?**

The research, also, explores logistical implications, supply chain perspectives, market forces and the cost-effectiveness approach to the establishment of bunkering facilities and their transition from incipiency stage towards a fully functional bunkering environment.

By exploring the configuration of LNG bunkering infrastructure in Baltic Sea region and by addressing the issues of LNG availability, accessibility and affordability, the potential findings may shed light on several functional patterns worthwhile for consideration.

More environmentally friendly LNG powered vessels trading in the area has been displayed as a desideratum addressed by the mainstream European Commission policies. The aforementioned rationale constitutes the motivation of conducting this research.

The following questions will contribute to answer the aforementioned research question and successfully attain the nominated goal:

1) Please rank (and explain your choice) for the following elements, by degree of importance in facilitating the transition towards LNG bunkering in the Baltic ECA area:

a) strict enforcement of IMO regulations for SOx (2015) and NOx (2016)

b) wholesale price of LNG vs. MGO vs. HFO

c) (for newbuilds) CAPEX of LNG ships vs. ships with MGO and NOx catalyst vs. ships with HFO, SOx scrubber and NOx catalyst

d) support schemes (fuel taxation for energy content/ emissions, voluntary schemes such as the NOx-fund) for choosing LNG instead of other fuels

e) safety regulations and standards for LNG bunkering in ports, including with passenger on-board

f) availability of LNG infrastructure for distribution to and bunkering in the main ports

g) difference between retail and wholesale LNG prices (i.e. cost of small-scale LNG distribution and value chain)

2. Focusing now on the distribution chain for LNG, from a large export/ import terminal to the bunkering location, what are the main bottlenecks for LNG bunkering of ships today? Again, rank and explain your choice:

a) Availability and cost of break-bulk facilities at the large LNG terminals and competition between them

b) Availability and cost of LNG capacity and slots at the break-bulk facilities

c) Availability and cost of small-scale LNG tanker ships/ trucks, to distribute LNG from the main terminals to smaller ones

d) Availability and cost of small-scale LNG receiving terminals in the main ports of the Baltic Sea, and bunkering terminals, connected to these

e) Regulations for LNG bunkering (including with passengers on-board) compared to regular bunkering and additional cost due to such regulations

3. To what extent are the current LNG bunker sales and purchase contracts supporting/ slowing down adoption of LNG as bunker fuel? Which elements in these contracts count mostly?

a) price level for the LNG - too high and close to the price of alternatives

b) price indexation mechanism for the LNG - spot gas price, or indexation to MGO/ HFO prices?

c) cost of small-scale LNG distribution chain, difference between price of retail and wholesale LNG?

d) contract duration and flexibility in making adjustments along the way?

e) lead time needed to negotiate and sign an LNG SPA, and standardisation of such contracts

4. Ship type and trade pattern influence the bunker contracting option. With this in mind, how would the LNG bunkering infrastructure have to develop from its infancy stage, via an intermediary stage and up to maturity and similar structure as compared to oil product bunkering markets? Describe briefly your vision for how elements a) to e) in question 2) would have to evolve concomitantly in order to secure a rapid scaling up of LNG bunkering in the Baltic Sea.

Thank you for your help!

Ludmila Patrascu

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Appendix 2: Consent Statement

Consent Statement

Dear respondent,

Integral to the completion of studies program -Master in Maritime Management, at University College Buskerud and Vestfold, I will conduct a research project with the topic: **'Cost effective integration of LNG medium and small-scale bunkering facilities within marine bunker fuel markets'. The focus area is Baltic SECA'.**

The main question this project aims to answer is: **How should the LNG marine bunkering infrastructure develop in order to effectively meet the small and medium scale demand in Baltic SECA?**

The research, also, explores logistical implications, supply chain perspectives, market forces and the cost-effectiveness approach to the establishment of bunkering facilities and their transition from incipiency stage towards a fully functional bunkering environment.

By exploring the configuration of LNG bunkering infrastructure in Baltic Sea region and by addressing the issues of LNG availability, accessibility and affordability, the potential findings may shed light on several functional patterns worthwhile for consideration.

More environmentally friendly LNG powered vessels trading in the area has been displayed as a desideratum addressed by the mainstream European Commission policies. The aforementioned rationale constitutes the motivation of conducting this research.

Thank you very much for agreeing to participate in this survey.

The information provided by you by means of the recorded open-ended answers and by means of ticking the appropriate answers for the pre-coded question will be used only for research purposes. It will not be used in a manner that would allow for the identification of your individual responses.

Respondents are assured of full anonymity, and that data obtained through the research process will not in any way be traced back to them.

Respectfully,

Ludmila Patrascu

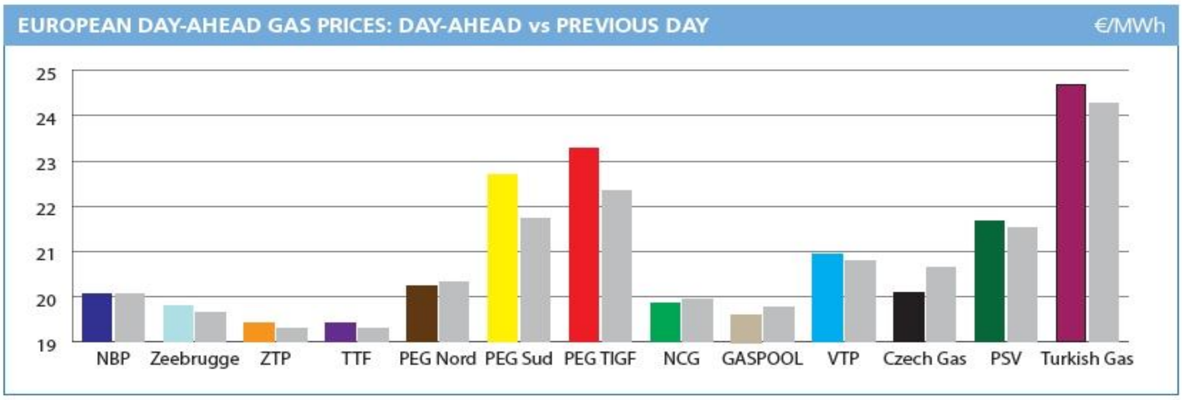
Email: Ludmila.Patrascu@student.hive.no
Tel: 928 090 55

Appendix 3: Spot Gas Markets

HEREN® MONTHLY CUMULATIVE INDICES MAY 14	
NBP, p/th	49.169
Zeebrugge, p/th	49.216
TTF, €/MWh	20.213
PEG Nord, €/MWh	20.355
NCG, €/MWh	20.516
GASPOOL, €/MWh	20.628
VTP, €/MWh	20.922
PSV, €/MWh	21.813

HEREN® DAILY INDICES 4 APRIL 2014	
NBP Within-day, p/th	48.123
NBP D-1, p/th	48.062
Zeebrugge D-1, p/th	46.833
TTF D-1, €/MWh	19.291
PEG Nord D-1, €/MWh	19.809
PEG Sud D-1, €MWh	22.922
NCG D-1, €/MWh	19.758
GASPOOL D-1, €/MWh	19.663
VTP D-1, €/MWh	20.676

Spot gas Markets: ESGM 20.067 | 4 April 2014 | Source: ICIS, London, UK



Spot gas Markets: ESGM 20.067 | 4 April 2014 | Source: ICIS, London, UK

Appendix 4: LNG facilities

Location	Type	Size (m^3)	Owner-ship	Status	Present/decided and possible future delivery capabilities
Fredriksstad/Øra, Norway	Closed	6 400	Skangass	In operation	Local gas grid and redistribution by truck.
Nynäshamn, Sweden	Closed	20 000	AGA	In operation	Redistribution by truck and pipeline.
Lysekil/Brofjorden, Sweden	Closed	30 000	Skangass	Under construction	Local gas delivery to refinery and redistribution by truck. Maritime redistribution by bunker barge. Planned operation by Q2 2014.
Świnoujście, Poland	Open	320 000	Polskie LNG	Under construction	European gas grid and redistribution by truck. Maritime as well as rail based redistribution and bunkering is under discussion. Planned to be operational by December 2014.
Klaipeda, Lithuania	TBD	170 000	Klaipedos Nafta	Under construction	FRSU unit designed to connect to the local gas grid. Planned to be operational by December 2014.
Regional terminal, Gulf of Finland	TBD	300 000	TBD	Under discussion	Regional terminal for the Baltic energy market area located in either Finland (Inkoo) or Estonia (Paldiski).
Tallin Muuga, Estonia	Open	TBD	VOPAK/Elering	Under discussion	Local gas hub in the first phase, regional open access hub in the second phase.
Pori, Finland	TBD	30 000	Gasum	Under discussion	Regional terminal dedicated to the Finnish gas market with planned truck distribution. Planned operation in 2016.
Turku, Finland	TBD	30 000	Gasum	Under discussion	Terminal with pipeline distribution in the Turku area, truck loading facilities and loadning and unloading via existing jetty. Planned to be in operation by 2017.
Tornio, Finland	Closed	50 000	ManGa LNG	Under discussion	Terminal mainly for industrial use. Unloading to trucks and vessels under discussion. Planned operation by 2017.
Gävle, Sweden	TBD	30 000	Skangass	Under discussion	Terminal with loading and unloading of LNG to vessels as well as unloading of LNG to trucks are discussed. For the future, train unloading is discussed.
Gävle, Sweden	TBD	TBD	Swedegas	Under discussion	Terminal in Gävle, potenially with a connected gas pipeline infrastructure.
Gothenburg, Sweden	Open	30 000	VOPAK LNG/Swedegas	Under discussion	Redistribution by truck and through a connection to Swe/Dan Gas Grid as well as bunkering is under discussion. EIA process is ongoing.
Malmö, Sweden	TBD	10 000	TBD	Under discussion	Redistribution by truck and train and through the Swe/Dan Gas grid as well as bunkering is under discussion.
Helsingborg, Sweden	TBD	<15 000	TBD	Under discussion	Redistribution by truck, train, maritime and through local gas grid as well as bunkering is under discussion

SSPA Sweden AB, 2014