



LNG in Baltic Sea Ports II

LNG Handbook



LNG in Baltic Sea Ports II **Partners**



LNG Handbook II, based on experiences from the project “LNG in Baltic Sea ports II”.

The Handbook is part of the project LNG in Baltic Sea Ports II. The Handbook is based on the experiences gained from the participating ports in the project, as well as other ports in the area with experience from planning, designing and establishing LNG terminals and LNG as ship fuel.

The Handbook has been produced by SSPA Sweden AB in cooperation with Motus Foundation.

Summary and recommendations

One of the main purposes of the project LNG in Baltic Sea ports II is to continue elaborating good solutions and manageable ways of developing LNG supply in ports, and disseminating the results is an important part of the project objective. The ports that have participated in the project have all gained a lot of experiences, which are summarized in this handbook, together with general recommendations for design and establishment of LNG. The purpose is to support further elaboration of LNG supply, and design and development of LNG terminals.

The cost of bunkers is one of the main cost components when operating vessels. Today, in principle, all vessels use the same fuels delivered through the same competitive and transparent supply market. This implies that the risk related to fuel cost is limited since it is unlikely that any competitor will be able to reduce the cost of fuel significantly. The introduction of LNG in the fuel mix changes this situation dramatically since the pricing mechanism and supply cost is still unknown and the market for LNG as marine fuel is a long way from being as competitive and transparent as the present fuel market. Before a ship-owner is prepared to change from the present fuels to an alternative fuel such as LNG, he must be convinced that he will be able to get the fuel where he needs it to a price level that gives him an equal or lower overall cost than his competitors.

For most of the different consumer types, the key question is not what the exact price of LNG will be in the future. Instead it is the comparative price to the main alternative that is the most important aspect.

Several projects have contributed to the development of LNG infrastructure in the Baltic Sea Region. There are several terminals in operation, while most of them are in the planning phase.

It is obvious that several of the ports participating in the project LNG in Baltic Sea Ports (both I and II) have come quite far in the planning and implementation of LNG introduction. Other ports in the Baltic Sea area are also preparing for an LNG introduction, by planning for, designing and building terminals.

One of the conclusions that can be made is that further development is now dependent on the price development of LNG, and its connection to the oil price. This has a major impact on the attractiveness of LNG on the market, and thus on the rate of development of LNG terminals.

The support given by EU has constituted the spark for many ports, giving the initial financial support needed to start the process.

When planning and constructing an LNG terminal, there are several steps that need to be taken and fulfilled in order to build and operate a successful terminal. The basis of the terminal is an idea

or a plan. This plan must be based in realistic figures in terms of demand and supply, and an early feasibility study is often the first step of the planning phase. This feasibility study is the first decision support document, focusing on the financial viability of the project, and this results in either a decision to go ahead, or to stop the plans. The feasibility study usually includes the facts regarding the demand for LNG, makes future prognosis, and predicts the necessary volumes and technical equipment needed. In the next step of the planning phase, other decision support documents need to be elaborated. This includes the technical background documents, analyses of relevant and necessary regulations and permits needed etc. A risk assessment is necessary for receiving permits for construction, and is often set as a demand by relevant authorities. Once the decision is taken to invest in the terminal, and the technical feasibility is shown, the technical design and organizational set-up must be initiated. The technical design gives a layout of the terminal area, and is complemented by a technical description, giving all necessary technical details needed for the permit process. The choices that have to be made during the design process include:

- Location of the terminal, and deciding on proper preparations of the land area
- Size of the terminal or supply
- Type of tank/supply
- Volumes of the tank
- Distribution system for LNG supply; bunkering, truck filling stations, pipelines etc.
- Financial aspects and investment costs
- Safety measures and security aspects

There are several environmental benefits with LNG. Compared to other bunker fuels, LNG has a smaller pollutant characteristic and does not contaminate the local environment or water if spilled. However, if spilled, there are risk and safety issues to deal with. LNG hazards result mainly from the physical and chemical properties, cryogenic temperatures, dispersion characteristics, and flammability characteristics. If an LNG release occurs there is an immediate potential for a range of different outcomes and types of consequences. Of the identified LNG specific potential outcomes of an accidental release of LNG, fire scenarios are found to be the ones governing for necessary risk control measures including determination of safety distances and site selection for bunkering facilities and operations.

The permit process and the public consultation process when building an LNG terminal is controlled by several different laws and regulations. The Seveso Directive, an EU Directive introduced in 1999 to prevent and limit the consequences from serious accidents with dangerous goods, is the foremost basis for national legislation within this area. Activities that handle certain volumes of dangerous goods (in Sweden the limit is 50 tonnes of LNG, but less than 200) are eligible for reporting to relevant authorities according to the Seveso Directive. For activities that store or handle volumes larger than the limit (in Sweden 200 tonnes of LNG), a higher level of specific demands apply. Permits according to environmental legislation are needed, and a consultation process is included in this. Summarizing the possibilities and challenges, in different aspects, from gathered experiences through LNG related projects, shows that some issues connected to the design phase remain to deal with: There is still a need for more international standardization regarding LNG as ship fuel. Even though there is a lack in regulations that cover LNG, several international organisations are involved in the

process of improving LNG handling and operations ensuring safe bunkering operations.

Regarding technical aspects in the development of LNG terminals, concepts and systems are already available. However, the technical equipment could be further standardized, in order to facilitate the use for both ports and ships.

The existing LNG terminals have all undergone thorough risk assessments, and the risks connected to LNG are well identified. The permit process generally asks for a risk analysis and once the risks are identified, and possible risk mitigation measures are proposed, the permits are issued. Therefore, the issue of risk and safety does not constitute an obstacle for development, more of a mandatory step towards receiving a permit and continued development. However, training of staff is crucial for future development and handling of LNG without incidents.

To conclude, for ports that are about to start the process of establishing LNG bunkering operations, or planning for LNG supply in their port, the following steps are recommended:

- **Technical feasibility study:** First, a thorough feasibility study regarding the market potential for LNG supply in a port and its hinterlands should be made to determine needed volumes and from that different set-ups for LNG storage and sourcing can be suggested. As there is a significant scale of economy in handling of cryogenic gases such as LNG, it is valuable to determine the optimal storage types and suitable bunkering techniques.
- Secondly, a **financial overview** is suggested to establish the maturity of the project.
- Also important is a thorough **inventory of all relevant stakeholders and applicable regulations**.
- Thereafter a **Design Process** can be initiated to determine the needed installations.
- Identify the relevant laws and regulations that apply for **the permit process**, and in parallel to this a permit process should be initiated to accommodate for any needed alterations and ensure a smooth process.
- Commence a dialogue with the **relevant authorities** at an early stage. This could be both on local and on national level.
- During the design phase, involve **stakeholders** and possible financiers of the terminal.

Table of content

Summary and recommendations	3
1 INTRODUCTION	7
1.1 Background to the project	7
1.2 Background to the Handbook	7
1.3 Objective	7
1.4 Method	8
1.5 Outline of the handbook	8
2 LNG AVAILABILITY AND MARKET DEVELOPMENTS	9
2.1 Natural Gas production and availability	9
2.1.1 The shale gas revolution	10
2.2 The present and future LNG market	10
2.2.1 Comparative price of LNG	10
2.2.2 Sourcing cost of LNG	11
2.2.3 The cost of Boil Off Gas handling	11
2.2.4 The LNG value chain	12
2.2.5 Enablers and critical factors	12
2.2.6 Prognosis for LNG vessels	12
3 LNG IN THE BALTIC SEA, AN UPDATED OVERVIEW OF STATUS	13
3.1 Existing and planned terminals	13
4 DEVELOPMENT OF LNG TERMINALS	15
4.1 General procedure of planning, design and establishment	15
4.2 Designing LNG supply	16
4.2.1 Location of the terminal	16
4.2.2 Choosing type of supply: size, type and volume of terminal	16
4.2.3 Distribution system and technical equipment	16
4.2.4 Financial aspects and investment costs	16
4.2.5 Risk and safety	17
4.2.6 Security aspects and considerations	17
4.3 Relevant laws and regulations	17
5 EXPERIENCES FROM PARTICIPATING PORTS	19
5.1 Status in project ports	19
5.1.1 Helsingborg, Sweden	19
5.1.2 Trelleborg, Sweden	20
5.1.3 Sundsvall, Sweden	20
5.1.4 Rostock, Germany	20
5.1.5 Klaipeda, Lithuania	21
5.2 LNG training	21
5.3 Other ports	21
5.4 Conclusions of port experiences	24

6 CONCLUSIONS AND RECOMMENDATIONS	25
6.1 Possibilities	25
6.1.1 Regulations	25
6.1.2 Technical aspects	25
6.1.3 Risk and safety	25
6.2 Challenges	26
6.2.1 Regulations	26
6.2.2 Technical aspects	26
6.2.3 Financial aspects	26
6.2.4 Security aspects	26
6.2.5 Risk and safety	26
6.3 Conclusions of the permit process	26
6.4 Recommendations	26
7 REFERENCES AND SOURCES	29
7.1 Written sources, reports, documents etc	29
7.2 Other sources	30

1 Introduction

1.1 Background to the project

The project *LNG in Baltic Sea Ports II*, is a continuation of the LNG in Baltic Sea Ports I, a project initiated in order to handle new sulphur content limits in marine fuels especially sailing in ECA⁴ (Emission Control Areas). Both projects are partly financed by EU and the TEN-T Program.

With focus on LNG as a key solution, the aim is to foster a harmonised approach towards LNG bunker filling infrastructure in the affected area. In the first project, participating ports where: Stockholm, Helsinki, Turku, Tallinn, Copenhagen-Malmö, Aarhus and Helsingborg. Their individual projects have resulted in physical investments in port infrastructure and have helped to enabled LNG bunkering through feasibility studies on LNG terminals and bunker vessels, EIAs, project designs, safety manuals, regional markets studies etc. The project was concluded in an LNG Handbook, containing guidance from experiences gained, for other ports to use when planning to establish LNG terminals or other types of supply for the marine market.

The sequel, LNG in Baltic Sea Ports II, is to be seen as an extension of the first LNG project, and will contribute to achieving the results of the global project as part of the Motorways of the Sea program. However, in the second project, focus lays more on the design and implementation of different solutions. Participating ports in the LNG II project are: Trelleborg, Sundsvall, Rostock, Klaipeda, and Helsingborg.

1.2 Background to the Handbook

One of the main purposes of the project LNG in Baltic Sea Ports II is to continue elaborating good solutions and manageable ways of developing LNG supply in ports, and disseminating the results is an important part of the project objective. The ports that have participated in the project have all gained a lot of experiences, which are summarized in this handbook, together with general recommendations for design and establishment of LNG. The purpose is to support further elaboration of LNG supply, and design and development of LNG terminals.

1.3 Objective

Just as the handbook from the first LNG project, the objective of this handbook is to provide information, advice and recommendations based on project partner experiences, in order to facilitate the establishment of LNG as ship fuel in ports in the Baltic Sea area.

⁴ *Covering the Baltic, the North Sea and the English Channel.*

1.4 Method

The recommendations of the LNG Handbook II are mainly based on the results and findings of the LNG design projects in the participating BPO ports. Some other relevant experiences from ports in the Baltic Sea area are also included in the assessment.

1.5 Outline of the handbook

The handbook includes an updated description of the LNG status in the Baltic Sea Region, and the LNG market development in general. Thereafter, the handbook lists all the relevant experiences that have been gained during the project, and the possibilities and obstacles in the designing phase of LNG establishment. Conclusions of findings, and recommendations for future developments concludes the handbook.

2 LNG availability and market developments

This chapter describes the development of the LNG availability and market worldwide. Since this development also has implications for the availability and LNG market in the Baltic Sea Region, the description is included in the Handbook.

2.1 Natural Gas production and availability

During the last 10 years there has been a significant increase in the availability of natural gas at the international market. The main reason for this change has been a combination of new technical developments concerning the exploration of so called shale gas but also significant investments in new production and distribution facilities of traditional natural gas sources in Qatar, Iran, China, Norway, Saudi Arabia etc.

The total production of natural gas worldwide was almost 5,400 billion m³ or 3,900 million tons in 2013 and the total increase during the period from 2003 to 2013 was about 29% according to BP, 2015. During the same time period the annual production of crude oil only increased with 12%.

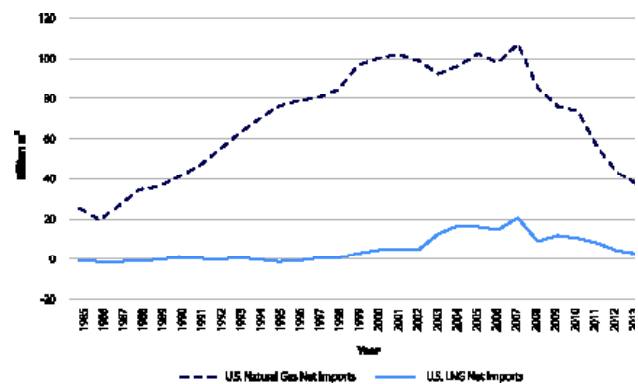


Figure 1 Total global Crude Oil and Natural Gas Production 1970-2013 (SOURCE BP, 2014)

During the last 10 years the distribution of the total natural gas production globally have undergone some rather significant changes. These changes are compiled in TABLE 1. Notable developments are the rise of especially China and Qatar as well as the relative decline of Russia.

Rank 2013	Country	Share of global prod. 2013	Rank 2008	Share of global prod. 2008	Rank 2003	Share of global prod. 2003	Trend
1	US	12,8%	2	11,2%	2	11,7%	↗
2	Russian Federation	11,2%	1	11,9%	1	12,1%	↘
3	Iran	3,1%	4	2,6%	6	1,8%	↗
4	Qatar	2,9%	9	1,5%	19	0,7%	↑
5	Canada	2,9%	3	3,5%	3	4,0%	↘
6	China	2,2%	8	1,6%	17	0,8%	↑
7	Norway	2,0%	5	2,0%	8	1,6%	↗
8	Saudi Arabia	1,9%	7	1,6%	9	1,3%	↗
9	Algeria	1,5%	6	1,7%	5	1,8%	↘
10	Indonesia	1,3%	10	1,4%	7	1,6%	↘
11	Malaysia	1,3%	14	1,3%	13	1,1%	→
12	Netherlands	1,3%	12	1,3%	10	1,3%	→
13	Turkmenistan	1,2%	13	1,3%	11	1,2%	↘
14	Mexico	1,1%	17	1,1%	15	0,9%	↗
15	Egypt	1,0%	16	1,2%	>20	0,7%	↗
16	United Arab Emirates	1,0%	18	1,0%	14	1,0%	→
17	Uzbekistan	1,0%	15	1,2%	12	1,1%	↘
18	Australia	0,8%	>20	0,8%	18	0,7%	→
19	Trinidad & Tobago	0,8%	20	0,8%	>20	0,6%	→
20	Thailand	0,8%	>20	0,6%	>20	0,5%	↗

Table 1 The main natural gas producers of the world (SOURCE BP, 2014)

2.1.1 The shale gas revolution

Shale gas is found in layers of flaky shale rock and cannot be extracted like normal gas. The existence of this gas has been known for a long time but it has not been possible to extract the gas from the shale rock in a commercially viable way. This changed in the last part of the first decade of the 21st century because of a combination in increasing prices and development of new extraction technologies called fracking. The extraction involves pumping huge amounts of water, mixed with chemicals, under high pressure into the layers of rock. The United States is in the forefront of the development of shale gas, a development that rapidly increasing their domestic production of natural gas. From being the world's

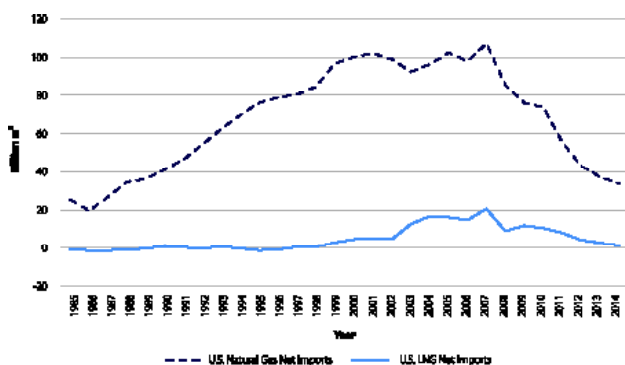


Figure 2 U.S. total (incl. LNG) natural gas net and LNG net imports 1985-2014 (SOURCE EIA, 2015)

biggest net importer of natural gas, U.S. are in the development of becoming a net exporter.

Since the US market has been one of the main import markets for LNG consisting of about 9% of the total market in 2007 the US shale gas development have had a significant impact on the trade of LNG. Shale gas is also available in other countries but the exploration of these resources is not as developed as in the US. China for instance is presumed to sit on even bigger shale gas reserves than the US and if these expectations actually materialize, it will have a significant impact on the natural gas and LNG markets since China during the last 5 year has gone from a natural gas exporter to becoming one of the largest natural gas importers in the world with a continuously growing natural gas consumption.

One clear dampening issue on the shale gas bonanza is that there are both environmental and health concerns of the exploration methods. Not much research has been done on the effects, long-term and short-term, of the procedures and chemicals. Besides that, compared to conventional gas extraction, more methane is discharged, which is a powerful greenhouse gas. These concerns have, among others, made France put a temporary ban on fracking since 2011.

2.2 The present and future LNG market

2.2.1 Comparative price of LNG

For most of the different consumer types, the key questions is not what the exact price of LNG will be in the future. Instead it

is the comparative price to the main alternative that is the most important aspect.

For most of the consumer types, oil based fuels are the main alternative but for some also other such as electricity, LPG, coal is a possibility.

The price of LNG primarily consists of two main components:

1. The cost of energy at the source
2. The cost of distribution from the source to the consumer

If taking a somewhat simplistic view, it is possible to assume that in relation to a specific consumer the cost of energy is related the general energy price development but the cost of distribution is fixed. A similar approach is possible make in relations to most energy types and the main difference between the different types of energy is the division of the total cost of delivered energy between the two cost components. For most oil based fuels it is the cost of energy which is the predominant component but for LNG the cost part related to the cost of distribution is significantly higher. The implication of this is that LNG usually is more competitive in an environment with high energy prices but have difficulties to become competitive when the general cost of energy is low. It is also important to understand that the proportional cost of distribution of LNG is higher for small consumers than for large. For some of the consumer groups, taxation also have a significant impact of the total cost of energy. Taxation may have a significant impact of the comparative competitiveness between different energy sources. Since taxation primarily is a political control measure on a national, regional or local level it is important to understand the political ambition in relation to different energy sources.

2.2.2 Sourcing cost of LNG

LNG production mainly takes place in Qatar, Algeria, Egypt, Indonesia, Malaysia, Australia, Trinidad and Tobago, Nigeria, United Arab Emirates, Oman, Libya, Brunei and the United States. Four of these countries (Indonesia, Malaysia, Qatar and Algeria) accounted for 60% of global LNG exports, see Figure below.

LNG deliveries has traditionally be contracted on long terms with the price usually related to a certain oil index such as Brent or JCC. Many of these contracts also include the transportation from the liquefaction plant to the import terminal. These types of contracts are still predominant but other means are gaining in popularity. The introduction of liquefaction plants connected to national and/or international gas grids in both Europe and the US have opened up for gas indexation pricing. Especially the US development will have a significant impact on the LNG supply market.

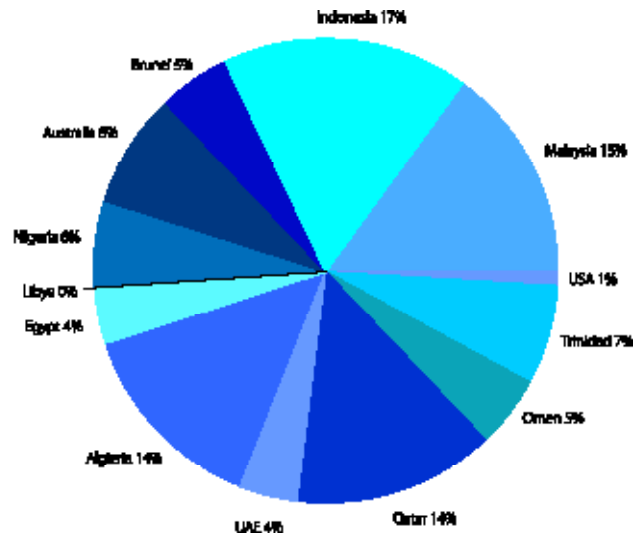


Figure 3 Global LNG exports (SOURCE: www.energytribune.com, 2015)

2.2.3 The cost of Boil Off Gas handling

When it comes to LNG distribution and the cost related to it, it is important to understand that LNG is perishable. Compared to oil, which basically keeps its value during storage, LNG loses value continuously during distribution. The reason for this is the cryogenic temperatures of LNG, continuously generating boil off gas (BOG). The handling of the BOG may be managed differently in different parts of the distribution chain depending on selected storage and transfer technology, time and available energy consumers. The main methods handling BOG is:

- Consumption
- Pressure increase
- Reliquefaction
- Flaring (hot)
- Flaring (cold)

Of these five methods the preferred method is consumption. The BOG is then used for production of energy in a form that is valuable in the vicinity of the BOG generation. This could be as fuel in a main engine of an LNG carrier or in a power plant, as heat, as raw material in an industrial process, or as feed gas to a gas grid. Cold flaring should, of environmental as well as commercial reasons, be avoided at any time. The other three are possible to use in different parts of a distribution chain but is all related to costs either in loss of valuable energy, costs related to operation and

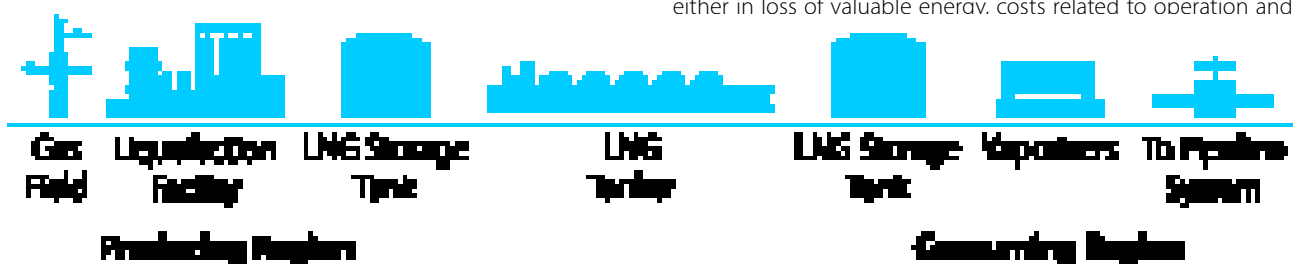


Figure 4 The LNG value chain

investments or a combination of both.

2.2.4 *The LNG value chain*

The LNG value chain from the producing region to the consuming region is shown in general in the figure below. The producing region contains the extraction of gas, the liquefaction of gas into LNG, and the storage of LNG at the production site. LNG is then transported by a large LNG carrier to the users. The consuming region includes the LNG storage tank, the vaporizers or the regasification process, and the distribution system to the end user.

The global market for LNG is in the middle of a rapid change moving from a stable predictable over regulated long-term market with few large players into a more fluent, diversified and deregulated market more similar to the global crude and oil product markets. The reason for this change is the rapid development of the availability of natural gas in some key markets in combination with significant change in demand in other markets. This has resulted in an LNG and natural gas market with significant regional price imbalances with market prices sometimes up to 4 times higher in some markets than in others. These imbalances are predicted to remain for some time, based on the lack of infrastructure to move significant quantities from one market to another, as well as a political and commercial inertia to deregulate and commercialize the markets.

It is reasonable to believe that the land based LNG market and the LNG maritime market will be closely connected in the future to be able to sign long term supply contracts, hence securing the terminal investment. Existing terminals have succeeded with this method.

2.2.5 *Enablers and critical factors*

The cost of bunkers is one of the main cost components when operating vessels. Today, in principle, all vessels use the same fuels delivered through the same competitive and transparent supply market. This implies that the risk related to fuel cost is limited since it is unlikely that any competitor will be able to reduce the cost of fuel significantly.

The introduction of LNG in the fuel mix changes this situation dramatically since the pricing mechanism and supply cost is still unknown and the market for LNG as marine fuel is a long way from being as competitive and transparent as the present fuel market. Before a ship-owner is prepared to change from the present fuels to an alternative fuel such as LNG he must be convinced that he will be able to get the fuel where he needs it to a price level that gives him an equal or lower overall cost than his competitors.

Seen in a global, regional as well as local perspective this implies that if LNG shall become a major fuel for shipping, it has to be available where the demand is and to a competitive cost level.

The build-up of a small-scale LNG infrastructure dedicated to ship bunkering is supported both by the EU and by several national initiatives, such as the Finnish government support for small scale LNG infrastructure (Sjöfartstidningen, 2013). This support will lower costs for the potentially large initial investments and function as a driver for continued infrastructure development. It will also contribute to the building of a cost effective supply chain, and produce an attractive price for LNG bunker fuel to customers in the

North European waters.

The terminals planned and constructed in the eastern part of the Baltic Sea region also aim for an alternative source of gas for the national gas grid infrastructure to increase security of supply.

2.2.6 *Prognosis for LNG vessels*

As per end of 2014, there were about 50 LNG fuelled ships in operation, of which most of them (44 ships) were in Norway. Also in 2014, 69 LNG fuelled ships were on order, where Norway, Europe and America had about one third each. (DNV GL, 2014)

The figures make a total number of LNG vessels of just above 100 in short term. In addition to this, there are currently also about 100 LNG vessels in China.

DNVGL has made a prognosis aiming as high as 1,000 ships by 2020. This estimation also includes the future global Sulphur limit of 0.5%, believed to create a higher demand for alternative fuels.

3 LNG in the Baltic Sea, an updated overview of status

Several projects have contributed to the development of LNG infrastructure in the Baltic Sea Region. There are several terminals in operation, while most of them are in the planning phase. This chapter gives an overview of LNG terminal statuses on the LNG supply market development.

3.1 Existing and planned terminals

There are a number of LNG terminal projects in the Baltic Sea Region of various capacities. Some projects have resulted in constructed LNG terminals, yet other LNG terminals are planned and/or under discussion.

Existing medium scale terminals are approximately larger than 10 000 m³ LNG while large scale terminals have a capacity of more than 100 000 m³ LNG.

The table below provides an updated list of LNG terminals in the Baltic Sea Region, in operation, under construction or in planning.

As shown in the TABLE 2, there are on-going projects under construction and under discussion that will be able to serve the bunkering market if needed. Also, the larger terminals built or planned could easily supply smaller terminals in the area with LNG, either by feeder vessel or by truck.

Table 2 Existing and planned terminal projects in the Baltic Sea Region

Terminal	Type ²	Capacity	Operator	Status	Comment
Fredriksstad/Øra, Norway	Closed	6 400	Skangas	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	Skangas	In operation	Local gas delivery to refinery and redistribution by truck. Maritime redistribution by bunker barge. In operation since 2014.
Świnoujście, Poland	Open	320 000	Polskie LNG	Under construction	European gas grid and redistribution by truck. Maritime and rail based redistribution and bunkering is under discussion. Planned operational start was December 2014 but has been delayed.
Klaipeda, Lithuania	TBD	170 000	Klaipeda's Nafta	In operation	FSRU unit designed to connect to the local gas grid. In operational since December 2014.
Regional terminal, Gulf of Finland	TBD	180 000	Gasum	Under discussion	Regional terminal for the Baltic energy market area located in either Finland (Inkoo) or Estonia (Paldiski). Planned operation by 2021.
Tallin Muuga, Estonia	Open	180 000	Vopak /Elering	Under discussion	Local gas hub in the first phase, regional open access hub in the second phase. Planned operation by 2018.
Pori, Finland	TBD	30 000	Skangas	Under production	Regional terminal dedicated to the Finnish gas market with planned truck distribution. Planned operation in 2016.
Turku, Pansio Port, Finland	TBD	30 000	Gasum/ Skangas	Under discussion	Terminal with pipeline distribution in the Turku area, truck loading facilities and loading/unloading via existing jetty. Planned to be in operation by 2017.
Tornio, Finland	Closed	50 000	ManGa LNG	Under production	Terminal mainly for industrial use. Unloading to trucks and vessels is under discussion. Planned operation by 2018.
Gävle, Sweden	TBD	30 000	Skangas	Under discussion	Terminal with loading and unloading of LNG to vessels as well as to LNG trucks is discussed. For the future, train unloading is discussed. Planned operation by 2017.
Gävle Norrsundet, Sweden	TBD	15 000	Swedegas	Under discussion	Terminal in Gävle, potentially with a connected gas pipeline infrastructure. Planned operation by 2018.
Sundsvall, Sweden	TBD	5 000	TBD	Under discussion	Terminal dedicated to industrial purposes and transportation. Planned loading to trucks and rail distribution. Planned operation by 2020.
Gothenburg, Sweden	Open	30 000	Swedegas	Under discussion	Redistribution by truck and through a connection to Swe/Dan gas grid as well as bunkering. Planned construction starting 2016.
Malmö/Copenhagen, Sweden/ Denmark	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.
Aarhus, Denmark	TBD	<10 000	TBD	Under discussion	Terminal for marine purposes. Possible loading of trucks.
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.
Trelleborg, Sweden	TBD	<5 000	TBD	Under discussion	LNG supply for maritime purposes, possible loading of trucks
Hirtshals, Denmark	TBD	500	HMN Naturgas	In operation	Small LNG tank for bunkering of ferries, in operation since 2015.
Rauma, Finland	TBD	10 000	AGA	Under discussion	Bunkering of ships from trucks and land. Planned operation by 2017.
HaminaKotka, Finland	TBD	30 000	Hamninan Energia	Under discussion	Terminal with distribution to industries, shipping and trucks. Planned operation by 2018.
Fjusö/Ingå Helsinki, Finland	TBD	TBD	Gasum	Under discussion	Floating storage facility is planned for maritime use. Planned operation by 2021.
Riga, Latvia	TBD	180 000	Latvenergo	Under discussion	Large scale terminal. Planned operation by 2016.
Rostock, Germany	TBD	360 000	Gazprom	Under discussion	Planned operation not yet decided.
Vaasa, Finland	TBD	TBD	TBD	Under discussion	Terminal for industrial and maritime use. Planned operation not yet decided.
Vysotsk	Closed	1 500 000 ³	Gazprom-bank	Under discussion	LNG production plant

² Closed type terminal implies that only the operator can store LNG, while open type implies that independent LNG suppliers may reserve capacity in the terminal.

³ Production capacity

4 Development of LNG terminals

4.1 General procedure of planning, design and establishment

When planning and constructing an LNG terminal or LNG supply, there are several steps that need to be taken and fulfilled in order to build and operate a successful terminal.

The basis of the terminal is an idea, a need, a plan. This plan must be based in realistic figures in terms of demand and supply, and an early feasibility study is often the first step of the planning phase. This feasibility study is the first decision support document, focusing on the financial viability of the project, and this results in either a decision to go ahead, or to stop the plans. The feasibility study usually includes the facts regarding the demand for LNG, makes future prognosis, and predicts the necessary volumes and technical equipment needed. At this stage, it is usually clear whether a terminal is needed, or if a truck should supply LNG.



Figure 5 Truck supplying LNG in Port of Stockholm, Photo: Ulrika Roupé

In the next step of the planning phase, other decision support documents need to be elaborated. This includes the technical background documents, analyses of relevant and necessary regulations and permits needed etc.

If the decision is taken to invest in a terminal, and the technical feasibility is shown, the technical design and organizational set-up must be initiated. The technical design gives a layout of the terminal area, and is complemented by a technical description, giving all necessary technical details needed for the permit process. Should the supply be met by a truck delivering LNG, facilities for this type of supply need to be prepared, and it is often similar steps as for a

terminal, but more simplified.

A risk assessment is necessary for receiving permits for construction, and is often set as a demand by relevant authorities.

This chapter describes the different components of the design process, and the permit process, for planning and building an LNG terminal or supplying LNG by truck.

4.2 Design LNG supply

Once the decision to build a terminal or to arrange for LNG supply is made, the design of the terminal or truck reception area/bunkering area starts.

The choices that have to be made include:

- Location of the terminal, and deciding on proper preparations of the land area (or preparations of quays for trucks)
- Size of the terminal or supply
- Type of tank/supply
- Volumes of the tank
- Distribution system for LNG supply; bunkering, truck filling stations, pipelines, regasification etc.
- Financial aspects and investment costs
- Safety measures and security aspects

4.2.1 Location of the terminal

Choosing a location for an LNG terminal must be based on the origin of the demand for LNG. The choice must include considerations to the surrounding activities and the proximity to activities that could be affected by the terminal. A risk assessment can determine whether the location is suitable or not from a risk perspective.

Import of LNG (for example from an LNG carrier) must be made possible, by locating the terminal in a quay area or connected to a quay. A jetty for LNG import as well as a suitable fairway for LNG carriers must be planned for. Necessary roads to and from the terminal area, and within the area, and possibly also a filling station for trucks, must be included in the planning of the terminal. To conclude, a land area large enough to include all necessary technical equipment and facilities must be chosen, but at the same time taking risk aspects into consideration.

4.2.2 Choosing type of supply: size, type and volume of terminal

Once the location is decided upon, there are several different types of tanks available, depending on the volumes needed, and the available land area. Some general storage possibilities are listed below:

- No terminal but a truck, supplying LNG directly to the ship
- No terminal but a bunkering vessel, supplying LNG to the ship
- Small storage tank, with pipelines or truck supplying the ship
- Larger storage tank, with pipelines or truck supplying the ship
- Floating storage, large or small size, supplying LNG directly to ships by truck or by pipeline



Figure 6 An LNG storage tank and evaporators, Source: Wikimedia Commons

4.2.3 Distribution system and technical equipment

The distribution of LNG from the tank, or gas if there is a regasification facility installed, is made by either truck or pipeline.

The distances are crucial, both for technical and safety reasons.

If LNG is delivered by pipeline, it needs to be properly insulated. This is only suitable for shorter distances, as an insulated pipeline is expensive. For longer distances of LNG distribution, a truck is more suitable. It is difficult to say exactly when the delivery should be by truck instead of pipeline, but generally up to 1 000 meters. If gas is delivered, a pipeline is the most suitable means of delivery.

In an early stage of design, or pre-design, it is not necessary to specify the technical equipment needed in detail. However, it is important to include the land area needed for specific equipment, such as pipelines, pump stations, truck filling stations etc.

4.2.4 Financial aspects and investment costs

The financial aspects of the development of an LNG terminal includes among others the issue of investment cost, the operation of the terminal, and the ownership.

When it comes to the investment, there is no general financial model of how an LNG terminal is financed. Generally, the cost is divided by several stakeholders, for example the port, the gas supplier/operators and possibly also ship owners using the terminal. The size of the investment cost depends on the technical equipment needed, and the type of storage chosen, and this in turn depends on the volumes needed and the supply cost of LNG.

Recent experiences have shown that financial institutes are hesitant to invest money, or give guarantees, to projects with short term contracts, such as LNG vessels. This could in turn jeopardize the development in ports, but other financial solutions can also be sought.

The owner of the terminal can be either the port, and then leased to an operator, or the operator or gas supplier owns the terminal. Another possible set-up is that the port could let/lease land area to owner/operator.

Operation of the terminal can be managed by the gas supplier, by a separate operator organization, or any other suitable set-up.

Most of the terminals that have been built thus far, are built close to a land based LNG demand, making the project financially viable.

4.2.5 Risk and safety

There are several environmental benefits with LNG. Compared to other bunker fuels, LNG has a smaller pollutant characteristic and does not contaminate the local environment or water if spilled. However, if spilled, there are risk and safety issues to deal with. The main risk and safety aspects of LNG are generally described below. LNG hazards result mainly from the physical and chemical properties, cryogenic temperatures, dispersion characteristics, and flammability characteristics. If an LNG release occurs there is an immediate potential for a range of different outcomes and types of consequences. Of the following identified LNG specific potential outcomes of an accidental release of LNG, fire scenarios are found to be the ones governing for necessary risk control measures including determination of safety distances and site selection for bunkering facilities and operations.

- Cryogenic damage – metal embrittlement, cracking, structural failure;
- Cryogenic injuries – frost bites;
- Asphyxiation – if the air oxygen is replaced methane asphyxiation may occur;
- Reduced visibility due to un-ignited vapor clouds (occurs also in normal operation);
- Thermal radiation from various fire scenarios;
 - delayed or immediate ignition of vapor clouds (flash fire),
 - slow fire front
 - delayed or immediate ignition of vapor-air mixture (fire ball),
 - rapid burn
 - LNG pool fires or
 - flame jets from leaks in pipes, hoses, tanks or pressure vessels
- Rapid phase transition, RPT;
- Vapor cloud explosion (in confined spaces and enriched with other hydrocarbons);
- Boiling liquid expanding explosions (BLEVE);
- Rollover in LNG storage tanks;
- Sloshing on board LNG tankers.

The level of consequence depends on the direct receiving environment and the behavior of the LNG. Since the flammability range for vaporized LNG (methane) in air is relatively narrow, 5 % (LFL) – 15 % (UFL) compared with many other flammable gases, it is hard to ignite. If ignited however the emissive power from methane is higher than e.g. for propane. Methane is, in contrast to propane, lighter than air and vaporized LNG from small leakages will therefore dissipate relative quickly. For a large LNG spill, the visible white cloud of cold vaporized LNG will initially have neutral buoyancy in air.

The ignition risk of a vapor cloud in the event of spilled LNG can extend for a longer distance, therefore ignition controls must cover both the inside and outside of a terminal area. Within these safety zones, it is important to remove all risks of ignition as far as it is possible. In the case of an LNG spill, this minimizes the risk for igniting the vapor cloud.

The range of a flammable gas cloud generated by a spill is principally dependent on spill rate and duration but inevitably the risk assessment spill scenario dependent. Factors such as climate, wind direction and speed are of importance. In addition local topography

such as harbor structures and the presence of the LNG carrier itself can have an effect.

It is therefore difficult to decide the minimum safety zones from which all ignition sources must be eliminated. It varies for different terminals. Sometimes large safety zones are recommended, especially when terminal safety systems are inadequate.

Minimizing the risk of a vapor cloud ignition is linked to minimizing LNG spills. An increased traffic with feeders and/or bunker vessels leads to an increase in ship movements in the port and an interaction with already existing flows. Safety measures can therefore be investments in more quays, wider fairway, surveillance etc.

Definition of safety distance is the minimum separation needed between a hazard source and an object; human, equipment or environment, which will mitigate the effect of likely foreseeable incident and prevent a minor incident escalating into larger incidents. Safety distances are not intended to provide protection from catastrophic events or major releases but rather create an adequate separation zone around equipment and offer a safe layout.

It is not possible to provide protection from all possible events and therefore it is important to understand which risks can be reasonably mitigated by a safety distance, minimizing the consequence in the case of an incident. If the needed safety distance is too large for practical solutions in a design, additional mitigating measures should be considered.

Mitigation measures suggested during the development of an LNG terminal is for example different types of safety equipment, such as ESD connections that stop the flow of LNG in case of any breakage or failure during bunkering. Relevant and sufficient training for staff that will handle LNG is also one of the most important safety measures that can be taken.

4.2.6 Security aspects and considerations

Generally, in the absence of foul play, LNG is quite safe. But in today's world, security issues are a normal part of any infrastructure planning and management. Therefore, relevant security issues could be identified and included in the risk assessment made for the development of LNG.

Security issues include the following aspects:

- International conflicts (could affect supply, and possibly also demand)
- Terrorism
- Theft
- Sabotage
- Vandalism
- Piracy (global issue that could have implications on supply)

In case of ISPS area, specific rules for entry and operation apply.

4.3 Relevant laws and regulations

The permit process and the public consultation process when building an LNG terminal is controlled by several different laws and regulations.

The Seveso Directive, an EU Directive introduced in 1999 to prevent and limit the consequences from serious accidents with dangerous goods, is the foremost basis for national legislation within this area. Activities that handle certain volumes of dangerous goods (in

Sweden the limit is 50 tonnes of LNG, but less than 200) are eligible for reporting to relevant authorities according to the Seveso Directive.

For activities that store or handle volumes larger than the limit (in Sweden 200 tonnes of LNG), a higher level of specific demands apply. Permits according to environmental legislation are needed, and a consultation process is included in this.

Specific laws

Apart from the Seveso directive, there are a number of national laws and legislation that apply during LNG development. Most of these are present in all countries, and a general list is presented below.

Law regulating Planning and Building

Building permit is generally needed for all land based installations. Handling of LNG must also be approved in specific plans. If the existing plan for an area does not allow for this, a change in plans according to the law is needed.

Law regulating flammable and explosive goods

This law generally includes handling, transfer, transport and import of flammable and explosive goods, and all preparatory measures needed considering the risk for fire and explosion and its consequences. This law should give permits for handling flammable and explosive goods.

Law regulating transport of dangerous goods

For distribution of LNG by truck and rail, there is generally a national law governing the transport and setting restrictions.

Law regulating the working environment

The working environment around an LNG terminal is not regulated by Seveso, it is generally national legislation that controls this. For certain large amount of LNG, a report must be made to the responsible authority, and this applies for work onboard ships as well.

Law regulating protection against accidents

According to this regulation, the operator is responsible for analyzing risks for serious accidents, and also make sure that necessary equipment and training is available for minimizing accidents risks and their consequences.

Environmental legislation

If the LNG terminal volume is above a certain capacity (in Sweden the limit is 200 tonnes) a permit according to the relevant environmental legislation is necessary.

5 Experiences from participating ports

5.1 Status in project ports

5.1.1 Helsingborg, Sweden



The objective of the Helsingborg's activity within the LNG in BSR II project was to design a multifunctional bunker ship facilitating supplies of LNG fuel to stakeholders in southern Sweden. From the technical and functional point of view, the vessel was intended to be a multi-functional ship serving LNG bunkering, MGO bunkering and other services e.g. ship supply services.

The outcome of this activity was a technical design of a multifunctional bunker ship that will satisfy all important stakeholders in the area and local ports' conditions were to be analysed.

Due to unsuccessful negotiations with bunker operators regarding technical support, market input and partnership regarding future bunker ship in the market area around Helsingborg, the port authorities decided to analyse four concepts, based on the information acquired from ship owners and bunkers operators. The potentially interesting concepts include:

- A. Retrofitting existing bunker ship, capable of carrying MGO, ECO fuel and LNG.
- B. Retrofitting existing bunker ship, capable of carrying MGO, ECO fuel and LNG. Conversion or replacement of the machinery towards LNG propulsion. Expected total tank volume ranges from 2000 to 3000 m³.
- Construction of a new bunker ship carrying LNG, MGO and HFO with high flexibility to adjust to new market conditions.

Expected total tank volume 2000-3000 m³.

- Construction of a new self-propelled bunker barge for LNG and MGO (classed for inland waterways).
- Retrofitting an existing bunker barge to carry MGO and LNG. The barge would be transported by an existing tug boat. Expected volume of the LNG tank as well as the MGO tank would be approximately 500 m³.

The initial financial analysis of the above concepts have been sub-contracted to a Danish design company. Results will allow selection of the most efficient concept that will further serve for preparation of the design specifications.

5.1.2 Trelleborg, Sweden



The Port of Trelleborg intended to study the possibilities and obstacles of building a ferry terminal adapted to LNG-powered ferries. In addition, within the framework of the LNG in BSR II project, the port aimed to prepare design concept of a berth. The activity included following tasks:

- Context analysis aiming to identify i.e. existing bunkering possibilities;
- Interest of customers in LNG bunkering,
- Assessment of the safety and other regulations
- Risk assessment
- Technical specifications for the final berth design including ships' loading/unloading, facilities to store and bunker LNG.

Another activity within the project aimed to prepare the technical design of the LNG storage and bunkering facility, to be installed at the berth. The activity's scope embraces elaboration of the design, including: existing LNG storage facilities, storage tank, potential adjustment of berth, LNG demand forecast. The activity also studied the possibilities of the LNG transport to the port storage facility - either by land or by sea.

Up to now, a geotechnical investigation and a technical design of the berth including LNG storage and bunkering risk and feasibility analyses have been completed. These steps have been crucial from a legal point of view in order to further proceed with the facility set up. Also the technical drawings and the documents containing technical description necessary to conduct the construction of the new quay at berth 13 have been presented and delivered to the port of Trelleborg. The feasibility study and risk assessment have

been submitted to the Swedish Transport Agency for approval. (SSPA, 2015A, 2015B)

5.1.3 Sundsvall, Sweden



Port of Sundsvall investigated the possibility to develop LNG bunkering facilities in the Sundsvall Logistic Park, in order to develop the offer for vessels. Secondly, the project aimed to provide access to alternative fuel supplies for the logistics park and other working port vehicles as well as offer LNG to the industry in the region and as a biogas back-up. Within the LNG in BSR project II, a comprehensive planning of the LNG infrastructure has been assumed to include:

- design of the LNG bunkering infrastructure facility, including LNG storage and bunkering facility for ships, optionally for port vehicles and trucks (size, type of storage tanks etc. will be subjects for further studies),
- long tubing/piping,
- efficient transshipment and transport,
- risk assessment and safety aspects related to the above,
- acquiring of necessary permits.

Up to now, studies conducted have been dedicated to the LNG facilities' location, design of the gas system as well as the risk assessment and safety aspects related to the location. The permission procedure for the location of an LNG storage has been also initiated. The procurement procedure for the preparation of feasibility study on the LNG bunkering facilities, which is expected to analyse both short- and long-term solutions. Completion of the study is expected by the end of 2015.

5.1.4 Rostock, Germany

Port of Rostock planned the preparation of all documentation necessary for bunkering operations, which includes administrative permits for the bunkering procedure itself as well as preparation of the technical design for a LNG bunkering and storage plant. Regarding design and planning activities, the following tasks, related to the development of LNG bunker, were meant to be undertaken:

- Complete technical design of the LNG-import berth for bunkering purposes,
- Complete technical design of the LNG-bunker berth,
- Complete technical design of pipeline connecting the storage

with the berth and the road- and rail-loading units,

- Complete technical design of LNG storage and road-/rail-loading facilities,
- Safety analysis assessing the risks for the plants in the vicinity of the LNG bunkering facility.



The LNG project in Rostock is currently under development, first feasibility and risk studies were subcontracted. The tender for a suitable port area was published in September 2015 and companies presented their offers. Completion of the tender procedure is expected by the end of 2015. Port of Rostock will aim to contract further specialised consultancy companies in order to support the further development of this very important activity LNG in Port of Rostock.

5.1.5 Klaipeda, Lithuania



The objective of the Klaipėdos Nafta, operator of the first LNG terminal in Lithuania, was to develop a small scale on-shore LNG reloading and bunkering facility. LNG in BSP II project was to support development of the technological design study that aims to analyse the current infrastructure and superstructure within the premises of SC Klaipėdos Nafta, in order to assess the development potential of the new LNG infrastructure. The study was expected to provide recommendations on the necessary adjustments of the current infrastructure and superstructure as well as

to indicate a suitable location for the LNG infrastructure, within SC Klaipėdos Nafta property. Moreover, the study was expected to provide description of the potential technologies for small scale LNG infrastructure including such elements as jetty, superstructure and infrastructure, cryogenic piping, LNG storage, bunkering and distribution equipment (suitable for trailers, trucks).

The progress of the Action is in line with agreed schedule. Up to now, the draft Front End Engineering Design (FEED) and Quantitative Risk Analysis (QRA) have been finalized and served as the basis for the preparation of call for public tender on engineering, procurement and construction services.

Having accepted FEED and QRA, the Environmental Impact Assessment (EIA) has been launched in accordance with the schedule. Up to now, the EIA report has been completed and submitted for review to relevant authorities, hence LNG bunkering and truck loading operations are expected to be launched in the first part of 2017. Having completed the new LNG bunkering facility, the Klaipėdos Nafta will achieve its strategic objective of the LNG hub for the Baltic Sea. The new facility along with the FSRU "Independence" floating LNG terminal, will make it feasible to establish the services of regasification, ship reloading, cargo break-bulking, truck loading and bunkering at the Port of Klaipėda.

5.2 LNG training

As a part of the on-going project LNG in Baltic Sea Ports II, the participating ports have been offered "LNG bunkering training for port communities". Training scheme included the basic properties of LNG, chemical, physical and safety features, risk mitigation, regulations, bunkering methods, and the permit process.

Apart from the theoretical sessions, the training has also included a practical session, with a separate relevant study visits. In Klaipėda, the FSRU Independence was visited, and in Stockholm, practical session took place on-board Seagas bunkering vessel.

Training has been held at two separate occasions during 2015: in Klaipėda, Lithuania, and in Ports of Stockholm, Sweden. Most of the partner ports, port authorities and key regional LNG stakeholder's representatives have attended the training scheme, and it was very positively received.

More information of the LNG training can be found on the project's website:

<http://www.lnginbalticseaports.com/en/news/143>

<http://www.lnginbalticseaports.com/en/news/156>

5.3 Other ports

Ports from the project LNG in Baltic Sea Ports I

Port of Stockholm (Sweden)

Port of Stockholm is the first port within Baltic Sea Region where the LNG bunkering operation is performed. Port started to offer LNG bunkering operation from January 2013, when the ship Viking Grace was put into service. Initially Viking Grace was refuelled from tank truck. However, at the beginning of April 2013 ship to ship bunkering started at the regular basis. The first vessel for bunkering purpose, Seagas, was formerly a small car ferry, however, is has been converted into an LNG bunker ship. The project was carried

out by AGA AB in the Port of Stockholm. The Bunker vessel is based in the Port of Stockholm and provides fuel to a new LNG-powered M/S Viking Grace ferry.



The project costs 1.3 million Euro. 261,000 Euro came from the European Union's TEN-T program.⁴ The LNG fuelling vessel is classified under the same regulations that apply to oceangoing LNG-tankers. The fuelling vessel is performed on a daily basis, supplying 60-70 tons of LNG to M/S Viking Grace. The fuelling process takes just under an hour. The natural gas used as fuel for M/S Viking Grace comes from AGA's LNG-terminal in Nynäshamn.

Port of Aarhus (Denmark)



The port of Aarhus has developed a feasibility study, showing suitable size, location, approximate costs and type of LNG terminal. The subsequent activity is the design of the terminal area and the process of retrieving a permit from relevant authorities. The design and the permit process is currently on-going and is expected to be finalized during 2016. The capacity of the planned tanks will be 10 000 m³. The terminal will be equipped with several semi-pressurized tanks of about 1,400 m³ each. The main users of the

⁴ http://www.bairdmaritime.com/index.php?option=com_content&view=article&id=14032:seagas-heralds-new-lng-bunkering-era&catid=114:workboats&Itemid=209

terminal will be ferries, the terminal is going to be located within ferry terminal.⁵

Port of Copenhagen-Malmo (Denmark/Sweden)



In Copenhagen-Malmo Port a feasibility study have been carried out, showing the needed volumes, possible locations of the LNG terminal and approximate costs. Three localisation within port of Malmo were investigated and one have been chosen in the northern part of the port. The recommended solution for the terminals is semi-pressurised tanks of total volumes of 10 000 m³.

Port of Helsinki (Finland)



In the port of Helsinki a feasibility study of LNG bunkering possibilities at the Port of Helsinki, including South port, West port and Vuosaari port have been carried out. From the study it has been determined that the most practical solution for LNG refuelling of ships is ship-to-ship bunkering. The bunkering capacity and localization have not been decided yet.

Currently, tank-to-ship bunkering is available in the Port of Helsinki. Bunkering is taking place for a new Finnish Border Guard's LNG-fuelled offshore patrol vessel 'Turva'. The Vessel operates in Gulf of Finland and it is possible to replenish fuels at various Gulf of Finland ports, such as Hanko, Hamina, Vuosaari, Turku, Pori and Raahe where LNG will be delivered by Skangass by road tankers from company's own production plant in Porvoo.

⁵ LNG in Baltic Sea Ports, LNG Handbook, 2014

Port of Turku (Finland)

In May 2012, Gasum and the Port of Turku signed a letter of intent for building an import terminal for LNG in the Pansio harbour. It is assumed that the terminal will supply LNG to shipping as well as the industry in Southwest Finland and neighbouring provinces. At initial stage, bunkering could be done by tank truck and at the later stage, it would be possible ship-to-ship bunkering. The capacity of the storage tank is planned to be maximum around 30,000 m³. The proposal of a local detailed plan for Pansio LNG terminals area was accepted in June 2013. The terminal was planned to be operational in 2015, but appeal regarding the terminal have been made to Turku Administrative Court and delayed the project. However, the court case has been now resolved and LNG project is to continue further.

Port of Tallinn (Estonia)

Together with Vopak LNG and Elering, Port of Tallinn has been studying the possibility to establish an LNG terminal in Muuga Harbour near Tallinn. The small LNG facility terminal would serve the bunkering market for ships, large industrial customers and small commercial and domestic customers. This could be considered as the first phase of the larger project, as companies are investigating the possibilities to develop the large scale import terminal.

Initiatives in other Baltic ports**Port of Gothenburg (Sweden)**

The LNG terminal in Gothenburg was a joint initiative of Royal Vopak and the infrastructure company Swedegas, which owns and operates the gas grid in south-west Sweden. The LNG terminal in Gothenburg is also part of a project being run together with Port of Rotterdam and Gasunie to create an efficient LNG infrastructure between Sweden and the Netherlands. The terminal will supply LNG to industry and shipping and will be open to all parties interested in the Swedish market. The planned storage capacity of the full developed terminal is 30,000 m³. The terminal will be built in the Skarvik Harbour. The facility is planned to be built in 2016.

Gävle (Sweden)

A small scale LNG terminal is planned to be built in Gävle. The terminal will be built by Skangass, the construction works are planned to start in 2015 and the terminal will be ready in 2017. The terminal will be equipped with one storage tank of 30,000 m³ and will have handling capacity of up to 500 000 tonnes of LNG each year.

Port of Hirtshals (Denmark)

The project in Hirtshals is co-financed by EU's TEN-T Programme (EU). The project has developed a 200 tonne/500 m³ pilot LNG storage tank and bunkering facility, with the perspective to develop it into a larger one of 3,000-5,000 m³. The new facilities will provide LNG for ships, as well as regional consumers including road transport. The project is in operation since 2015.

Port of Hou, Island of Samsø (Denmark)

In February 2015, the first gas-driven domestic ferry in Denmark was bunkered in the port of Hou. The bunkering facility in the port of Hou includes inter alia: cryogenic transfer pump unit built into a 20 feet container, piping system including specially designed LNG dry couplings, 2 specially designed LNG road tankers, parking ramp for road tanker, control system including safety system. The LNG bunkering facility makes it possible to fuel a ferry for a whole day's operation in less than 30 minutes.

Finnish ports (Tornio, Pori, Rauma and HaminaKotka)

Within the next few years, four small scale LNG import terminals are going to be built in Finland. In 2014 the Finnish Ministry of Employment and the Economy granted totally 92.8 million EUR in four new LNG terminals. The terminals are going to be located in Tornio, Pori, Rauma and HaminaKotka.

The terminal in Tornio will be built by Manga LNG Oy, it will be equipped with a storage capacity of 50,000 m³. It is scheduled to be put into operation in 2017. The terminal in Pori will be built by Skangas Oy. The Pori terminal will have an LNG storage capacity of 30,000 m³. It is scheduled to be ready in autumn 2016. Rauma's terminal is going to be built by Oy Aga Ab. The combined storage capacity of the Rauma terminal's eight LNG tanks will be 10,000 m³. Work on the terminal is set for completion in early 2017. Terminal in HaminaKotka will be built by Haminan Energia. The Haminan Energia LNG terminal, which is scheduled to be ready in 2018, will be equipped with one LNG tank of 30,000 m³ and facilities related to receiving, unloading, storing and delivering LNG.⁶ It is planned that all terminals will supply the LNG to industry, maritime transport and road transport.

⁶ https://www.tem.fi/en/energy/press_releases_energy?89521_m=116897

5.4 Conclusions of port experiences

It is obvious that several of the ports participating in the project LNG in Baltic Sea Ports (both I and II) have come quite far in the planning and implementation of LNG introduction. Other ports in the Baltic Sea area are also preparing for an LNG introduction, by planning for, designing and building terminals. One of the conclusions that can be made is that further development is now dependent on the price development of LNG, and its connection to the oil price. This has a major impact on the attractiveness of LNG on the market, and thus on the rate of development of LNG terminals. The support given by EU has constituted the spark for many ports, giving the initial financial support needed to start the process.

Partnering ports of the LNG in BSP II project have reported various stages of planning and permitting processes.

The Port of Helsingborg has conducted necessary steps to select the most suitable option of the infrastructure development and awaits results of analysis that will provide basis to make a final decision and start preparing technical specification.

The Port of Trelleborg has advanced with geotechnical research and technical documentation of the berth that will host the LNG bunkering infrastructure, also the risk assessment and the feasibility study have been completed.

The Port of Sundsvall conducted the location analysis, including necessary risk and safety aspects. The feasibility study shall indicate relevant technical solutions taking into consideration short- and long-term perspective.

The Port of Rostock awaits completion of the tendering procedures for the location study and the bunker risk analysis. Moreover, the procurement for the preparation of feasibility study is expected to be conducted shortly.

Klaipėdos Nafta is advanced with the Front End Engineering Design, Quantitative Risk Study and Environmental Impact Assessment, which have already been completed. Having completed that stage, Klaipėdos Nafta prepares for the call for tender regarding engineering, procurement and construction services.

Other Baltic ports, such as Stockholm and Helsinki possess operational experience at LNG truck-to-ship or ship-to-ship bunkering, thanks to hosting LNG-fueled vessels – M/S Viking Grace (Port of Stockholm) and the patrol vessel of the Finnish Border Guard (Port of Helsinki). The Danish port at the island of Samsøe keeps operating the LNG terminal for the domestic gas-driven ferry.

Ports of Turku, Malmoe-Copenhagen, Tallinn and Turku having completed the feasibility studies determined the required infrastructure, volumes of LNG tanks, necessary accompanying infrastructure and most of them are advanced with further studies concerning location, administrative decisions and cost analyses.

Examples of Swedish, Danish and Finnish ports present advancement of the LNG projects, out of which Gothenburg and Hirtshals are expected to be operating in 2015-2016, while four Finnish ports will launch operation of the LNG infrastructure between 2016 and 2018.

The overview of the ports' advancement in planning and operation of the LNG infrastructure as well as launches of new terminals expected within forthcoming 2-3 years, create a significant potential for more dynamic deployment of the LNG infrastructure and LNG-driven vessels around the Baltic Sea.

6 Conclusions and recommendations

This chapter concludes possibilities and challenges, in different aspects, from gathered experiences through LNG related projects. The issues identified are specifically connected to the design phase of the development of an LNG terminal.

6.1 Possibilities

6.1.1 Regulations

Even though there is a lack in regulations that cover LNG, several international organisations are involved in the process of improving LNG handling and operations ensuring safe bunkering operations. Guidelines for LNG handling are being produced on local and national levels, and relevant authorities are greatly improving the process of LNG permits, mainly through increased knowledge and experience.

Several attempts are made to increase the knowledge of LNG development. The introduction of SGMF (Society for Gas as Marine Fuel) has created an industry body dealing with the technical and safety issues associated with the use of LNG as ship fuel and the maintaining of high standards across the industry. The recommendations from SGMF are valued as advice for LNG introduction. When it comes to guidance for LNG fuelled vessels, the IGF Code is under development (seagoing vessels) and regulation for inland waterway vessels is expected soon.

6.1.2 Technical aspects

Regarding technical aspects in the development of LNG terminals, concepts and systems are already available. There are many suppliers of technical equipment for LNG terminals, such as piping, connections, hoses etc.

6.1.3 Risk and safety

The existing LNG terminals have all undergone thorough risk assessments, and the risks connected to LNG are well identified. The permit process generally asks for a risk analysis and once the risks are identified, and possible risk mitigation measures are proposed, the permits are issued. Therefore, the issue of risk and safety does not constitute an obstacle for development, more of a mandatory step towards receiving a permit and continued development.

6.2 Challenges

6.2.1 Regulations

There is still a need for more international standardization regarding LNG as ship fuel. Especially when it comes to LNG bunkering related regulations, more guidance is needed.

On a local level, a harmonized approach to the permit process, to bunkering permits etc., would facilitate the introduction of LNG. Today bunkering LNG is only allowed with special permission.

6.2.2 Technical aspects

Although the technical aspects of the LNG development are quite under control and do not constitute a major obstacles, there are some areas that could be improved:

- There is still a lack of standardised equipment and technical solutions e.g. couplings and ESD, especially relevant for ships calling at several ports.
- LNG bunkering and ship design must be competitive to traditional fuels and design when it comes to time, price, location and procedures.
- Importance of building necessary bunkering infrastructure at the ports.

6.2.3 Financial aspects

There are still some financial issues that need to be solved before any larger development of LNG terminals will take place:

- Pay-back time for investments, it is necessary to find financial schemes that are positive for investors
- Investment vs operational costs
- Finding investors/partners often crucial for ports
- Safety distances affecting other activities, makes the project costly
- Additional structures are expensive
- Permit process takes time and money, and as the experience and knowledge within this area grows, the permit process can be expected to be shorter and less costly

6.2.4 Security aspects

An increased level of insecurity in society, with a constant threat of terrorism and other fatal deeds, also puts demands on all handling of dangerous substances, to reach and maintain a high level of security.

6.2.5 Risk and safety

Even if LNG is considered a safe substance, and very few incidents occur, there are some issues that still need attention:

- Training and education of on-board and shore-based personnel needs to be harmonized in structure and content for different levels.
- Parallel cargo and passenger handling during bunkering

procedures puts high demands on safety measures.

- An agreement on acceptable risk levels, risk assessment procedures etc. is needed when performing risk assessments for LNG development.
- In order to ensure safe operations, standardisation of operations is needed.
- In order to increase knowledge and create a better understanding of LNG, promoting public knowledge of LNG as a marine fuel is needed.
- Standardisation of equipment systems are essential for a well-functioning and safe infrastructure.

6.3 Conclusions of the permit process

Even though there are international rules and guidelines issued to some extent regarding the small scale handling of LNG, they are not uniformly applied or interpreted in the different countries. A source of uncertainty in many LNG bunkering projects is the process to obtain permits from relevant authorities. As LNG is a new substance in most areas there are few, if any, existing regulations for the storage and handling of it and there is no standardized or even harmonized process to obtain the needed permits, not even for different regions in the same county is the process necessarily the same. An operator might go through one process in one port and face a different process in another, and it is far from sure that an approval in one port is enough to ensure one in a neighbouring one. Local authorities, for example rescue services, typically lack experience in handling LNG and tend to take a very conservative and careful approach to it. In some cases it is up to the applicant to prove that the risks are manageable, without stipulating how or what the evidence should be. Experiences gained so far from permit processes confirm that it is often very important to involve all relevant stakeholders for the permit process in an early stage and tie them to the process. The possibility to explain what LNG is, and in which forms and cases it presents a risk to the environment and the surroundings, can greatly facilitate the process, especially the local rescue services or equivalent emergency response organisation is important to involve early on to handle and meet their input to the LNG operations.

A harmonised approach in the permit process would greatly simplify it and be of valuable support to both the applicants and to the authorities involved. Even though an application would still be evaluated and the permits issued by local authorities, it would be of significant help if the processes and needed documentations were the same.

6.4 Recommendations

For ports that are about to start the process of establishing LNG bunkering operations, or planning for LNG supply in their port, the following steps are recommended:

- **Technical feasibility study:** First, a thorough feasibility study regarding the market potential for LNG supply in a port and its hinterlands should be made to determine needed volumes and from that different set-ups for LNG storage and sourcing can be suggested. As there is a significant scale of economy

in handling of cryogenic gases such as LNG, it is valuable to determine the optimal storage types and suitable bunkering techniques.

- Secondly, a **financial overview** is suggested to establish the maturity of the project.
- Also important is a thorough inventory of all relevant stakeholders and applicable regulations
- Thereafter a **Design Process** can be initiated to determine the needed installations.
- Identify the relevant laws and regulations that apply for **the permit process**, and in parallel to this a permit process should be initiated to accommodate for any needed alterations and ensure a smooth process.
- Commence a dialogue with the **relevant authorities** at an early stage. This could be both on local and on national level.
- During the design phase, involve **stakeholders** and possible financiers of the terminal.

7 References and sources

7.1 Written sources, reports, documents etc

Bureau Veritas (BV), 2014, Guidelines on LNG Bunkering, Guidance Note NI 618 DT R00 E.

Danish Maritime Authority (DMA), 2012, North European LNG Infrastructure Project, Full report

DNVGL, 2014, LNG as ship fuel, The Future – Today, No 1, 2014

EC, European Commission, 2014, “Chemical Accidents (Seveso I, II and III) – Prevention, Preparedness and Response”, <http://ec.europa.eu/environment/seveso/>

LNG in Baltic Sea Ports, 2014, LNG Handbook, Project Coordinator: Port of Helsingborg

International Association of Oil and Gas Producers (OGP), 2013, OGP Draft 118683 - Guideline for systems and installations for supply of LNG as fuel to ships, 2013-06-04

International Maritime Organization (IMO), 2003, International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)

International Maritime Organization (IMO), 2009, Interim guidelines for natural gas-fuelled engine installations in ships, MSC.285(86)
International Standardisation Organization (ISO), Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface, ISO TC 67

SGMF, 2015, Gas as a Marine Fuel, Contractual Guidelines

SGMF (The Society for Gas as a Marine Fuel), 2014, <http://www.socgmf.org>

SSPA Sweden AB, 2015a, Feasibility study regarding LNG in Port of Trelleborg, Draft, November 2015

SSPA Sweden AB, 2015b, Risk assessment regarding LNG in Port of Trelleborg, Draft, November 2015

WPCI, 2014, LNG Fuelled vessels – world map, <http://www.lngbunkering.org/lng/map/node>

7.2 Other sources

AGA Gas AB Jonas Åkermark
Baltic Port Organization, Bogdan Oldakowski
Port of Aarhus, Kim Meilstrup
Port of Copenhagen-Malmö, Brian Kristensen/Gert Nørgaard
Port of Göteborg, Edvard Molitor
Port of HaminaKotka
Port of Helsingborg, Roland Brodin
Port of Helsinki, Jukka Kallio
Port of Hirtshals
Port of Klaipeda, Mindaugas Aleska
Port of Trelleborg, Ulf Sonesson
Port of Riga
Port of Rostock, Gernot Tesch
Port of Samsø
Port of Stockholm, Sandra Gegerfelt
Port of Sundsvall, Anders Nordström
Port of Tallinn, Marju Zirel
Port of Turku, Christian Ramberg
Swedish Transport Agency, Saeed Mohebbi

Notes

