LNG
in Baltic Sea Ports

LNG in Baltic Sea Ports

LNG HANDBOOK

AARHUS HAVN
PORT OF AARHUS

CMP COPENHAGEN MALMÖ PORT

HELSINGBORGS HAMN
PORT OF HELSINGBORG

PORT OF HELSINKI

PORTS OF STOCKHOLM

PORT OF TALLINN
The Port of Good News

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FINLAND

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Co-financed by the European Union
Trans-European Transport Network (TEN-T)

LNG Handbook, based on experiences from the project "LNG in Baltic Sea Ports"

The Handbook is part of the project *LNG in Baltic Sea Ports.* The purpose of the handbook is to provide advice and guidance for other ports planning to establish LNG terminals or other types of supply for the marine market.

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 establishing LNG terminals and LNG as ship fuel.

Summary and recommendations

The project *LNG in Baltic Sea Ports,* partly financed by TEN-T, supports and initiates the establishment of LNG terminals in participating ports. The ports that participate are: Stockholm, Helsinki, Turku, Tallinn, Copenhagen-Malmö, Aarhus and Helsingborg. Some of the ports have reached far in their planning and development for supplying LNG to ships. Stockholm, for example, has a functioning LNG supply chain for the ferry Viking Grace. Port of Helsinki has a functioning LNG supply chain for the coast guard vessel Turva. Other ports are planning for and acquiring permits for the establishment.

One of the main purposes of the project LNG in Baltic Sea ports is to find good solutions and manageable ways of establishing LNG in ports, in order to supply LNG to end users. The ports that have participated in the project have all gained a lot of experiences and have reached far in striving towards LNG establishment.

It is also equally important to disseminate the results from the project, in order to facilitate the establishment of LNG in other ports in the Baltic Sea area, and the rest of Europe as well.

The experiences gained from the participating ports are therefore summarized in this handbook, created for supporting ports in their work of planning and developing LNG.

The handbook outline is based on the process of developing an LNG terminal, and the phases that are connected to this process (planning, construction, production, operation, bunkering etc).

The handbook starts with an overview of the status of LNG supply in the Baltic Sea countries today, including future scenarios, and possible market and supply chain development.

The general process of establishment is described, looking specifically at technical, financial and safety aspects.

The obtained experiences from the participating ports are described and discussed. The experiences are summarized into obstacles and possibilities for the development of LNG, from a technical, financial and safety viewpoint, and to conclude, a checklist to ports for LNG development is given.

The table below shows the existing LNG terminals.

Terminal	Type	Capacity	Operator	Status	Comment
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

The table below gives an overview of the LNG planned so far.

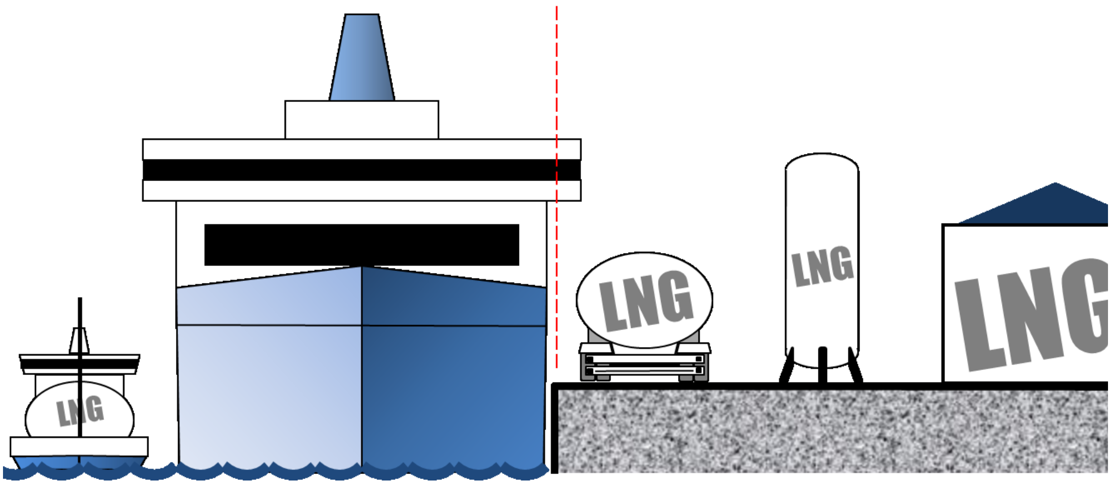
Terminal	Type	Capacity (m^3)	Operator	Comment
Lysekil/ Brofjorden,	Closed	30 000	Skangass	Local gas delivery to refinery and redistribution by truck. Maritime redistribution by bunker

Sweden				barge. Planned operation by Q4 2014.
Świnoujście, Poland	Open	320 000	Polskie LNG	European gas grid and redistribution by truck. Maritime and rail based redistribution and bunkering is under discussion. Planned operational start: December 2014.
Klaipeda, Lithuania	TBD	170 000	Klaipeda's Nafta	FSRU designed to connect to the local gas grid. Planned to be operational by December 2014.
Regional terminal, Gulf of Finland	TBD	300 000	TBD	Regional terminal for the Baltic energy market area located in either Finland (Inkoo) or Estonia (Paldiski).
Tallin Muuga, Estonia	Open	TBD	Vopak /Elering	Local gas hub in the first phase, regional open access hub in the second phase.
Rauma, Finland	TBD	10 000	AGA	Work on the terminal is set for completion in early 2017. The Finnish government has decided on financial support to Rauma.
Pori, Finland	TBD	30 000	Gasum/ Skangass	Regional terminal dedicated to the Finnish gas market with planned truck distribution. Planned operation in 2016. Finnish government support has been granted.
Turku, Finland	TBD	30 000	Gasum/ Skangass	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	Terminal mainly for industrial use. Unloading to trucks and vessels is under discussion. Planned operation by 2017. Finnish government support has been granted.
Lübeck, Germany	TBD	TBD	TBD	LNG station in the Port of Lübeck planned to be completed 2016. Bunkering and storage.
Hamburg, Germany	Closed	5 500	Bomin/Linde	Terminal with loading/unloading of trucks, containers and ships. Option to expand. Planned operation by 2015.
Gävle, Sweden	TBD	30 000	Skangass	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 2018.
Gävle, Sweden	TBD	TBD	Swedegas	Terminal in Gävle, potentially with a connected gas pipeline infrastructure.
Sundsvall, Sweden	TBD	5 000	TBD	Terminal dedicated to industrial purposes and transportation. Planned loading to trucks and rail distribution.
Gothenburg, Sweden	Open	30 000	Vopak /Swedegas	Redistribution by truck and through a connection to Swe/Dan gas grid as well as bunkering is under discussion.
Malmö/ Copenhagen, Sweden/ Denmark	TBD	10 000	TBD	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	Terminal for marine purposes. Possible loading of trucks.
Helsingborg, Sweden	TBD	<15 000	TBD	Redistribution by truck, train, maritime and through local gas grid as well as bunkering is under discussion.
Rostock, Germany	TBD	360 000	Gazprom	Planned operation by 2016
Trelleborg, Sweden	TBD	TBD	TBD	Project starts in 2014. Terminal for marine purposes.
Hirtshals, Denmark	TBD	TBD	TBD	Small tank for bunkering of ferries.

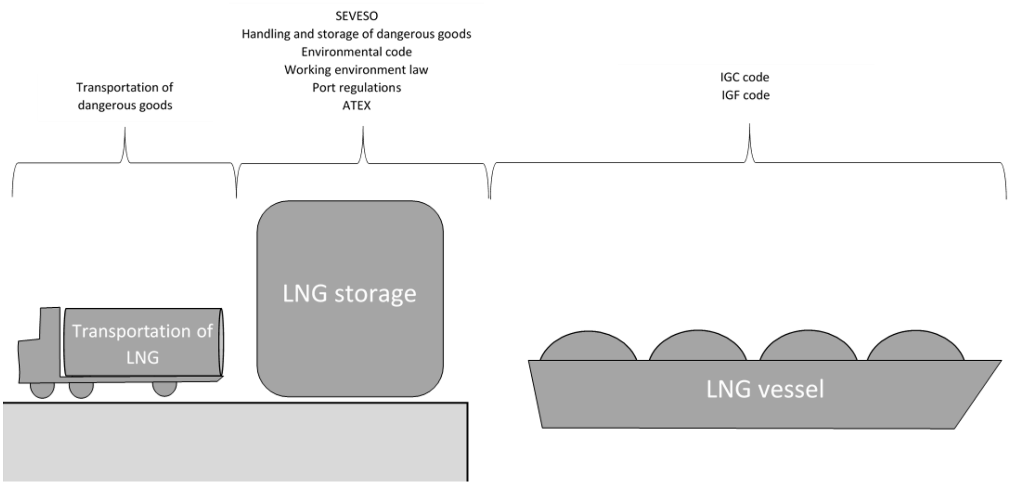
There are several issues that need to be considered with applications for LNG bunker operations and the establishment of LNG terminals: regulative work, technical, financial and security and risk and safety aspects, among others.

From a regulative perspective, an LNG project can be divided into two parts: the maritime side which is usually regulated by a national authority, and the land side that is usually covered by a local authority (e.g. national Maritime Authorities and affected municipalities/rescue agencies), but other authorities may/need be consulted and/or grant permits for specific activities. Road transports are regulated by the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) applicable from 1 January 2013.



During the planning and development phase of an LNG terminal, it is necessary that different stakeholders and responsible authorities have regular communication, enabling a clear project outline and discussions of different alternatives, opportunities, risks etc.

The illustration gives a picture of the regulations and conventions that are relevant for each step of the supply chain.



The ports that have participated in the first phase of LNG in Baltic Sea Ports have gained important experiences, which can assist following ports in the development of LNG. The experiences are summarized in the list below.

- As a first step, a clear distinction should be made of the roles in establishing the LNG terminal. The port is most often the owner of the land, while the investment in the terminal can be the responsibility of the port, the municipality, the gas supplier and/or the operator. Determining the different investment roles is important at project start.
- The development of an LNG terminal and the volume estimations must be based on demand, which implies that a thorough analysis of demand and market must be performed. This analysis must include the land based demand, as this is crucial for obtaining volumes that are large enough for the establishment. To avoid over establishment of LNG supply, cooperation between ports is recommended.
- The permit process takes time and can be costly for the port. One lesson learned is that the process for LNG is often unknown to the authorities involved, and therefore the process takes even longer time.
- The regulations controlling LNG are several: international directives and conventions, as well as national laws and local regulations. Finding and involving the relevant authority responsible for LNG is sometimes difficult.
- Risk and safety is deemed as crucial when planning for LNG, when discussing it with the relevant authorities, and when applying for a permit. Training of staff in risk and safety measures is necessary.

- Land use and design: for the design of the LNG terminal, the land use and the surrounding area must be designated. The technical equipment needed in the terminal increases the land use significantly.
- Financial aspects: it is very important to find ways of cooperation with stakeholders, in order to share the investment cost for the terminal. In an early stage of the planning process, it is necessary to start a dialogue with financers, gas suppliers, operators etc, for identifying financing solutions.

LNG in Baltic Sea Ports

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Abbreviations and Definitions

Abbreviation	***Explanation***
AIS	Automatic Identification System
BLEVE	Boiling liquid expanding explosions
BOG	Boil off gas
BPO	Baltic Port Organization
CAPEX	Capital Expenditure
CNG	Compressed Natural Gas
DNV	Den Norske Veritas
dwt	Dead Weight Tonnage (tot weight of a ship's cargo, fuel, etc.)
ECA	Emission Control Area
EIA	Environmental Impact Assessment
FBT	Flat Bottom Tank
FEED	Front End Engineering Design
FID	Final investment decision
FOB	Free On Board (with regard to bunker prices)
FSRU	Floating Storage and Regasification Unit
GIIGNL	The International Group of Liquefied Natural Gas Importers
GHG	Green House Gas
GT	Gross Tonnage (an index of ship's overall internal volume)
HFO	Heavy Fuel Oil
IGC	International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk
IGF	draft International Code of Safety for Ships using Gases or other Low flashpoint Fuels
IMO	International Maritime Organization (www.imo.org)

Abbreviation	***Explanation***
ISO	International Organization for Standardization
ISPS	The International Ship and Port Facility Security Code
ITPS	Intermediary Tank via Pipeline to Ship (LNG bunkering concept)
LFL	Lower Flammability Level
LNG	Liquefied Natural Gas
MARPOL	The International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto.
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MMbtu	Million British Thermal Unit, 1 MMBtu = 293 kWh = 1.055 MJ
NBP	The National Balancing Point, commonly referred to as the NBP, is a virtual trading location for the sale and purchase and exchange of UK natural gas. Together with TTF it is use as the main indicator of the natural gas price in Europe.
Nm	Nautical miles
OGP	International Association of Oil and Gas Producers
OPEX	Operating Expenditures
RPT	Rapid Phase Transition
SECA	Sulphur Emission Control Area
STS	Ship To Ship (LNG bunkering concept)
TTS	Truck To Ship (LNG bunkering concept)
UFL	Upper Flammability Level

1 INTRODUCTION

1.1 Background to the project

The project *LNG in Baltic Sea Ports,* partly financed by TEN-T, supports and initiates the establishment of LNG terminals in participating ports. The ports that participate are: Stockholm, Helsinki, Turku, Tallinn, Copenhagen-Malmö, Aarhus and Helsingborg.

Some of the ports have reached far in their planning and development for supplying LNG to ships. Stockholm, for example, has a functioning LNG supply chain for the ferry Viking Grace. Port of Helsinki has a functioning LNG supply chain for the coast guard vessel Turva. Other ports are planning for and acquiring permits for the establishment.

1.2 Background to the Handbook

One of the main purposes of the project LNG in Baltic Sea ports is to find good solutions and manageable ways of establishing LNG in ports, in order to supply LNG to end users. The ports that have participated in the project have all gained experiences and have reached far in striving towards LNG establishment.

It is also equally important to disseminate the results from the project, in order to facilitate the establishment of LNG in other ports in the Baltic Sea area, and the rest of Europe as well.

The experiences gained from the participating ports are therefore summarized in this handbook, created for supporting ports in their work of planning and developing LNG.

1.3 Objective

The objective of this handbook is to provide information based on previous experiences, in order to facilitate the establishment of LNG as ship fuel in ports in the Baltic Sea area.

1.4 Method

The elaboration of the LNG Handbook is based mainly on the results and findings of the LNG projects in the participating BPO ports. Some other relevant experience from ports in the Baltic Sea area are also included in the assessment of obstacles and possibilities during the development and establishment of LNG as marine fuel.

The participating ports have been visited and/or interviewed, and the results and findings have been compiled into these recommendations and guidance for other stakeholders.

1.5 Outline of the handbook

The handbook outline is based on the process of developing an LNG terminal, and the phases that are connected to this process (planning, construction, production, operation, bunkering etc).

The handbook starts with an overview of the status of LNG supply in the Baltic Sea countries today, including future scenarios, and possible market and supply chain development.

The general process of establishment is described, looking specifically at technical, financial and safety aspects.

The obtained experiences from the participating ports are described and discussed. The experiences are summarized into obstacles and possibilities for the development of LNG, from a technical, financial and safety viewpoint, and to conclude, a checklist to ports for LNG development is given.

2 LNG IN THE BALTIC SEA, AN OVERVIEW OF STATUS

Several projects have contributed to the development of LNG infrastructure in the Baltic Sea Region. This chapter gives an overview of LNG terminal statuses and estimations on the LNG market development.

2.1 Existing and planned terminals

There are a number of LNG terminal projects in the Baltic Sea Region of various capacities. While some projects have resulted in constructed LNG terminals, other LNG terminals are planned and/or under discussion. Of the existing terminals in the Baltic Sea Region, listed in Table 1, there is none of large scale. Large scale terminals have a capacity of more than 100 000 m^3 LNG. Both of the existing are of the type closed, meaning that the storage capacity is reserved by the operator of the terminal. An open access terminals implies that independent LNG suppliers may reserve capacity in the terminal.

Table 1. Existing terminal projects in the Baltic Sea Region.

Terminal	Type	Capacity	Operator	Status	Comment
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

The majority of terminals under discussion are medium scale terminals, approximately larger than 10 000 m^3 LNG. A few large scale terminals are under consideration in the northeast part of the Baltic Sea Region. Table 2 gives examples of planned terminals, but is not exhaustive as new plans are made continuously. Figure 1 shows a map of existing and planned terminals/bunkering possibilities in the Baltic Sea Region.

Table 2. Planned terminal projects in the Baltic Sea Region. (TBD= To Be Determined)

Terminal	Type	Capacity (m^3)	Operator	Comment
Lysekil/ Brofjorden, Sweden	Closed	30 000	Skangass	Local gas delivery to refinery and redistribution by truck. Maritime redistribution by bunker barge. Planned operation by Q4 2014.
Świnoujście, Poland	Open	320 000	Polskie LNG	European gas grid and redistribution by truck. Maritime and rail based redistribution and bunkering is under discussion. Planned operational start: December 2014.
Klaipeda, Lithuania	TBD	170 000	Klaipeda's Nafta	FSRU designed to connect to the local gas grid. Planned to be operational by December 2014.
Regional terminal, Gulf of Finland	TBD	300 000	TBD	Regional terminal for the Baltic energy market area located in either Finland (Inkoo) or Estonia (Paldiski).
Tallin Muuga,	Open	TBD	Vopak	Local gas hub in the first phase, regional open

Estonia			/Elering	access hub in the second phase.
Rauma, Finland	TBD	10 000	AGA	Work on the terminal is set for completion in early 2017. The Finnish government has decided on financial support to Rauma.
Pori, Finland	TBD	30 000	Gasum/ Skangass	Regional terminal dedicated to the Finnish gas market with planned truck distribution. Planned operation in 2016. Finnish government support has been granted.
Turku, Finland	TBD	30 000	Gasum/ Skangass	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	Terminal mainly for industrial use. Unloading to trucks and vessels is under discussion. Planned operation by 2017. Finnish government support has been granted.
Lübeck, Germany	TBD	TBD	TBD	LNG station in the Port of Lübeck planned to be completed 2016. Bunkering and storage.
Hamburg, Germany	Closed	5 500	Bomin/Lin de	Terminal with loading/unloading of trucks, containers and ships. Option to expand. Planned operation by 2015.
Gävle, Sweden	TBD	30 000	Skangass	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 2018.
Gävle, Sweden	TBD	TBD	Swedegas	Terminal in Gävle, potentially with a connected gas pipeline infrastructure.
Sundsvall, Sweden	TBD	5 000	TBD	Terminal dedicated to industrial purposes and transportation. Planned loading to trucks and rail distribution. Two bunker vessels planned.
Gothenburg, Sweden	Open	30 000	Vopak /Swedegas	Redistribution by truck and through a connection to Swe/Dan gas grid as well as bunkering is under discussion.
Malmö/ Copenhagen, Sweden/ Denmark	TBD	10 000	TBD	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	Terminal for marine purposes. Possible loading of trucks.
Helsingborg, Sweden	TBD	<15 000	TBD	Redistribution by truck, train, maritime and through local gas grid as well as bunkering is under discussion.
Rostock, Germany	TBD	360 000	Gazprom	Planned operation by 2016
Trelleborg, Sweden	TBD	TBD	TBD	Project starts in 2014. Terminal for marine purposes.
Hirtshals, Denmark	TBD	TBD	TBD	Small tank for bunkering of ferries.

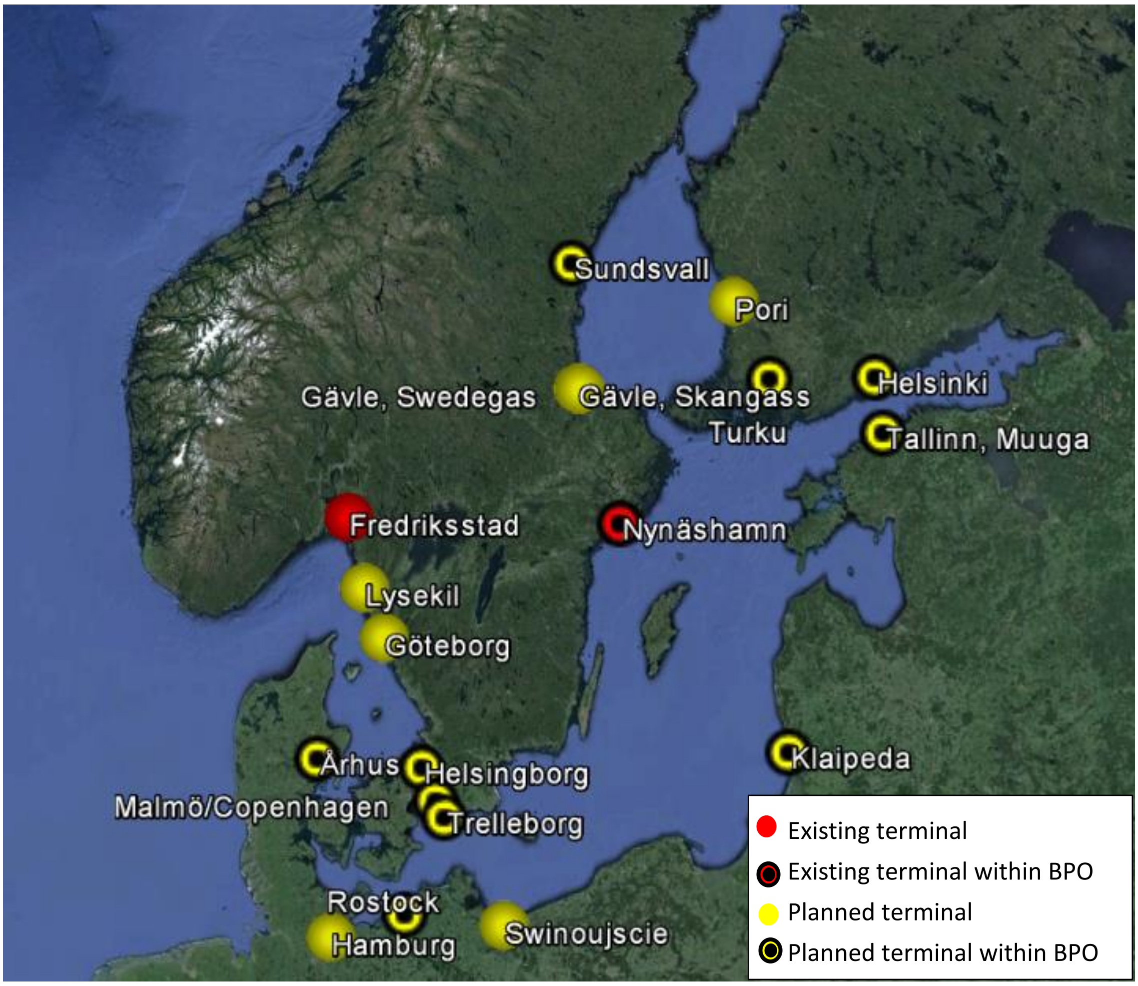


Figure 1. Planned and existing LNG terminals in Baltic Sea region.

Planned terminals in the eastern parts of the Baltic Sea Region aim for an alternative source of gas for the national gas grid infrastructure besides the marine distribution. This increases security of supply.

2.2 Prognosis for LNG vessels

Several factors will affect the development of LNG vessels. Uncertainties regarding global trends, forces and technological development are difficult challenges. More and more geographical areas will have emission restrictions, so called emission controlled areas (ECA), boosting the number of LNG fuelled vessels. North America already have ECA, while Asia, specifically Singapore and Hong Kong will have stricter restrictions from 2020 (DNV, 2013). The stricter regulation of sulphur in Northern Europe (SECA) will also affect the development.

The price of LNG, tied to global trends in global economy, and the transport demand is one perspective. Maritime regulations and technical developments are other identified factors.

Different studies indicate that liner traffic and vessels with regular routes initially are the types of vessels assumed to convert to LNG propulsion. It is also reasonable to assume that more new-buildings than retrofits will be LNG fuelled due to the fact that it is less expensive compared to a retrofit. This makes the transition to LNG long-term compared to other SECA compliance strategies, such as using scrubbers or switching to MGO.

In March 2014 there were in total 101 confirmed LNG fuelled ship projects (DNV GL, 2014). Figure 2 shows the development of the LNG fuelled fleet.

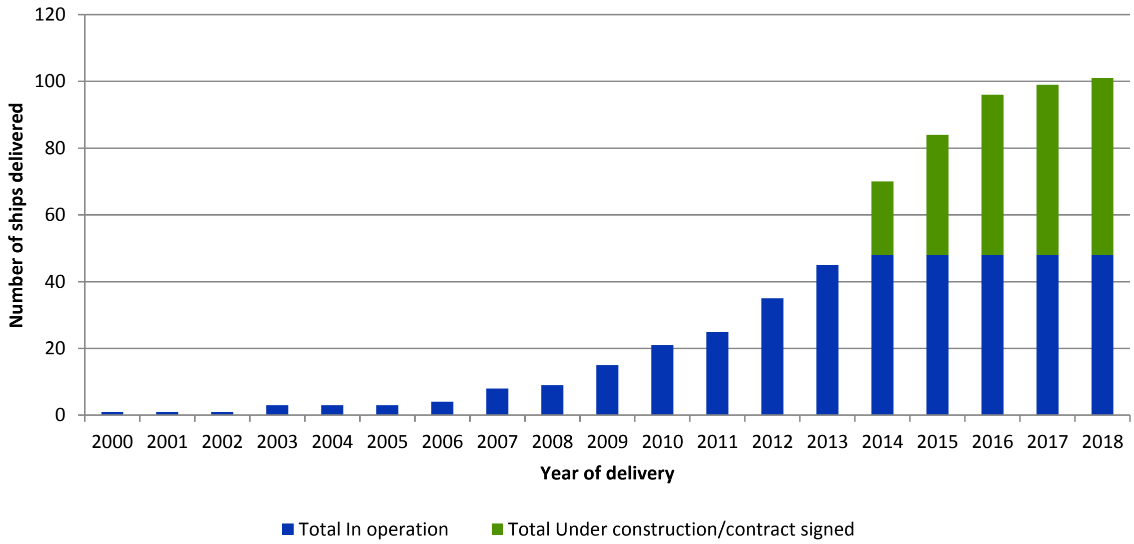


Figure 2. Development of LNG fuelled fleet. Confirmed projects in 2014-03-07 (DNV GL, 2014)

The number of LNG fuelled ships through 2020 depends heavily on fuel prices. With a LNG price 10% above heavy fuel oil (HFO), it has been estimated that 7-8% of the new-buildings between 2012 and 2020 will run on LNG. If the LNG price would go down to 30% below HFO, the uptake of LNG is expected to increase to 13% and, in the extreme case of LNG price 70% below HFO, the LNG share of new-buildings is 30 % (DNV GL, 2014).

2.3 Market development and LNG availability

The availability of LNG in the North European and Baltic Sea market can be connected to two main developments; the development of a small scale distribution network for LNG in the North European countries, and the costs of such an infrastructure on one hand, and the availability of LNG shipped to Europe on the other hand.

The small-scale infrastructure in the Baltic Sea region in the near future (up to 2017) will offer different sourcing alternatives for LNG to a terminal. Depending on the size of the terminal, sourcing possibilities looks different. For a medium scale terminal, serving demand from the maritime side as well as local industrial customers and other land based users, it might be possible to serve a medium scale terminal with a feeder vessel. A medium size or a small size terminal could also be served by truck loads from larger terminal establishments in the vicinity.

In the last couple of years, due to the relatively high price levels in Asia, very few spot LNG supply vessels have been going to Europe. Possibly, this situation will change in the near future due to American gas export permits. It is not likely though that this will have large effects on pricing levels neither for the Asian nor the European markets. Figure 3 shows estimated world LNG prices in September 2014 where the highest prices were found in Asia and the lowest in North America.

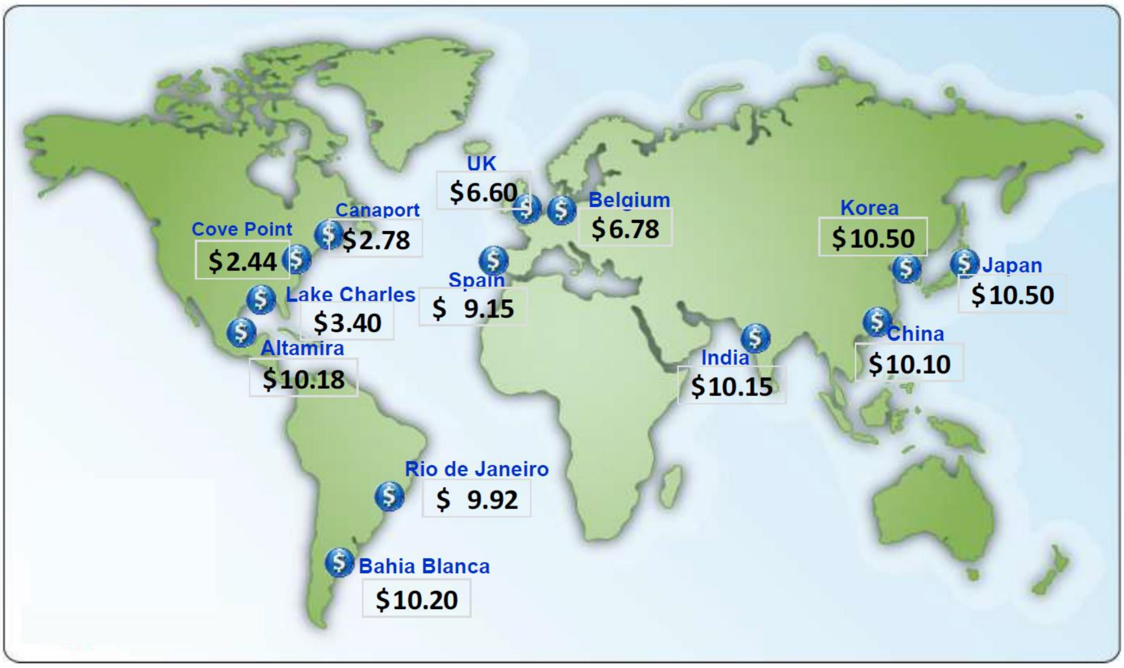


Figure 3. Estimated world LNG prices September 2014 in $US/MMBtu (Waterborne Energy Inc, 2014).

When evaluating the potential market for, and the price of LNG supplied to the maritime sector, the development of the underlying demand of LNG in combination with availability and price is considered as the dominating factors. In a more local perspective, factors like EU project support and governmental initiatives, such as the Norwegian NOx Fund and the Finnish government support for small scale LNG infrastructure, will strongly influence the development of LNG.

The FOB price, which is the price of LNG delivered as bunker fuel, consists of two main cost components. The first is the market price of LNG, based on the HUB price of gas. The second cost component is the supply cost that occurs when moving the LNG from the LNG source to each specific user.

Since the HUB cost is difficult to influence, the main focus when developing a supply chain for LNG as marine fuel is to create the most cost efficient supply chain that is possible, in order to meet the demand of the client in terms of both availability and price.

Seen in a long term perspective, the price development of LNG and NG compared to crude oil related products such as the traditional ship fuel looks very promising, primarily dependent on the lower consumptions to reserves ratio for NG. For crude based products there are also a lot of less price sensitive consumers within other industries than energy and transportation, such as plastics, lube oil etc.

2.3.1 Future market scenarios

There are many scenarios outlining probable future demand of LNG. DNV GL have forecasted the bunker demand in 2020 to 4 -7 million tonnes globally, based on that there will be 1000 LNG fuelled vessels. The demand in Europe and the Baltic Sea has been forecasted to 1.4 – 2.2 million tonnes (DNV GL, 2014), see Figure 4.

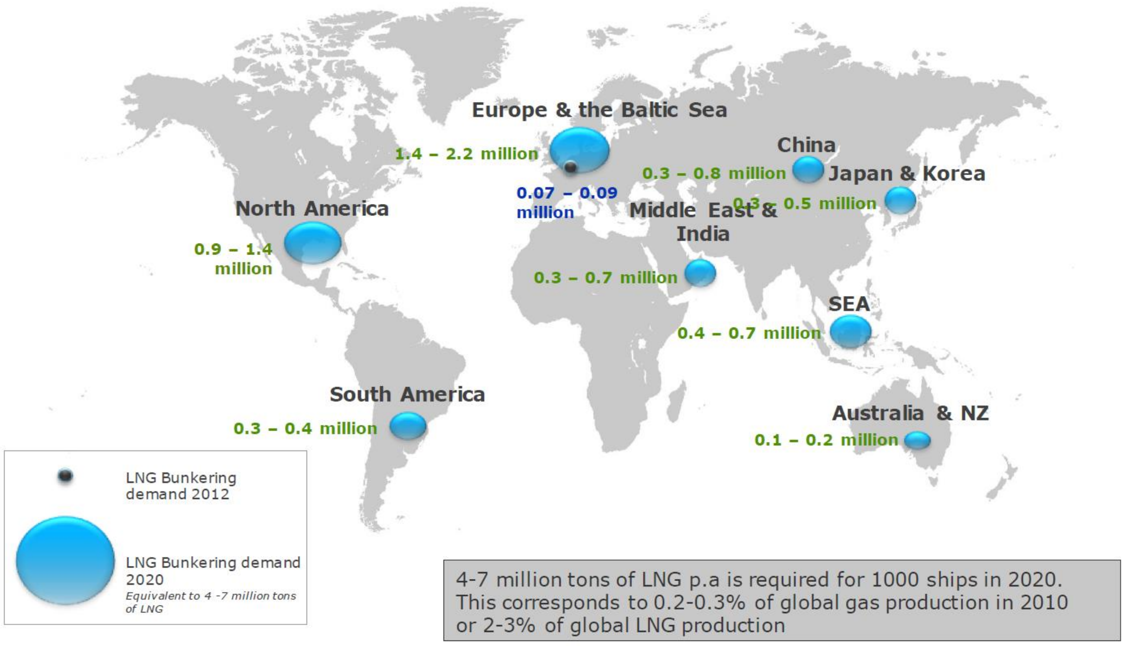


Figure 4. Global LNG bunker demand by 2020 (Océane Balland DNV GL, 2014)

For a scenario of 2030 while business as usual is assumed, Lloyds Register Marine & University College London (2014) has forecasted the share of LNG as shipping fuel on a global market to 11 %. According to an analysis by Pöyry (2013), a higher share, 29 %, is likely in the Baltic Sea region.

In a study by DMA (2012), the total demand of LNG by 2020 in SECA has been forecasted to 4 million tonnes annual. Figure 5 is showing the forecasted demand in different sub-regions for ships spending 100 % of their time is SECA (total demand from these vessel types is about 2 million tonnes).

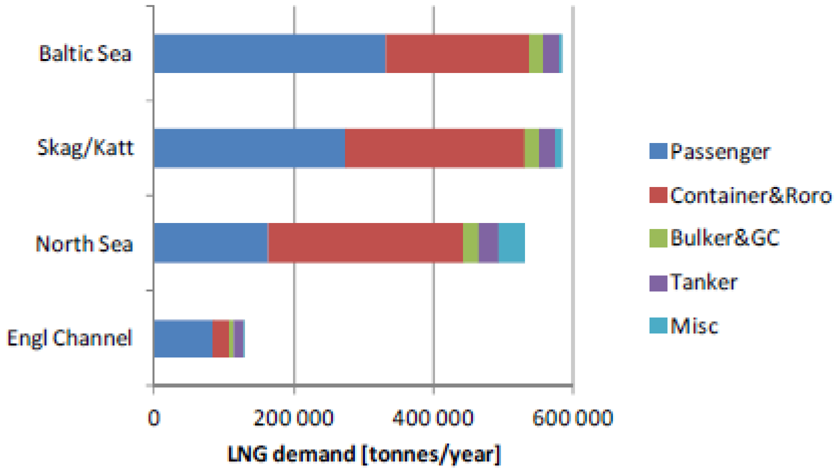


Figure 5. Annual LNG demand 2020 for different sub regions of the SECA for ships being 100% of the time in SECA (DMA, 2012).

It is reasonable to believe that the land-based LNG market and the LNG maritime market will be closely connected in the future, enabling to sign long term supply contracts, hence securing the terminal investment. Within the BPO projects, local market analyses have been performed for the participating ports. From these, it can be concluded that most of the planned terminals rely on land-based demand in addition to the expected demand from shipping. For those ports that have not identified any land-based demand, the volumes of LNG are smaller and demand predictions are difficult to make.

3 ESTABLISHING AN LNG TERMINAL

3.1 General procedure of establishment

There are several issues that need to be considered with applications for LNG bunker operations and the establishment of LNG terminals: regulative work, technical, financial and security and risk and safety aspects, among others. This chapter give a general overview of the process of establishing an LNG terminal, from a regulative, technical, financial, safety and security perspective.

3.2 Regulations

When planning for an LNG terminal and associated activities, a number of rules and regulations need to be considered to get a permit approval. The regulative process seen from an EU perspective is illustrated in the figure below, where EU directives are agreements between EU states regarding what rules should be included in each nation's laws.

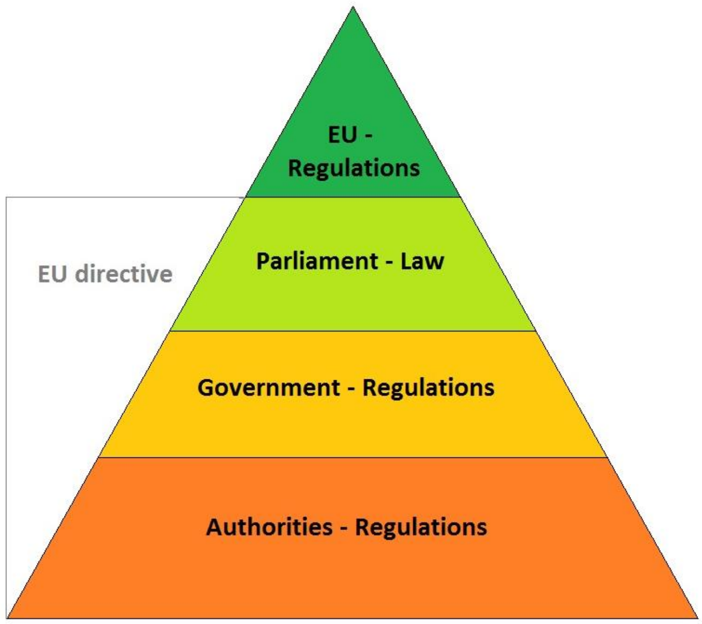


Figure 6. Rules and regulations process from an EU perspective.

On government level the regulative authorities differ depending on aspect but no authority is solely responsible for the whole permit approval.

The overall permit process requires consultation with different authorities and stakeholders for the planned activities, enabling the continued process and collecting opinions and data to be used in the permit process.

From a regulative perspective, an LNG project can be divided into two parts: the maritime side which is usually regulated by a national authority, and the land side that is usually covered by a local authority (e.g. national Maritime Authorities and affected municipalities/rescue agencies), but other authorities may/need be consulted and/or grant permits for specific activities. Road transports are regulated by the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) applicable from 1 January 2013.

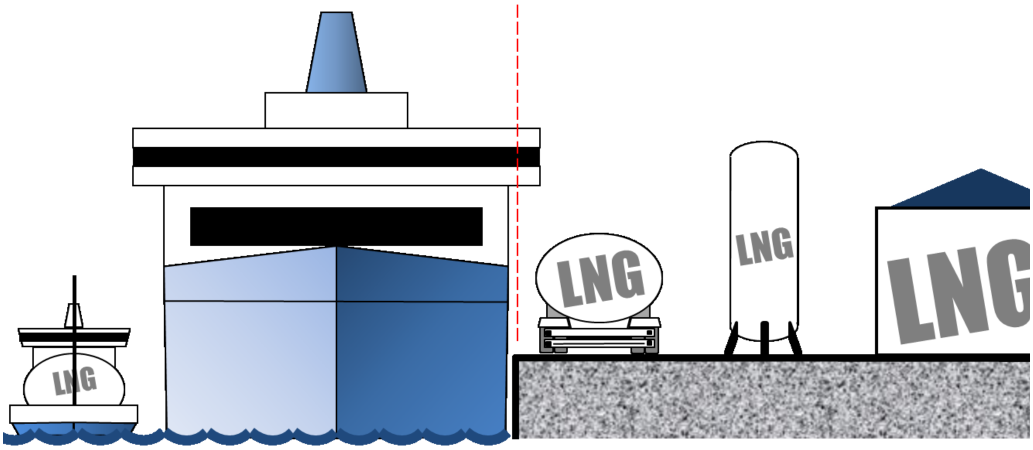


Figure 7.Interface in Denmark between maritime and shore side legislative areas, where the Maritime authority is responsible for the left side, and the municipality is responsible for the land side. (DMA, 2014)

During the planning and development phase of an LNG terminal, it is necessary that different stakeholders and responsible authorities have regular communication, enabling a clear project outline and discussions of different alternatives, opportunities, risks etc.

3.2.1 Permits

Once the terminal layout and the different activities have been decided upon, the regulative/legal permit process can start and consideration must be taken to both safety and environmental issues. Note that the permit process can start earlier, but there is a risk that permit application details will change along the way if not discussed thoroughly at project start, and/or that the permit application is incomplete, resulting in longer permit process times.

Necessary permits are: Building permit, environmental permit and permit for handling and storage of dangerous goods. If distribution is to be performed with pipelines and/or truck, additional regulations in accordance with pipeline regulations/transportation of dangerous goods are applicable. Import by LNG carrier requires a permit for the port. The land-use is usually regulated in a municipal local plan (*detaljplan* in Sweden, *lokalplan* in Denmark). If the regulations in the plan do not include handling of LNG, a process for correction of the local plan is required.

The illustration in Figure 8 shows schematically the different laws and regulations that need to be considered for various parts of the LNG handling.

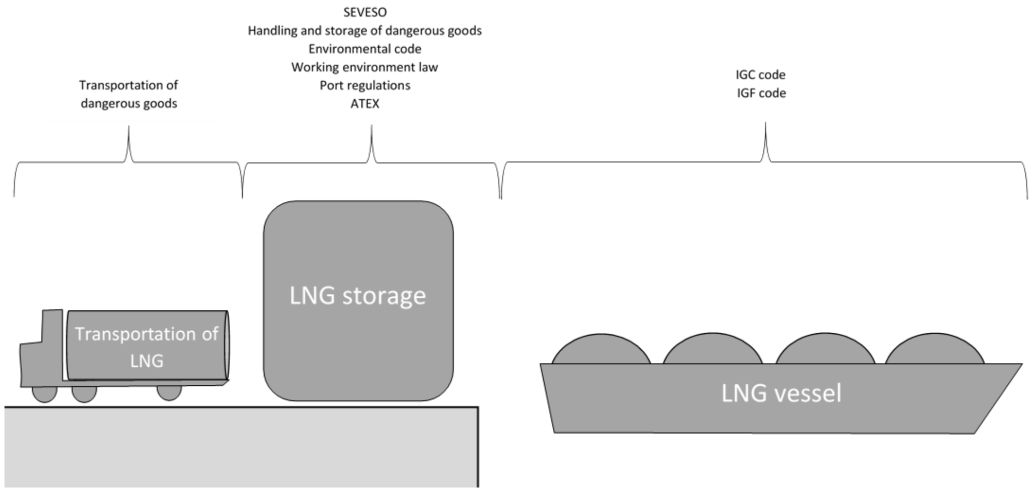


Figure 8. Laws and regulations to be considered for LNG handling.

To enable construction and operation, the impact of the installation on the environment must be assessed and a permit will be given according to the national government's Act on environmental protection. Smaller quantity terminals are usually handled by the Municipality.

The environmental permit process requires an Environmental Impact Assessment (EIA). The act on environmental protection gives instructions on what an EIA shall include and once the location is set, a detailed EIA is performed. The threshold value when EIA is required varies between governments, e.g. in Sweden and Denmark the limit is 200 tonnes stored LNG, while in Finland, the need for an EIA is decided from case to case.

In Table 3, an overview of the steps in the regulative process for the construction and operation of a LNG terminal is presented.

Table 3.Short descriptive table overviewing the steps of the regulative process for an LNG terminal establishment.

Step	Permitting Authority	Comment
Initial consultation	The Municipality	Responsible authorities and stakeholders discuss possibilities, risks etc.
Feasibility study	Approval by the port	Ordered by port/stakeholders to get a focused and specific outline of the project.
Consultation document	The Municipality	Generates necessary information for further decisions regarding the project proposal.
Occupational health	Work Environment Authority/Municipality	Included in the building permit. Requires a written action program according to Seveso.
Risk assessment	The Municipality	Includes QRA, HAZID and

process		consultation, further described in 3.6.2
Building permit application	The Municipality	Licence for construction
Environmental permit application	Ministry of Environment/ Municipality/County	Including full EIA. Scope and permitting authority is dependent on stored quantity at the terminal.
Permit for handling and storage of dangerous goods	The Municipality/Regional rescue services	Licence for handling and storing dangerous goods

Seveso is a European Directive for consequence reduction in the case of a serious chemical accident that is applied to around 10 000 industrial establishments where dangerous substances are used/stored in large quantities; chemicals, petrochemicals, storage, and metal refining sectors. All installations holding storage of more than 50 tonnes (1 tonne ≈ 2.32 m^3, 50 tonnes ≈ 116 m^3) of LNG fall under the scope of the Seveso Directive. Establishments with more than 200 tonnes (≈464 m^3) also require a safety report and an action program. The operators of such installations are also obligated to regularly inform the public likely to be affected by an accident, providing safety reports, a safety management system and an internal emergency plan. The process, permits and operations concerning risk and safety is further described in section 3.6.

For the maritime side, all installations where LNG is used as fuel, the IMO MSC.285(86), ”Interim guidelines for natural gas-fuelled engine installations in ships” is applicable, awaiting the IGF Code (The draft International Code of Safety for Ships using Gases or other Low flashpoint Fuels). For LNG carriers, the IGC Code is applicable (the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk).

There is currently no common regulatory framework addressing the LNG bunkering in the EU. On the other hand, various safety standards and regulations, making initiatives in relation to the LNG bunkering developments, have been produced, including the preparation of international guidelines for the LNG bunkering (BV, 2014) and LNG bunkering guidelines developed at International Standardisation Organization (ISO), ISO TC 67 WG10.

3.2.2 Specific example of amendments

Within the project LNG in Baltic Sea ports, the Ports of Stockholm has elaborated a safety manual with LNG specific check lists as a complement to the port regulations and guidance for training needs. Within this work, different authorities and rules applicable in different links of the LNG supply chain have been identified and mapped. This is illustrated in Figure 9.

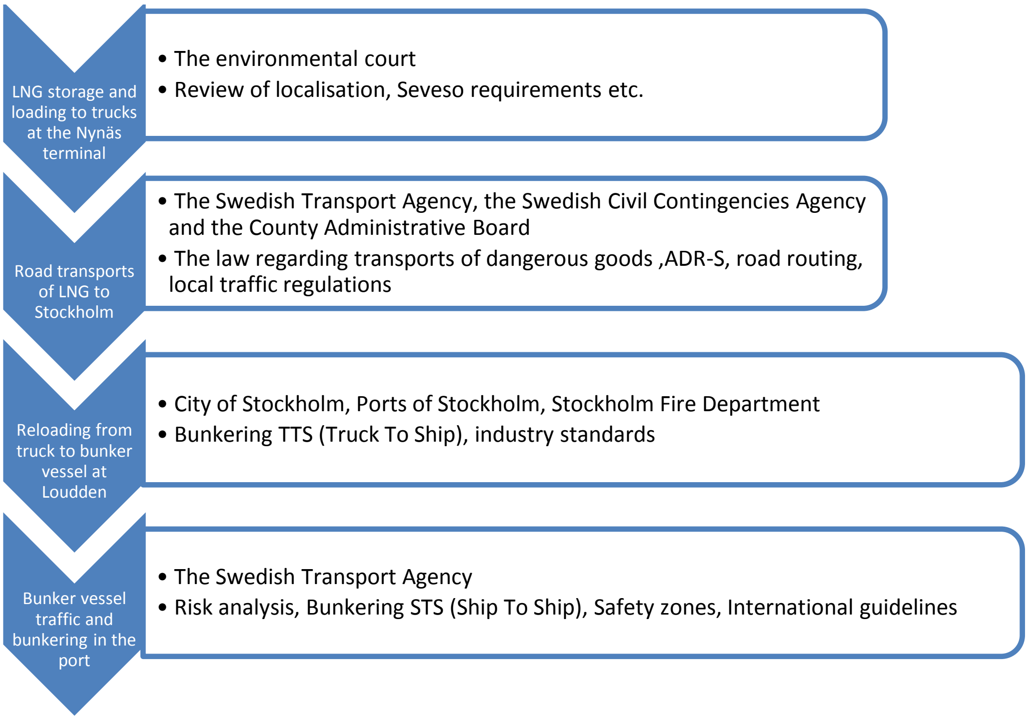


Figure 9. Example of authorities and rules applicable in different links of the LNG supply chain.

3.3 Technical aspects and logistics

3.3.1 Technical equipment and tanks

An LNG terminal functions as a link in the supply chain between import and local and/or regional markets. Depending on activity and function, the terminal includes a storage facility for imported volumes and a distribution system from terminal to end users. Figure 10 shows a schematic flow diagram of terminal activities.

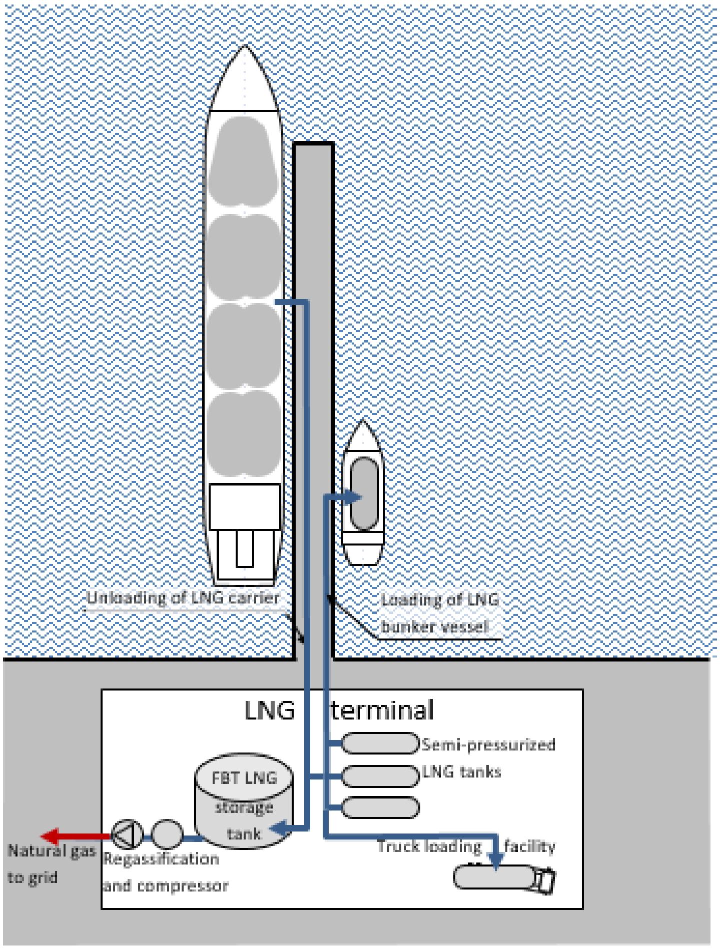


Figure 10. Schematic flow diagram of terminal activities.

In the localization process for the terminal, several aspects need to be considered, for example;

- Water depth at the quay and need for dredging
- Characteristics of the ground and sufficient stability where the storage tank/s are to be located
- The surrounding infrastructure and possible distribution systems; tank trucks, pipeline, feeder vessel
- Possible need for BOG (Boil Off Gas) handling

There are two different main types of storage tanks; semi-pressurised tanks, illustrated in Figure 11, and Flat Bottom Tank (FBT), illustrated in Figure 12.

Figure 11. Example of semi-pressurized tanks

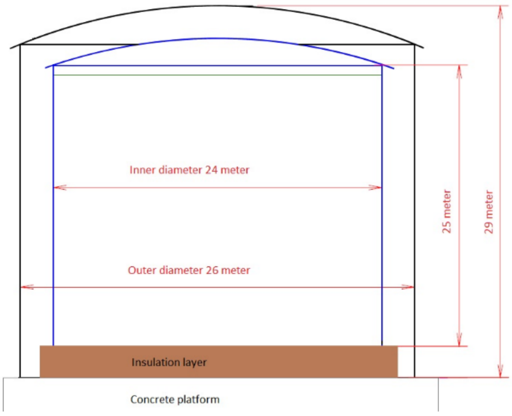


Figure 12. Example of design and dimensions for a FBT

Both types of tanks have double walls to minimise boil-off. The better the insulation, the lesser the boil-off, even if it can never be totally prevented. An FBT tank stores LNG under atmospheric pressure while a semi-pressurised tank can store LNG under pressure (approximately 12 bars). In Table 4 and in Table 5, respectively, some of the main points in regards to evaluating site-built FBT versus vacuum-insulated semi-pressurized tanks are summarized.

Table 4. Pros and cons of FBT as LNG storage technique

Advantages of FBT	Disadvantages of FBT
One tanks as opposed to several	Atmospheric, requiring downstream user or boil off system
Keeps temperature of LNG low	Generally more expensive for smaller tanks
Generally allows for larger filling and discharge	Requires continuous operational management
Lower cost solution for larger volumes	Generally larger project period
	Depending on size roll-over protection to be required

Table 5. Pros and cons of semi-pressurized tanks

Advantages of semi-pressurized tanks	Disadvantages of semi-pressurized tanks
Requires less operational staff.	As pressure rises the LNG becomes warmer
Easier to scale tank park as change of consumption	Filling and discharge from several tanks
Longer holding time, easier pressure management and sectioning	
Generally easier foundation work	
Less onsite work, which reduces risk of weather prolonging installation period	
Possibility to start-up operations earlier	

The land area needed depends on the physical dimensions of the terminal and associated activities. A full activity terminal, including areas for loading and unloading of LNG, taking into account both berths and tank truck filling stations, areas for piping, possible liquefaction equipment and safety distances, usually generates a total terminal area of about 30,000 to 40,000 m^2. Figure 13 shows the layout for the planned terminal in Gothenburg with both semi-pressurised tanks and an FBT.

Figure 13. Principal layout of the planned terminal in Gothenburg.

In addition to storage tanks, other major technical components to consider for the terminal are:

- Loading and circulation pumps
- Cryogenic pipelines
- Loading/unloading arms and/or hoses
- BOG handling compressors

3.3.2 Bunkering

Methods for bunkering are generally divided into:

- Ship-to-ship bunkering (STS)
- Truck-to-ship bunkering (TTS)
- Intermediate tank-to-ship bunkering, via pipeline (ITPS)

The main types of LNG bunkering are shown in Figure 14.

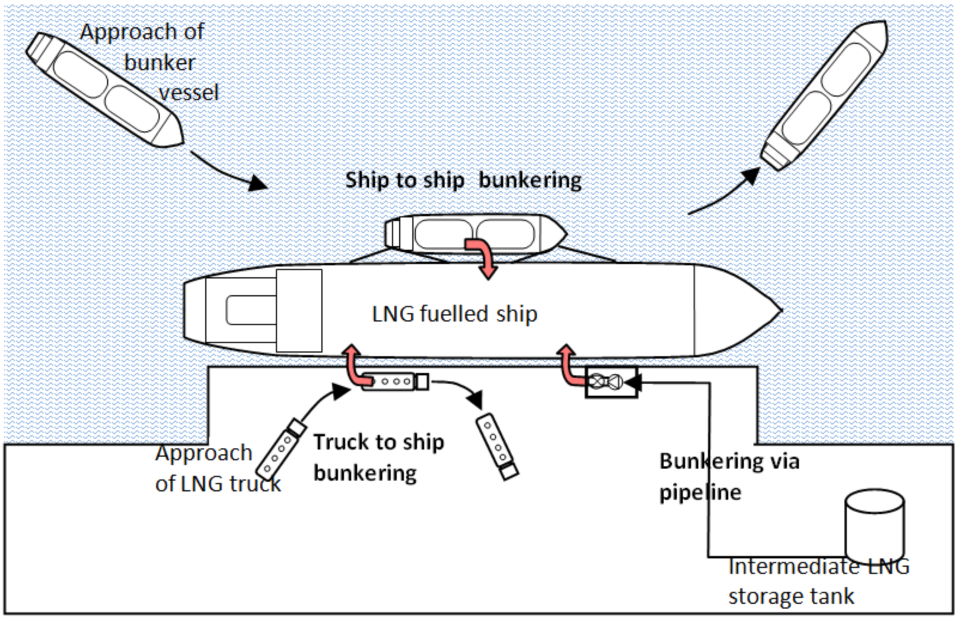


Figure 14. Methods of bunkering (SSPA Sweden AB)

Bunkering ship-to-ship requires less space since this does not cause any installation ashore. For ports where the demand of LNG is spread out in different locations of the harbour, this alternative might be the most favourable. This is the case for Helsinki where the demand of LNG is assumed to be spread out in different parts of the port. Both tank-to-ship and truck-to-ship implies fixed installations ashore which may constrain the accessibility for some vessels.

In order to select the best suitable solution for an individual port, parameters such as bunkering volumes, physical limitations and logistical issues need to be considered. The total LNG volume to be handled on a yearly basis in a port is perhaps the most important critical parameter that affects the suitable solution for LNG bunkering of vessels. Also the bunker frequency and the size of vessels are two very central issues when selecting appropriate method. Requirements of large bunker volumes per vessel and also high bunkering speed, point towards STS solutions rather than TTS. However, a high bunker frequency of smaller vessels in a port probably also require a supplementary land-based system (ITPS) in order to be able to handle all vessels, especially if there are physical limitations in the port basin.

A useful standard for finding what materials to use for the construction of the terminal is the European standard EN1160 "*Installations and equipment for liquefied natural gas. General characteristics of liquefied natural gas*".

Special requirements for LNG facilities can be found in:

- EN 13645:2001 "Installation and equipment for liquefied natural gas. Design of onshore installations with a storage capacity between 5 t and 200 t".
- EN 1473:2007 "Installation and equipment for liquefied natural gas. Design of onshore installations".

In addition to the European standards, local regulations, standards and guidelines may be applicable.

3.4 Financial aspects

Similar to other infrastructure projects, the investments are very heavy for the development and construction of an LNG terminal. It is of importance for the project owner to find supplementary financing sources.

Important aspects to consider during the planning phase of the project are:

- An extensive market analysis of potential suppliers, customers, souring and forecast is crucial to estimate the demand of LNG and the financial possibilities for a LNG terminal. The market potential of a terminal can thereby be examined. This step is crucial before starting the process of retrieving permits and designing the terminal.
- Existing onshore demand is important as a basis. Location of an LNG terminal may be decided on onshore demand considerations. There is so far not one single large-scale LNG project being planned or developed in the Baltic Sea Area based on marine fuel use only.
- When starting up a process of LNG development, it is important to start by identifying, starting a dialogue with, and coming to agreement with a gas supplier. The supplier can also be the operator of the facility. Questions to be discussed are for example; sourcing, pricing, ownership, and sharing of investment cost.

3.5 Security aspects

Security of the terminal implies measures for protection of the facilities. If a terminal is to be constructed within the area of an international port, the terminal will most likely be under the International Ship and Port Facility Security (ISPS) regulation and national port regulations regarding port facility security. It is the obligation of the local port administration to meet the regulations. Example of measures to enable a high security of a terminal could be:

- Fencing of the area
- Surveillance of the area
- Only allowing authorized persons within the area. All persons moving in the port area shall carry an identity card with photo.
- Establishment of a security zone

Maritime authorities/authorities responsible for maritime security need to be involved regarding securing the port area and LNG bunker installations according to provisions on maritime security.

3.6 Risk and safety

Risk and safety aspects are composing a major part when an LNG terminal and LNG bunkering possibilities are planned and outlined. As LNG bunkering to ships is relatively new, available accident records cannot be used to derive accurate accident statistics and probability figures. There are not yet any established standards for LNG bunkering installations and procedures, however, there is a number of guidelines and recommended practices concerning risk assessments presented by ISO and other recognized organizations which should be considered:

- Guidance on performing risk assessment in the design of onshore LNG installations including the ship/shore interface - ISO/DTS 16901, 2013-02-20
- Guideline for systems and installations for supply of LNG as fuel to ships – OGP Draft 118683, 2014-01-16
- Guidelines on LNG Bunkering, Bureau Veritas, July 2014
- Recommended practices – Development and operations of liquefied natural gas bunkering facilities, DNVGL, DNVGL-RP-0006:2014-01

3.6.1 Hazards

Hazards associated with the introduction of an LNG terminal can be identified in a number of operational phases, such as import, truck loading, railroad loading, bunker vessel loading and LNG bunkering.

LNG hazards result mainly due to 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 burns
- Asphyxiation – if the air oxygen is replaced methane asphyxiation may occur
- Reduced visibility due to un-ignited vapour clouds
- Thermal radiation from various fire scenarios
    - delayed or immediate ignition of vapour clouds (flash fire), slow fire front

  - delayed or immediate ignition of vapour-air mixture (fire ball), rapid burn
  - LNG pool fires
  - flame jets from leaks in pipes, hoses, tanks or pressure vessels
- Rapid phase transition, RPT
- Vapour 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
- Geysering – expulsion of LNG from a quiescent liquid in piping

The figure below illustrates a pool fire when LNG is spilled on a water surface.

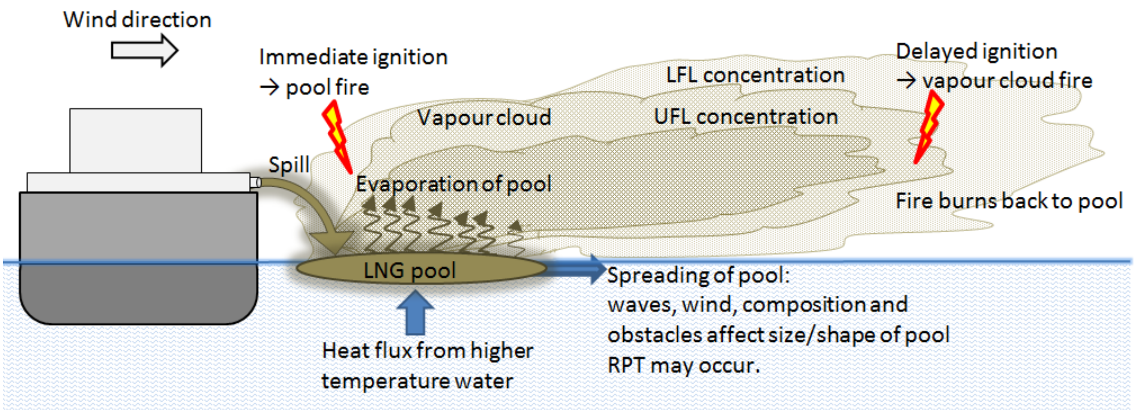


Figure 15. Possible fire scenarios when LNG is spilled on water [SSPA, (Based on Luketa-Hanlin, 2006)].

The level of consequence depends on the direct receiving environment and the behaviour 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 vaporised LNG will initially have neutral buoyancy in air.

3.6.2 Risk assessment process

The structure of the risk assessment process includes basic components according to the figure below.

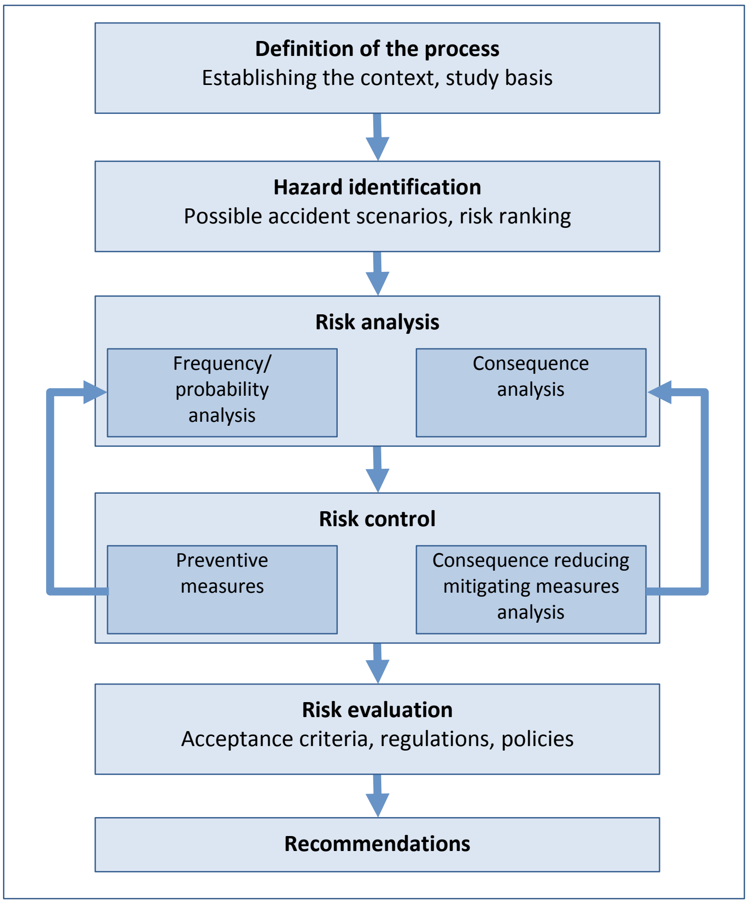


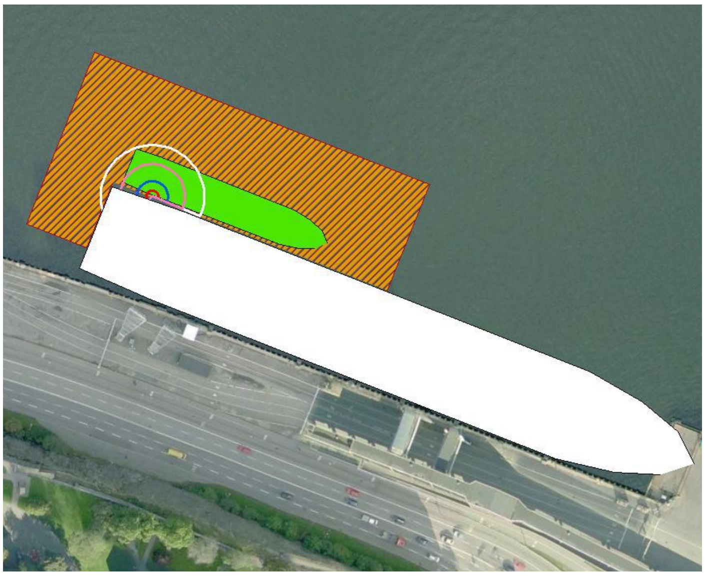
Figure 16. General structure of risk assessment approach.

The draft guidelines from OGP (International Association of Oil and Gas Producers) (OGP, 2013) suggest two different approaches for conducting the risk assessment. These recommendations depend on the characteristics and complexity of the bunkering system and facility. For the non-complex basic case, a set of 24 functional requirements, based on internationally recognised standards and good engineering practices, is formulated. If these 24 functional requirements are met and if there is no cargo handling conducted in parallel with the bunkering and no passengers on board the receiving vessel during bunkering operation, a qualitative risk assessment may be sufficient.

If the bunkering concept deviates from the non-complex base case or if all 24 functional requirements have not been met or if cargo handling is conducted in parallel (SIMOPS, Simultaneous Operations), a more comprehensive quantitative risk assessment (QRA) approach should be undertaken. If passengers will be present on board the receiving vessel during LNG bunkering, acceptance from national competent authorities and all other stakeholders is also required.

3.6.3 Safety zones

One of the primary output results for the risk assessment of an LNG bunkering system and facility is the establishment of adequate safety zones for LNG bunkering operations. The safety zone is the area around the bunkering station on the receiving vessel where only dedicated and essential personnel and activities are allowed during bunkering, see Figure 17.



Safety zones/safety distances:
Range 25 meter in every direction from the bunker vessel and along the whole ferry (orange area).

Only educated and trained personnel are allowed within the safety zone.

The area is an active safety zone only during the bunker operation.

Figure 17. Schematic picture over the safety zone range during bunkering and the risk area in case of an accident.

Safety zones/ 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.

Corresponding safety zones may also need to be established for other LNG transfer interfaces of the LNG supply chain, and it may also be relevant to establish additional exclusion zones outside the safety zone where other categories and third parties must not have access. In addition to the safety zone around the bunkering site, it may also be necessary to establish a security zone around the bunkering facility and vessel where ship traffic and other activities are monitored.

Zoning considerations and classifications are also important with regard to type and location of electrical installations at the bunkering facility and standards such as the IEC EN 60079 (IEC, 60079) and corresponding national standards.

There are two options for defining the design release scenario of adequate safety designs. The first and simplest way is the deterministic approach, where a conservative maximum credible accidental release is defined on the basis of the characteristics of the bunkering system. This option takes into account such factors as hose dimension, flow rate, pressure, temperature and ESD design. The second, and more sophisticated way, is to apply a probabilistic approach, where the cumulative consequences of a number of possible different leakage scenarios are summarised, e.g. by the use of an event tree model.

If a quantitative risk assessment (QRA) approach needs to be applied, the zoning considerations and definitions of safety zones are normally based on probabilistic approaches including detailed LNG dispersion, vapour cloud modelling and fire calculations for derivation of heat radiation and contours for individual risk around the bunkering site and supply facility.

4 EXPERIENCES GAINED

This chapter gives an overview of the status in the seven project ports. Experiences gained from on-going and implemented LNG related projects are summarized and concluded. The main obstacles and possibilities in different aspects that have been encountered are listed as a summary of all experiences.

The purpose of this chapter is to provide other ports with valuable information about the process of establishing an LNG terminal.

4.1 Status in project ports

4.1.1 Stockholm

Port of Stockholm is one of the two participating ports that have a functioning LNG supply chain (the other being Helsinki). The ferry Viking Grace is bunkering LNG in the port of Stockholm, using the bunker vessel Seagas for ship-to-ship bunkering.

The LNG is stored in the LNG terminal in Nynäshamn, with a volume of 20 000 m^3, and is transported by truck to the port area in Stockholm, where the bunker vessel is loaded. The bunker vessel then approaches Viking Grace on the outside, allowing for bunkering while passengers are on-board, see Figure 18.

Figure 18. Bunkering of Viking Grace in Stockholm (Source: AGA, 2014)

Within the project LNG in Baltic Sea ports, the Ports of Stockholm has developed a safety manual that describes the risk and safety aspects of LNG bunkering, and gives recommendations for safety management. Also, a study of future demand and distribution of LNG in all parts of Ports of Stockholm (Kapellskär, Stockholm, Nynäshamn) was conducted.

4.1.2 Helsingborg

A business orientated design approach and localization studies shows that Helsingborg is a suitable site for a regional LNG terminal in the southern part of Sweden, serving the market between the terminals in Gothenburg and Swinoujscie. A terminal in Helsingborg will serve 3 segments, shipping, industry and heavy vehicles. There is a fast growing demand for liquefied biogas and LNG to be used by heavy vehicles. It is most likely that the LNG volumes for the shipping segment will grow slowly, significant volumes could be foreseen 2018 -2020.

This means that Helsingborg as a first step should invest in a liquefaction plant that produce LBG and LNG for the transport sector (heavy vehicles and smaller ships). The next step is to establish a regional LNG terminal of 15 000m^3 serving the 3 segments.

The liquefaction plant and terminal is planned to be placed within the industrial area of Industry Park of Sweden (IPOS), see Figure 19.

The business possibilities in the area, are in the long run excellent, due to the fact that Helsingborg is the logistic hub in south of Sweden. 3 million heavy vehicles and 45 000 ships is passing Helsingborg every year. LNG will in Helsingborg, significant lower the environmental impact from the transport sector.

Figure 19. Localization for LNG terminal in Helsingborg within the industrial area of Industry Park Of Sweden (IPOS).

The Port of Helsingborg has been the leading applicant in the LNG in Baltic Sea Ports and will remain so even in the second phase of the project, with other participating ports. Within the framework of the second phase of the project, Helsingborg will design a multifunctional bunker ship. The multi-function ship will be able to provide LNG bunkering, MGO bunkering and other ship supply services. When the maritime market is ready the aim is to provide a sustainable bunker solution in the market area of Helsingborg.

4.1.3 Copenhagen Malmö Port

The Copenhagen Malmö Port has produced a Feasibility Study, showing the volumes needed, possible locations of the terminal and approximate costs. The demand in the area and the volume estimations needed also include land-based demand, which is an important basis for reaching larger volumes of the terminal.

The volume of the terminal is estimated to 10 000 m^3. The recommended technology for the terminal is semi-pressurised tanks, enabling a gradual build-up. The most suitable location of the terminal was found to be in the northern part of the port, location C in Figure 20.

In addition to the localisation study, a mapping of shipping activities within the area and a cost market analysis has been conducted.

Figure 20. Three localizations within the port of Malmö were investigated. Alternative C was found to be the most suitable (Source: CMP, 2013)

4.1.4 Port of Aarhus

The Port of Aarhus has developed a feasibility study, showing suitable size, location, approximate costs, and type of the 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 (2014) and is expected to be finalized during 2015.

The LNG supply in Aarhus is closely connected to the ferry traffic, hence the ferries will be the main users of LNG as marine fuel. The terminal will therefore be located within the ferry terminal.

The ferry companies have stated that they will most likely switch to LNG in the future, even though a time plan for the switch has not yet been decided.

Other ships do not bunker in Aarhus today, and their future LNG demand is therefore deemed low. There is currently no land-based user of LNG, which reduces the total volume of LNG demanded in the future.

The volume of the planned terminal will be maximum 10 000 m^3, using semi-pressurized tanks of about 1 400 m^3 each, and thus allowing for a gradual increase in volume.

Figure 21. Overview of Port of Aarhus (Source: Port of Aarhus, 2013).

4.1.5 Port of Tallinn

Together with Vopak LNG and Elering, Port of Tallinn has been studying the possibility to establish an LNG terminal at Muuga Harbour near Tallinn. The terminal would serve:

- a cluster of industrial and domestic customers which are isolated from the grids or wish to have an alternative access to the gas supplied through the grids;
- the bunkering market of the ships, which is shortly going to face a challenging change in the emissions regulation starting from the January the 1st 2015.

In order to fulfil the needs of the bunkering market and, eventually, also the demand of small commercial and domestic customers, Port of Tallinn and Vopak LNG are investigating and preparing the possibility to develop a small facility which could be considered as the first phase of the terminal development.

It remains the initiators' ambition to develop the regional import terminal as phase II of the project, as soon as the market conditions and the commercial demand will require it.

Figure 22. Overview of Muuga Harbour (Source: Port of Tallinn, 2013)

4.1.6 Port of Helsinki

A feasibility study of LNG bunkering possibilities in the Port of Helsinki has been conducted. From the study, it has been determined that the most practical solution for LNG refuelling of ships is ship-to-ship bunkering since there are several separate ports in Helsinki. One bunkering vessel could serve all of the harbour areas of the Port of Helsinki. The vessel is assumed to be able to fill its tank with LNG flexibly from a LNG terminal in Finland or, for example, Estonia. LNG can also be refilled to the bunkering ship using tank trucks or by loading a filled cryo container onto the ship.

The expected demand and the users of LNG in Helsinki are still unknown. Hence the bunkering capacity and localization have not yet been decided.

Figure 23. South Harbour and Katajanokka (Source: Port of Helsinki, 2013)

4.1.7 Port of Turku

A LNG terminal has been proposed to be established in Pansio Harbour, which is a part of Port of Turku. The facility is planned to have storage capacity of 30 000 m^3 and the bunkering is planned to be performed by trucks.

Figure 24. Proposed localization for LNG-terminal in Pansio Harbour, Port of Turku.

In the project, the Port of Turku has also identified bunkering facilities of LNG in the port's berth areas from both technical and safety perspectives, as well as set up safety instructions for LNG bunkering. The LNG bunkering would be done with a tank truck, and at a later stage, it will be possible to switch to bunkering with a vessel or from a solid intermediary tank.

There is also a terminal planned in Pori (about 140 km from Turku) by the same operator, Gasum, and the procedure of the project in Turku is partly dependent on the project in Pori. The proposal of local detailed plan for Pansio LNG terminal area was accepted in June 2013. The terminal was planned to be in operation in 2015 but an appeal regarding the terminal have been made to the Turku Administrative Court and is delaying the project.

4.2 Communication

Regarding communication with the general public, it is generally perceived by all participating ports to be of great importance during the phase of permit application and construction/start of operation.

The only port from the project *LNG in Baltic Sea Ports* that have successfully established an LNG terminal/LNG supply that is operational is Stockholm. Ports of Stockholm have been working proactively when it comes to informing about the LNG bunkering in Stockholm to the general public. Information was published on the webpage and a brochure with basic information about LNG and the bunkering process has been provided, to mention two examples. The port has also communicated about LNG, the bunkering process and the LNG vessel through other digital channels such as social medias; Facebook and Twitter.

Ports of Stockholm held a meeting with the main stakeholders and relevant authorities in order to discuss how to communicate in the event of an incident, both internally between the stakeholders and with external parties.

Stockholm has also, as well as other ports such as Helsinki, Tallinn, Turku and Helsingborg, communicated regularly with the authorities on different levels: local level as well as national level. This has facilitated the process of retrieving permits, and has increased the understanding of the process and the regulations.

Other stakeholders with whom a dialogue is crucial are the gas suppliers, the shipping companies, the technical experts and the operators of bunkering vessels. Information to nearby activities that may get affected and to local residents is also important in order to get a smoother permit process and to avoid appeals later on.

4.3 Obstacles

The subsequent sections, listing some obstacles and possibilities during the establishment of LNG in the participating ports of the project, are summaries of the experiences gained during the implementation of the project.

4.3.1 Regulations

- Lack of international standardization regarding LNG as ship fuel, especially - lack of LNG bunkering related regulations. Today bunkering LNG is only allowed with special permission. This is experienced in several of the ports. For example Ports of Stockholm was the first port to receive a permit for bunkering and during the permit process discussions were held with relevant authorities.
- Different local/regional regulations
- Responsible authority not always clear. Port of Aarhus have experienced that the responsibility for bunkering permits in ports was not yet clarified in Denmark. During the implementation of the project, new instructions and clarifications were received from the Danish Maritime Authority, stating the responsibility for each authority.
- Ownership and responsibilities is not clear
- Permit for building process is long and sometimes complex. This is an experienced gained from almost all the ports that have gone through a building permit process. The terminal in Lysekil, Sweden, is one example.
- The environmental permit process (including EIA) requested from the authorities takes time and has a high cost. Again, Lysekil in Sweden can serve as an example.

4.3.2 Technical aspects

- Finding the right dimensions and type of terminal for intended purposes is a process. Both Copenhagen Malmö and Aarhus have experienced that finding the right size volume of the terminal is an iterative process, with decisions along the way that are changed and corrected.
- Localisation of LNG activities and facilities can be complex. All participating ports have performed localization analyses in order to find the optimal localization for the terminal.
- Finding suitable area for LNG activities is sometime complex. All ports have experienced that suitable areas for LNG terminals must take risk and safety aspects into consideration, which limits the number of suitable locations.
- Lack of standardised equipment and technical solutions *e.g*. couplings and ESD

- LNG bunkering must be economically competitive to traditional fuels when it comes to time, price, location and procedures
- Connecting infrastructure and ports logistic system need to be updated
- Mitigating measures in case of leakage/spill affects port infrastructure nearby. This must be included in a risk assessment, or a safety manual such as the Ports of Stockholm have produced.

4.3.3 Financial aspects

- As a first step, a clear distinction should be made of the roles in establishing the LNG terminal. The port is most often the owner of the land, while the investment in the terminal can be the responsibility of the port, the municipality, the gas supplier and/or the operator. Determining the different investment roles is important at project start.
- Safety distances affecting other activities require space and increase costs. Port of Aarhus has experienced that the planned LNG terminal require more land area than first anticipated. The technical equipment and the safety distances strongly affect the land use in the terminal.
- Additional structures
- The permit process is costly for the ports.
- Finding investors/partners can be difficult
- Lack of competitive and transparent supply market. This is experienced by all operational LNG suppliers, as the price of LNG controls the supply and the availability of LNG.
- Risk of over establishment. Finding a balance between demand and supply is difficult in a developing market. The participating ports partly compete for the same customers. It is therefore important to find ways of cooperation instead of competition. The participating ports are located in two regions: around the Finnish Gulf, and around the Öresund region. Localization analyses could therefore be inclusive of the ports in the same region, in order to facilitate optimal distribution of LNG. Port of Helsingborg has performed such a regional localisation analyses, including the Öresund Region.
- Supply of LNG to the ports is controlled by a large scale global market where the dominating parties are found in Asia which makes it harder for smaller importer in the Baltic Sea to be competitive

4.3.4 Security aspects

- The enlargement of ISPS area may prevent the development of other activities in the vicinity. This is a possible obstacle, however, it has not been experienced by any of the participating ports.

4.3.5 Risk and safety

Risk assessments include considerations to the risk and safety aspects listed below. The Port of Aarhus and the Ports of Stockholm have performed risk assessments or safety manuals that include risk and safety aspects.

- Characteristics of LNG – Methane is characterized as extremely flammable
- Parallel cargo and passenger handling during bunkering procedures
- Parallel activities adjacent LNG activity
- Embrittlement of structures, in case of contact with LNG
- Safety zones may prevent development of other activities in the port
- Standardization of operations needed in order to ensure safe operations
- Absence of thresholds for acceptable risk levels
- Absence of standardized risk assessment procedures etc.
- Standardisation of equipment systems - essential for a well-functioning and safe infrastructure.
- Personnel exposed to dangers due to cryogenic temperatures
- Training and education of on-board and shore-based personnel needs to be harmonized in structure and content for different levels
- Mitigating measures must be identified and education provided. Ports of Stockholm have included this in their safety manual.
- Location of terminal close to civilians

4.4 Possibilities

Some of the possibilities presented below apply for the participating ports. Some, however, will be available during later stages of development, during design and building of the terminals. This will be valid for ports that chose to follow the first early developers.

4.4.1 Regulations

- New regulations and guidelines are developed, for example, ESSF LNG sub-group and PIANC 172.

- The introduction of SGMF (The Society for Gas as a Marine Fuel) will result in the presence of 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 IGF Code is under development (seagoing vessels) and regulation for inland waterway vessels is expected soon.
- As several of the participating ports have experienced, for example Stockholm and Aarhus, the knowledge and experience among authorities increase over time, as they are involved in LNG projects, and decisions are made regarding bunkering, building, and handling of LNG etc. The experiences gained among authorities facilitate smoother processes for ports that follow.

4.4.2 Technical aspects

- Concepts and systems are already available.
- Several international organisations are involved in the process of improving LNG handling and operations ensuring safe bunkering operations.
- Developing and establishing ground breaking facilities/ports in every solution
- Effective procedures through better equipment

4.4.3 Financial aspects

- Dividing investment costs into different market segments/end customers
- Finding operators/investors for an LNG terminal which can reduce the investment cost. The participating ports that are in the planning stage, such as Port of Turku, Port of Aarhus, and Port of Tallinn, all have large financial gains in finding operators that can share the investment costs. For Ports of Stockholm, development of the bunkering vessel Seagas was financed by the operator.
- Depending on market development: early adopters of LNG can possibly get financial advantages compared to competing fuel alternatives.

4.4.4 Security aspects

- Establishments within ISPS regulated area imply a high level of security.

4.4.5 Risk and safety

- Overall LNG is a safe fuel, with low risks
- The technical equipment is relatively simple – with maintenance and correct and adequate training of staff, it can be handled in a safe manner

- The safety will increase along with gained experiences from existing terminals in operations. This will be an advantage mainly for the ports that develop LNG as marine fuel as followers to the first ports.

4.5 Conclusions of experiences gained

The ports that have participated in the first phase of LNG in Baltic Sea Ports have gained important experiences, which can assist following ports in the development of LNG. The experiences are summarized in the list below.

- As a first step, a clear distinction should be made of the roles in establishing the LNG terminal. The port is most often the owner of the land, while the investment in the terminal can be the responsibility of the port, the municipality, the gas supplier and/or the operator. Determining the different investment roles is important at project start.
- The development of an LNG terminal and the volume estimations must be based on demand, which implies that a thorough analysis of demand and market must be performed. This analysis must include the land based demand, as this is crucial for obtaining volumes that are large enough for the establishment. To avoid over establishment of LNG supply, cooperation between ports is recommended.
- The permit process takes time and can be costly for the port. One lesson learned is that the process for LNG is often unknown to the authorities involved, and therefore the process takes even longer time.
- The regulations controlling LNG are several: international directives and conventions, as well as national laws and local regulations. Finding and involving the relevant authority responsible for LNG is sometimes difficult.
- Risk and safety is deemed as crucial when planning for LNG, when discussing it with the relevant authorities, and when applying for a permit. Training of staff in risk and safety measures is necessary.
- Land use and design: for the design of the LNG terminal, the land use and the surrounding area must be designated. The technical equipment needed in the terminal increases the land use significantly.
- Financial aspects: it is very important to find ways of cooperation with stakeholders, in order to share the investment cost for the terminal. In an early stage of the planning process, it is necessary to start a dialogue with financers, gas suppliers, operators etc, for identifying financing solutions.

5 GUIDANCE AND CHECKLIST

The actions needed when establishing an LNG terminal are summarized in Table 6. The table aims to serve as a checklist for the procedure and the required actions. The actions are basically listed chronologically, even though some of the work can be done in parallel.

Table 6. Checklist for actions in the procedure of developing a LNG terminal.

Action	Time aspect	Authority/stakeholder	Comment
Inform the municipality of the plans		Municipality	
Initiate feasibility study including:	2-6 months		
Possible localizations			
Expected demand of LNG			
Possible technical solutions			
Finding possible financial solutions			
Consultation with concerned authorities and municipality		Municipality, Maritime authority, County administration	
Corrections made to municipal local/development plan	Between 3 and 12 months	Municipality - Planning unit	When handling of LNG is not in accordance with the existing plan
Basic design concept			
Financial engineering, possible cooperation with investors/operators/gas suppliers		Investors/operators/gas suppliers	
Initiate environmental permit process	8 – 12 months	County administrative board (Sweden), Municipality – Environmental unit	
EIA		County administrative board (Sweden), Municipality – Environmental unit	The required scope depends on storage volume, threshold varies between countries
Risk analysis		County administrative board (Sweden), Municipality – Environmental unit, Emergency preparedness	
Technical specification			

Permit for handling and storage of dangerous gods		
Building permit		
Safety report	3 months before start of operation	For installations falling under the Seveso Directive and the qualifying quantity 200 ton
Action program		For installations falling under the Seveso Directive
Permit for transportation of dangerous goods		If distribution will be performed with trucks and/or rail
Permit for pipelines		If distribution will be performed with pipelines to the grid
Detail engineering design		
Contracting costumers		
Contracting gas suppliers		

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This Handbook has been prepared by SSPA Sweden AB, assigned by the Baltic Ports Organization.

Client's reference: LNG in Baltic Sea Ports, Emil Arolski

SSPA report No: RE20136642-01-00-A

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