

LNG IN THE BALTIC SEA REGION OPPORTUNITIES FOR THE PORTS

LNG (Liquefied Natural Gas) may play an important role in the Baltic Sea Region in the near future – both as an alternative energy source for Baltic countries and as an alternative fuel for ships operating on the Baltic Sea. However, it requires construction of special port infrastructure. At present, a number of LNG terminals are planned to be constructed in Baltic Sea Region in the near future. Some of them are large scale LNG import terminals (Świnoujście, Riga, Klaipeda, Paldiski) and others are smaller scale LNG distribution terminal (Nynäshamn, Gothenburg, Gävle). Construction of infrastructure for distribution of LNG to ships is also essential. LNG is considered as an alternative fuel mainly for ships operating in liner service. Hence, LNG terminals for bunkering purpose should be constructed in locations where there is the most dense liner services.

1. LNG AS AN SOURCE OF ENERGY FOR ECONOMIES AROUND THE BALTIC SEA

World energy use is constantly increasing. Countries around the Baltic Sea are no exception. However, in some countries energy consumption is increasing at a higher rate, while in others the level of energy consumption is already very high and increases slowly. It has to be noticed that the energy use is expected to increase at a high rate especially in developing countries.

The energy issue is closely linked with major environmental issues such as the climate issue, acidification and over-fertilisation. Today, the world is dependent on oil as a source of energy. It contains many harmful components and replacing it would be good for the environment. It is rich in carbon which means high CO₂ emissions when combusted. The natural gas is also a fossilised fuel. It is however, a better source of energy in terms of CO₂ emissions and environmental effects.

A list of natural gas main producers includes such countries as: Russia, United States, Canada, United Kingdom, Netherlands, Iran, Norway, Algeria, Indonesia, and Saudi Arabia. Because of the difficulty of transporting natural gas over long distances, natural gas has been generally imported by close regional neighbours of gas producers.

The energy security is a very important issue in current international relations. There is an increasing dependency of the energy-consuming countries on the energy-producing countries. The situation of Europe and especially Baltic Sea

Region is an example. There are no large natural gas supplies in Eastern Europe, so Russia is a dominant supplier of gas to the Baltic countries such as: Estonia, Finland, Latvia and Lithuania and Poland. This part of Baltic region is still an energy island, because of energy isolation and dependence on a single source. Therefore, in case of an emergency situation, these countries do not have any alternative solution to assure continuous supplies of natural gas. That's why diversification of energy sources of these Baltic countries become a priority for the Baltic Sea Region as well as the whole European Union.

When natural gas is imported from nearby producers, its transportation through pipelines is an obvious choice. However, building pipelines long distances across oceans or mountains in order not to be dependent on nearby producers of gas and to import natural gas from gas producers located further, is very expensive and introduces various challenges. A technology which is changing distance limitations and is cheaper at long distance is liquefaction. Cooling down natural gas to -162 degrees Celsius turns it into a liquid (LNG – Liquefied Natural Gas). This process causes that volume of natural gas is reduced significantly. As a cryogenic liquid, it takes up about 1/600 of the volume of uncompressed gas. As a result natural gas in its liquid form is an easier product to store and to transport. Hence, LNG provides an excellent way to diversify Baltic counties' energy sources away from Russia. However, LNG import terminals must be constructed.

LNG is also considered as an alternative source of energy by another two Baltic countries, Sweden and Denmark. In Sweden, natural gas is used to cover only 2% of the total energy input. Some of the most densely populated areas are covered by the pipeline network, but there is still great area of the country left, including larger cities such as Stockholm, Uppsala and Linköping as well as some industrial areas [4]. The absence of natural gas causes that these regions have to rely on fuel oil, coke or coal. If these sources of energy were replaced by natural gas, great environmental benefits could be achieved. Natural gas could be delivered to these regions as a LNG if special LNG import terminals were constructed. In turn, Denmark is expected to rely on pipeline gas from offshore North Sea fields in the medium term. Existing pipelines and existing contracts give this county sufficient supply in the near future. However, in long term, LNG is considered as an alternative source of energy.

2. LNG AS AN ALTERNATIVE FUEL FOR SHIPS SAILING ON THE BALTIC SEA DUE TO IMO REGULATIONS

The extent of the pollution in the Baltic Sea is very high and the situation is constantly getting worse. The shipping industry is one of the several contributors to local pollution, especially in terms of NO_x , SO_x and particle emission. For example Baltic Sea shipping in 2008 emitted about 135 000 tonnes SO_x , 393 000 tonnes NO_x and 18.9 million tonnes CO_2 . This is the same amount of NO_x and twice the amount

of the SO_x as the total land-based emissions from Sweden and Denmark combined [3].

There are several steps undertaken to save the ecosystem in Baltic Sea area, one of these is emission reduction requirements for shipping industry. The Baltic Sea as well as the North Sea are IMO Emission Control Area (ECA) seas. In order to reduce SO_x emissions in ECA, IMO requires reduction of fuel sulphur content. From 1 July 2010 the fuel sulphur contents must be below 1%. In turn, from 1 January 2015 fuel sulphur content must be below 0.1%. However, according to directive 2005/33/EC, valid from 1 January 2010, ships at berth in all ports of the European Community shall not use marine fuels with a sulphur content exceeding 0.1% by mass. Ships have been given a transitional period till the end of August 2010 to make the necessary technical changes.

IMO specifies also existing and future NO_x emission limits for marine engines. The IMO NO_x emission standards are commonly referred to Tier I, Tier II and Tier III standards. Currently Tier I standard is in forced. It applies to a diesel engine which is installed on a ship constructed on or after 1 January 2000. Tier II goes into effect in January 2011. It means that NO_x emissions of the engines will have to be approximately 20% lower than the current IMO Tier 1 standard. However, vessels with a keel-laid date on or after 1 January 2016 that travel in NO_x ECA will require IMO Tier III certified engines. It means that another 75% NO_x reduction will be required for these ships.

Table 1

SO_x limits in fuel in ECA [6]

Date	Sulphur Limit in Fuel in ECA [%]
2000	1.5
1 July 2010	1.0
2015	0.1

Table 2

NO_x emission limits [6]

Tier	Date	NO _x limit [g/kWh]		
		n < 130 rpm	130 rpm ≤ n < 2000 rpm	n ≥ 2000 rpm
Tier I	2000	17.0	45* n ^{-0.2}	9.8
Tier II	2011	14.4	44* n ^{-0.23}	7.7
Tier III*	2016	3.4	9* n ^{-0.2}	1.96

* in ECA

New regulations on emissions of sulphur oxides (SO_x) and nitrogen oxides (NO_x) within the Baltic Sea and the North Sea have recently increased the interest in and demand for alternative fuels. Liquefied Natural Gas (LNG) as an alternative

fuel is currently the most popular option. Using LNG instead of oil considerably lowers the emissions of SO_x and NO_x .

Natural gas is the cleanest form of fossil fuels. Natural gas consists of methane with minor concentrations of heavier hydrocarbons such as ethane and propane. When ships are fuel with LNG, no additional abatement measures are required in order to meet the ECA requirements. The burning process of natural gas is clean. LNG contains virtually no sulphur, hence SO_x emissions from natural gas engines are reduced by close to 100%. The particle emission is also reduced by close to 100%. Moreover, burning LNG produces 85–90% less NO_x than conventional fuel and greenhouse gas emissions are reduced by 15–20% [3]. There is currently much research being made on ships propelled by LNG. For example, replacing a conventional passenger ferry in Norway to a LNG-powered vessel would be equivalent to taking 160 000 cars out of traffic as far as NO_x emissions are concerned [4].

LNG has been used as marine fuel since 2001. Norway has been the forerunner for LNG – powered ships. Currently, about 20 LNG-fuelled ships are being operated in Norwegian waters. LNG ships that are in use in Norway today, ranging from coast guard boats and supply vessels to ferries.

Many manufactures are offering LNG fuelled engines already. Gas engines which are currently available on the market can be divided in two main categories: dual fuel engines (e.g. Wärtsilä, Man), lean-burn gas engine (e.g. Rolls-Royce, Mitsubishi). These engines have varying characteristics and levels of efficiency. The dual fuel engine runs on both LNG and conventional fuel. It is flexible solution when the availability of LNG fuel is uncertain (e.g. lack of LNG bunkering stations). Whereas, the lean burn mono fuel engine gives a simpler installation onboard and is a more suitable solution for ships operating in regions with a developed grid of LNG bunkering stations.

MARINTEK carried out the studies which indicate that additional costs for a gas fuelled ship will be of 10–15% of the total cost of a conventional ship. This additional cost is connected mainly with large LNG tanks and the fuel piping system. It can be estimated that for a typical RoRo ship of 5600 DWT, the additional costs will be about 3.2 million EUR [5].

There are major challenges to the widespread implementation of LNG as a ship's fuel. The one of the main challenges is that the large space is required onboard for LNG tanks and this contributes to the loss of cargo space. For example LNG requires about 1.8 times more volume than MDO (marine diesel oil) with equally energy content. If we added the tank insulation the needed volume is about 2.3 times higher [21]. For new-build ships it is quite simple to find space for the larger fuel tanks, while this may be much more difficult, or even impossible, to find it on ships which are already in operation. That's why there is very little probability that existing ships will be using LNG instead of conventional fuel. It is more likely that LNG as marine fuel will be used by new-build ships.

Moreover, it has to be noticed that in order not to lose much cargo space, the operational range due to bunker capacity of the vessel must be reduced. Therefore,

LNG is a fuel alternative basically for vessels which can be re-fueled quite often. Hence, this fuel alternative is not suitable for large vessels engaged in deep sea shipping. LNG as ship's fuel is most convenient for short sea shipping and such ships as ro-ro and ferries. That's why more investment in LNG powered ships is expected in this segment.

Apart from LNG, there are two other alternatives to meet the future ECA requirements: switching to low sulphur fuel (MGO, MDO) or installing an exhaust gas scrubbers. However, of this three options, LNG has the best environment impact. NO_x, SO_x, particles and CO₂ emissions from natural gas engines are the lowest. What's more LNG is an economically the best solution. According to DNV estimation, a switch to LNG power could potentially save 12% on total vessel operational costs over a 10-year period compared to HFO with scrubber and 35% on total vessel operational costs compared to MGO. In turn, over a 20-year period a switch to LNG power could potentially save 22% on total vessel operational costs compared to HFO with scrubber and 45% on total vessel operational costs compared to MGO [7].

3. INVESTING IN LNG INFRASTRUCTURE – OPPORTUNITIES FOR THE PORTS

3.1. Construction of the LNG import terminals

A number of LNG terminals are planned to be constructed in Baltic Sea Region in the near future. Plans assume constructions of large import terminals as well as smaller terminals for local LNG distribution. Construction of a LNG terminals would allow countries around the Baltic Sea easy access to a much broader energy market since LNG is not limited to transmission by pipeline and like crude oil, it can be transported by specially designed sea vessels. A liquefied gas terminals become an important tool to ensure energy security of the Baltic countries. Localization of the planned LNG terminals are shown on map below. However it has to be mentioned, that some of these terminals are only proposed terminals. Their construction depends on many factors and it is not certain if they will be established.

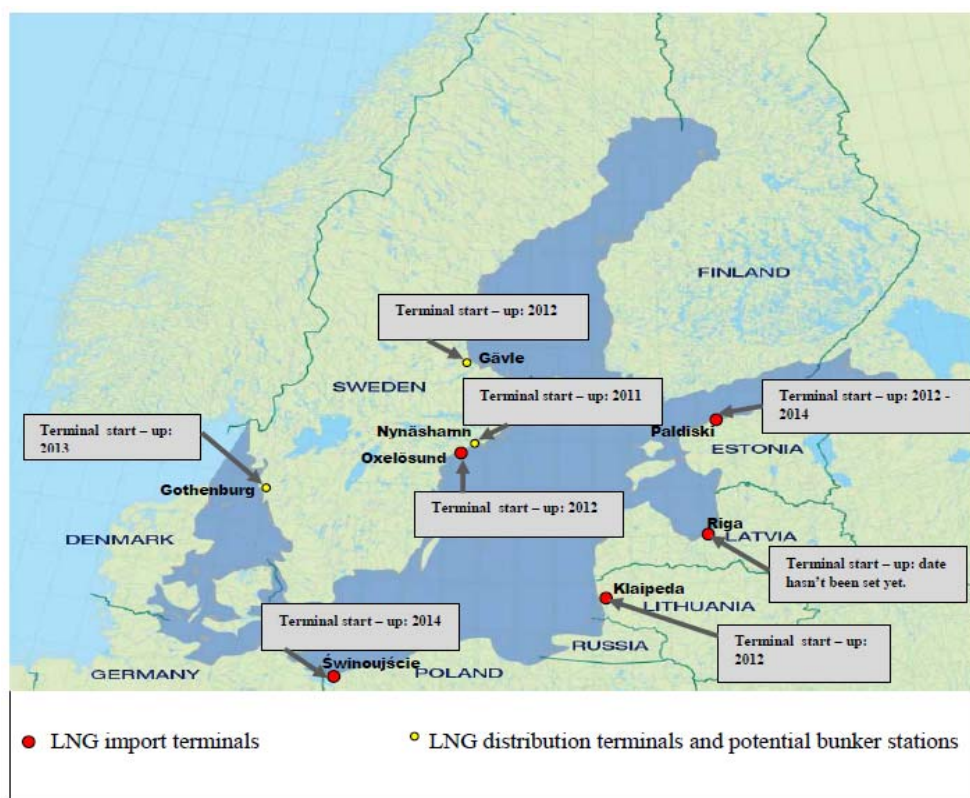


Fig. 1. Proposed Baltic LNG import terminals in the Baltic Sea Region

3.2. LNG terminal in Świnoujście (Poland)

The plans to build an LNG terminal resulted from the need to diversify sources of natural gas supply in Poland, and gaining independence from one supplier.

The sea part of the terminal is designed as an external port situated next to the eastern breakwater. The terminal will receive vessels of about 70 000 DWT, transporting approx. 145 000 m³ of liquefied gas. The land part of the terminal will occupy about 38 ha. However, twice as much land is available. According to the plans, the annual handling capacity of the terminal will vary from 2.5 to 7.5 billion cu. m of gas following the demand of the market [17].

There are three investors carrying out the works: Polskie LNG Ltd. is responsible for the construction of the LNG terminal. Szczecin Maritime Office is responsible for breakwater construction and dredging works (navigation routes and rotation points). Port of Szczecin and Świnoujście Authority are responsible for the construction of the port jetty with some dredging works around the jetty.

Whole project is financed by state or state owned companies. The cost of the construction of LNG terminal is estimated at 2 946 559 860 PLN brutto (2 415 213 000 PLN netto) [15]. The cost of the breakwater construction and dredging works are estimated at 814 million PLN. The cost of constructing the port jetty is estimated at 167 million PLN [18]. The LNG terminal is expected to be put into operation in 2014.



Fig. 2. Visualization of LNG terminal in Świnoujście [10]

3.3. LNG terminal in Klaipeda (Lithuania)

In July 2010 the Government of the Republic of Lithuania adopted a decision to construct a liquid natural gas (LNG) terminal in Klaipeda. The public company “Klaipedos Nafta” was chosen as the main terminal building tool.

The terminal is due for launch in 2012. The feasibility study for the project is currently under way. The terminal is expected to be constructed at the oil product terminal Klaipedos Nafta at the port. The proposed capacity for the LNG terminal is 3 billion cubic meters a year [8]. It is not clear where the LNG shipments will be sourced from.



Fig. 3. Visualization of LNG terminal in Klaipeda [19]

3.4. LNG terminal in Riga (Latvia)

According to the Free Port of Riga Development Programme there are plans to construct LNG terminal in the port of Riga. The LNG terminal will be located on north – east bank on the River Daugava, near to the mouth. The area of the LNG terminal is expected to be 34 ha. The proposed capacity for the LNG terminal is 1 500 000 tonnes LNG per year (about 2 billion cubic meters). The LNG terminal will comprise of the following elements [1]:

- a tanker berth with unloading equipment,
- LNG storage facility,
- Re-gasification process plant
- Infrastructure connecting terminal to the pipeline transmission network

3.5. LNG terminal near the town of Paldiski (Estonia)

There are plans to construct an LNG terminal on Pakri peninsula near the town of Paldiski. The proposed capacity for the LNG terminal is 3 million tonnes a year. The estimated cost of investment is about 7.5 billion EEK (480 million EUR). It is expected that the LNG terminal will be built by 2014 at the latest [14].

3.6. LNG terminal in Oxelösund (Sweden)

E.ON Rurgas plans to open the LNG import terminal in Oxelösund. The terminal will have a capacity of 2 billion cubic meters per year. The capacity of the storage tanks will be 250 000 cubic metres. The terminal will be able to accommodate the largest LNG carriers which are in use today. It is expected that the terminal will be launched in 2012 [9].

3.7. LNG terminal in Nynäshamn (Sweden)

In Brunnsviksholme near the eastern part of port city of Nynashamn the terminal for liquefied natural gas is under construction. The terminal is being built for AGA Gas AB. NCC Construction Sweden AB (NCC Construction) has been commissioned by AGA Gas AB to construct a LNG terminal. NCC Construction is responsible for construction of the infrastructure required for the new terminal. The LNG tank itself was design and is being built by Cryo AB (Gothenburg, Sweden), part of Linde's engineering division.

The terminal will have a capacity of 300 000–400 000 tonnes per year. Natural gas for the terminal will be sourced from a liquefaction plant in Stavanger, Norway, and Central Europe. Tank height is 36.6 meters, diameter 37.5 meters, and the volume 20 000 cubic meters.

The harbour for the terminal will receive tankers up to 160 m in length, 9 m in depth and with a capacity of 50 000 cubic meters. A 100 m bridge will connect the mainland to Brunnsviksholme [11].

It is expected that the terminal will be complete by May 2011. The estimated cost of terminal and tank is 275 million SEK [16].



Fig. 4. Visualization of LNG terminal in Nynäshamn [20]

3.8. LNG terminal in Gothenburg (Sweden)

The proposed LNG terminal in Gothenburg will be a small scale terminal. This terminal will be established especially for bunkering purpose. According to the planned schedule the terminal will be put into operation by year 2013. The overall project was initiated by Göteborg Energi together with Port of Gothenburg. Gasnor have later joined, providing experience and expertise from dealing with LNG in Norway. In early 2010, Göteborg Energi and Gasnor formed a new company, *LNG GOT*, which will manage the operations of the terminal [12, 13].

4. PORT INFRASTRUCTURE FOR DISTRIBUTION OF LNG TO SHIPS

To offer LNG as a fuel to ships, infrastructure for distribution of LNG fuel in the Baltic Sea Region must be established. This infrastructure should consist of a small scale LNG terminals designed especially for bunkering purposes. They could be supplied by a small scale LNG shuttle vessel (e.g. 20 000 m³) from local LNG import terminal which would serve as a hub to such bunker stations.

Currently, 13 LNG terminals are available for fuelling ships in Norway and the number of such terminals in Norway is growing.

The choice of location for a LNG terminal for bunkering purposes depend both upon where potential users of LNG are and where there are areas available. LNG is consider as a alternative fuel mainly for ships operating in liner service (such as ro-ro ships, ferries and feeder container vessels). Hence, LNG terminals for bunkering purpose should be constructed in locations where there is most dense liner services.

It has to be noticed, that mentioned before planned LNG terminals in Baltic Sea Region could be considered as part of a future supply infrastructure for LNG fuel. The proposed terminals in Germany, Estonia, Lithuania and Poland could be potential hubs for LNG fuel because they will be capable of receiving full size LNG vessels. The proposed terminals in Sweden could be a potential bunker stations.

A good distribution ways of LNG as a fuel for the ships is very important issue for ship owners. However, it doesn't necessarily mean, that the LNG terminal has to be a bunker station for every ship. There are possibilities for distributing LNG by land transport as well. This solution assumes that vessel is being bunkered at berth directly from tanker truck (Fig. 5). Moreover development of ship to ship LNG bunkering solution is also considered.



Fig. 5. Bunkering of the vessel from tanker truck [2]

CONCLUSION

The chances are that LNG may play an important role in the Baltic Sea Region in the near future. It is a significant alternative to actually used sources of energy in the region and to bunker fuels currently used by ships operating in the Baltic Sea. Majority of Baltic countries is still an energy island because of energy isolation and dependence on a single source. Hence, the diversification of energy sources of Baltic countries become a priority for the Baltic Sea Region. And LNG seems to be an important factor for Baltic Sea Region future energy supply security. Moreover, LNG as a ship fuel is the supreme solution to compliance with the upcoming ECA requirements concerning limits of sulphur and nitrogen contents in the fuel used by ships operating in the Baltic Sea.

However, widespread use of LNG as an alternative source of energy and as an alternative ship fuel requires construction of special infrastructure. LNG import terminals and port infrastructure for distribution of LNG to ships (e.g. bunkering stations) is essential. At present, a number of LNG terminals are planned to be constructed in Baltic Sea Region in the near future. Some of them are large scale LNG import terminals and others are smaller scale LNG distribution terminals and potential bunkering stations. However, LNG terminal construction depends on many factors. That's why it is not certain yet, if all of these proposed terminals will be built.

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LNG W REGIONIE MORZA BAŁTYCKIEGO SZANSA DLA PORTÓW

Streszczenie

W niedalekiej przyszłości LNG (Liquefied Natural Gas) może odgrywać znaczącą rolę w regionie Morza Bałtyckiego – zarówno jako alternatywne źródło energii dla państw nadbałtyckich, jak i jako alternatywne paliwo dla statków pływających po Morzu Bałtyckim. Oba zastosowania LNG stwarzają konieczność powstania odpowiedniej infrastruktury portowej. W regionie Morza Bałtyckiego planowana jest budowa kilku terminali LNG. Plany zakładają konstrukcję dużych importowych terminali (Swinoujście, Klaipeda, Ryga, Paldiski), jak również mniejszych terminali na potrzeby lokalne (Nynäshamn, Gothenburg, Gävle). Niezbędne jest także powstanie odpowiedniej infrastruktury portowej do celów zaopatrywania statków w paliwo LNG. Z wielu praktycznych powodów LNG jest paliwem najbardziej odpowiednim dla statków żegluga liniowej, dlatego też terminale LNG o przeznaczeniu bunkrowym powinny powstać tam, gdzie istnieje najbardziej gęsta sieć połączeń żegluga liniowej.