BLUE CORRIDOR STRATEGY FOR THE BALTIC SEA REGION

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Abbreviations

AI	EU Directive of Alternative Fuel Infrastructure
BCM	Billion Cubic Metres of natural gas
BIMCO	Baltic and International Maritime Council
BSR	Baltic Sea region
CNG	Compressed Natural Gas
COP	Conference of parties
CPT	Clean Power for Transport
CSS	Carbon Capture and Storage
DNV GL	Det Norske Veritas and Germanischer Lloyd
ESD	Emergency shut-down
FDI	Foreign Direct Investment
BP	former British Petroleum
BSR	Baltic Sea Region
CO_2	Carbon dioxide
CSI	Clean Shipping Index
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
ERDF	European Regional Development Fund
EU	European Union
FSRU	Floating Storage and Regasification Unit
GHG	Green House Gas
IGC	Liquefied Gases in Bulk
IMO	International Maritime Organization
ISO	International Organization for Standardization
IWT	Inland Waterways Transportation
KN	Klaipedos Nafta
LBG	Liquid Bio Gas
LNG	Liquified Natural Gas
LPG	Liquefied Petroleum Gas
MARPOL	The International Convention for the Prevention of Pollution from Ships
MGO	Marine Gas Oil
MDO	Marine Diesel Oil
MPTA	Million Tonnes Per Annum
NECA	NO_x Emission Control Area
PV	Photovoltaic
SCV	Submerged Combustion Vaporizer
SEEMP	Ship Energy Efficiency Management Plan
SECA	SO_x Emission Control Area
SIGTTO	The Society of International Gas Tanker and Terminal Operators

SGMF	Society for Gas as a Marine Fuel
SOLAS	The International Convention for the Safety of Life at Sea
TEN-T	The Trans-European Transport Network
UK	United Kingdom
USCG	United States Coast Guard
ZVT	Zero Vision Tool

PREFACE

The *Go LNG* project (http://www.golng.eu/) is aimed at facilitating the introduction of LNG as an alternative fuel in the Baltic Sea Region (BSR). It has been operating from 2016 to 2019, and forms part of the implementation of the EU Directive on the Deployment of Alternative Fuel Infrastructure. The project is part-financed by the ERDF funds made available under the EU INTERREG V scheme. The main objective of the project is to provide a strategy that links transport flows, LNG infrastructure development, and business models into an efficient LNG infrastructure development plan and an LNG distribution strategy for the BSR – enabling blue transport corridors. A further objective is to create new business opportunities in energy, port operations, and transportation sectors relating to the use of Liquefied Natural Gas – LNG and Liquefied Biogas (LBG). For this purpose, a regional LNG business cluster and a competence center was established in April 2017, offering information on the LNG value chain.

In summary, the main three activities in developing the infrastructure strategy were:

- Integrated LNG value chain
- LNG Fuel distribution strategy for BSR
- LBG Business Concept

Where information was made available, BSR countries that do not have any partners in the Go LNG project were included, especially for the development of LNG infrastructure in the region.

Abstract

The Blue Corridor strategy provides a road map for the development of LNG infrastructure as a fuel for transport and energy. It is aimed at giving recommendations for the development of LNG infrastructure in the Baltic Sea Region by identifying the conditions necessary for its successful use. The strategy was developed by analyzing the existing structure of transport flows, existing LNG infrastructure, current policy and regulations, security and safety aspects, and studying current LNG-related business models. This situation was analyzed, regarding its strengths and weaknesses, the conditions required for the successful formation of business clusters, and by analyzing the critical infrastructure necessary to provide favorable conditions for the use of LNG over other fossil fuels. These analyses were used to describe how Blue Corridors should be planned in the Baltic Sea Region by identifying strategic locations for LNG infrastructure and highlighting maximum distances acceptable between LNG facilities. Analysis showed that Blue Corridors should integrate maritime transport, rail and road transport, as well as the industrial and power generation sectors as potential LNG users. Opportunities for the potential expansion of the LNG value chain and its integration between various modes of transport and types of industries were identified. Examples of incentive schemes that could be used for the promotion of LNG were provided, with some evaluation of their past successes. Information was also provided regarding education efforts currently being undertaken in the Baltic Sea Region (BSR), and how knowledge and experience created in the development of LNG in the BSR could be internationalized. Finally, an outlook is given on the expected market trends for LNG, including sectorial demands and global supplies, suggesting that LNG is becoming increasingly important in the BSR and globally.

Highlights

- A strategy for the development of LNG-powered transport corridors in the BSR.
- Analysis of transport flows.
- Analysis of existing infrastructure.
- Analysis of the framework of policies and legal instruments which affects LNG development.
- Definition of the conditions necessary for the successful formation of business partnerships in clusters.
- Assess strengths and weaknesses of the LNG business case.
- Identification of the infrastructure requirements for successful LNG-powered corridors, including strategic locations and maximum acceptable distance between LNG infrastructure.
- Evaluation of the possibilities for an integrated value chain for LNG and expansion opportunities.
- Examines useful incentive schemes for the development of LNG.
- Provides a plan for education and training development for LNG
- Assess requirements for security and safety for LNG infrastructure.
- Outlook on expected market trends, sectorial demand and global supplies of LNG.

1 INTRODUCTION

Humanity is currently experiencing an era of unprecedented climate change and action is urgently needed in order to ensure a sustainable future (IPCC, 2014). International goals for stabilizing GHG emissions have been set out by the United Nations Framework Convention on Climate Change (UNFCCC, 1992) and to limit the temperature increase to below 2 K as set forth in the Paris agreement (COP 21, 2015). International shipping plays an essential role in the facilitation of world trade as it is the most cost-effective and energy-efficient mode of mass cargo transport. However, the expected growth of world trade represents a challenge to meeting future emission targets that are required to achieve stabilization in global temperatures. It is estimated that for the period of 2007-2012, on average, international shipping accounted for approximately 2.4% of the annual global greenhouse gas (GHG) emissions (Third IMO Greenhouse Gas Study, 2015). Without changes, the negative externalities of shipping will increase. For example, in the same study scenarios, CO_2 emissions are predicted to increase by between 50% and 250% by 2050 depending on future economic and energy developments. Interestingly, it is also mentioned that actions on efficiency and emission reduction can mitigate the emission growth, although all scenarios but one project emissions from international shipping in 2050 to be higher than in 2012. Under a business-as-usual scenario for shipping, and if other sectors of the economy reduce emissions to keep global temperature increase below 2°C, shipping could by 2050 represent 10% of the global GHG emissions.

At the last United Nation climate change summit (COP21) held in Paris on December 12th 2015, it was unanimously agreed by 195 nations to keep the global temperature increase below 2°C compared to pre-industrial levels. This commitment requires worldwide GHG emissions to be reduced by 40-70% by 2050 and that carbon neutrality (zero emissions) needs to be reached by the end of the century at the latest. In spring 2018 the International Maritime Organisation (IMO) adopted the 'Initial IMO Strategy on Reduction of GHG emissions from ships' (IMO, 2018a) in order to align itself with the goals of the Paris agreement of the COP21. The goal set by this strategy is the reduction of CO_2 emissions from international shipping by 40% by 2030, and by 70% by 2050, with respect to the 2008 emissions level.

LNG is a fuel which results in lower emission of CO_2 by approximately 28% while releasing the same amount of energy when compared with the fuels currently dominating international shipping, such as Marine Diesel Oil (MDO) or Heavy Fuel Oil (HFO). LNG itself is a more potent greenhouse gas (GHG) than CO_2, so its release to the atmosphere must be limited throughout the entire supply chain, if it is to retain its GHG advantage over MDO and HFO. LNG may thus be considered an initial stepping-stone in reducing CO_2 emissions from international shipping. On its own, however, it is insufficient to even meet the 40% reduction of CO_2 emissions required by 2030. LNG in combination with energy efficiency measures may be key to achieving GHG emission reduction goals in the short term. However, it is predicted that these efforts alone cannot curb the rising emissions of international shipping as the sector is growing faster than the existing energy efficiency measures working to achieve a reduction in GHG reduction. It is very clear that major efforts in introducing non-fossil fuel need to be taken by the maritime industry itself in order to be able to reach a fossil free industry by the end of the century (IMO, 2018a).

Timeliness is of utmost important in the reduction of greenhouse gas emissions. The reason that LNG is of strategical importance to the BSR is its potential for reducing greenhouse gas emissions in the short and medium term. It is considered to be a bridging technology between the current situation dominated by fuel oil and a fully fossil-free sustainable energy economy, which will be required in the long term.

Thus, the promotion of the use of LNG can bring significant environmental benefits and significant economic savings in the short term. The technical innovation in the production of LNG has already allowed this specific type of fuel to be counted among the least expensive among types of fuel that can be transported. It can also serve as an important means of diversifying the fuels supplied to the maritime industry, by providing the potential for the introduction of more sustainable fuels, such as Liquefied Biogas (LBG), or LNG produced synthetically from renewable resources.

International policies and regulations play a key role in the development of the use of marine LNG in the BSR - they will affect the demand of the maritime sector for different fuels, which in turn affects fuel prices making the technology and infrastructure available economically advantageous as well for other modes and industries: in the area of the BSR there are various working solutions of LNG and business models present in the transport sector as can be deduced from the best practices cited below.

Safety is an important issue for LNG, since it is a cryogenically liquefied gas and is classified as a dangerous good according to the SOLAS Convention on Maritime Dangerous Goods Code. The current document will provide an overview of the international and national safety regulations and standards.

In addition to this, LNG is considered to be an important business opportunity for the BSR. As of March 2018, it is estimated that more than half of confirmed LNG driven ship newbuildings are destined to operate within Europe (DNV GL, 2018 a). This promises important opportunities for the entire LNG value chain.

Several challenges exist with respect to the development of LNG in the BSR. These comprise appropriate planning and coordination for infrastructure development, the implementation of appropriate and efficient safety regulation, and public acceptance of the new fuel and technologies. Another major challenge is the fact that LNG from fossil resources only reduces CO_2 emissions by around 10-20% (DNV GL, 2018 b). In order to achieve future scenarios of truly sustainable shipping, plans need to be made on how LNG can be combined with other renewable energy sources such as LBG, or LNG produced synthetically from renewable resources, but also with energy saving methods, such as hybrid engine systems. Since LNG is likely to be a bridging technology towards fully sustainable energy, the transition from LNG to a fully sustainable fuel or transport form should already be planned at this stage.

2 SITUATION ANALYSIS

This section presents background information on different aspects of LNG in the BSR – education, training and consulting capacities, legal international and national instruments, and gives an overview of the currently available as well as the planned LNG infrastructure.

2.1 WHY LNG AND WHY THE BALTIC SEA REGION?

The Baltic Sea Region (BSR), comprising of Denmark, Finland, Estonia, Germany, Latvia, Lithuania, Norway, Sweden, Poland, and Russia, is committed to being a leading region of the world when it comes to high innovation and advanced technological achievements. The region is also committed to environmental protection and to developing a sustainable use of energy. All BSR countries are dependent on maritime transport for the further development of their economies, and as a result, the BSR has developed into a maritime center with major international companies present. During the last decades, ships within the Baltic have increased both in number and size, currently handling up to 15% of the total world cargo traffic (Stankiewicz and Vlasov, 2009). It is also necessary to note that the level of traffic continues to grow, by about 5% per year. At the same time, the Baltic Sea is a very ecologically sensitive area being semi-enclosed with brackish water and is highly eutrophic as a result of anthropogenic pollution. Recognizing the need to protect its fragile environment, the region has been assigned as a SECA (Sulphur Emission Control Area) region by the IMO, through the Convention on Prevention of Pollution by Ships (MARPOL) (IMO, 2010). This implies that since January 1st 2015, ships entering the Baltic Sea must comply with less than 0.1% sulphur content in their fuel (IMO, 2013). The Baltic Sea is also to become a NECA (Nitrogen Emission Control Area) as of 2021, meaning that vessels built after 2021 will be required to reduce nitrogen oxide (NO_x) emissions by 80% compared to the present emission level.

Currently, around 10,000 ships are mainly used for European Short Sea Shipping of which around 5,000 are spending more than 50% of their time in SECAs. While operating in a SECA, ships must either employ low sulphur fuels, or use an exhaust gas after treatment system. (i.e. a Scrubber) to remove the sulphur from the exhaust gases, so that remaining sulphur emissions correspond to 0.1% sulphur in MDO. The available options can be summarized as follows:

a) integrating an emission abatement technology (i.e. a scrubber) in the current propulsion system

b) using low sulphur -but more expensive- fuel such as MGO (marine gas oil) or MDO (marine diesel oil)

c) opting for liquefied natural gas (LNG) (Madjidian et al., 2013, Dalaklis et al., 2016, Dalaklis et al., 2017), Ethane, Liquefied Petroleum Gas (LPG), Dimethyl Ether (DME) or other gaseous fuels

d) Methanol, e.g. Stena Germanica will be running on methanol (Stena Line, 2018), or other low-sulphur liquid fuels such as plant oils, Biodiesel, or Ethanol.

Given its availability, and CO_2 advantage even as a fossil fuel, LNG is likely to be the most promising alternative fuel in the short to medium term, at least for short sea (and possibly inland waterway transport), but also for maritime activities outside transport, e.g. fishing and offshore services, as it will help to reach environmental targets of sulphur, nitrogen, and particulate matter emissions in SECAs and NECAs spelled out by the IMO (Bengtsson et al., 2014, Brynolf et al., 2014, Thomson et al., 2015, Deniz and Zincir, 2016). LNG fueled ships emit nearly no sulphur oxides and particulate matter and net greenhouse gas emissions by 10-20% (DNV GL, 2018b). Emissions of nitrogen oxides (NO_x), can be reduced by 85% when using Otto cycle engines or by about 20-30% when using classic Diesel cycle engines. Otto cycle engines emit some unburned methane (methane slip) when operating, which is virtually non-existent in Diesel engines. Methane emissions are currently not regulated by the IMO but given their GHG effect, they need to be included in this discussion.

With the above IMO regulations on SO_x and NO_x in place, a forced shift has been placed upon the maritime industry in the BSR. The countries surrounding the Baltic Sea are not only examining and applying different pollution reduction technologies, but also considering/introducing other measures, such as adopting alternative fuels coupled with an interest in new-builds, retrofits, port LNG infrastructure, and bunkering facilities. This trend is not restricted solely to the maritime domain but also to other means of transport such as cars/trucks and the rail industry which are also under continuous scrutiny for their level of emissions to air and water. Using LNG can be part of the solution of complying with stricter emissions regulations.

2.1.1 Safety records

Natural gas is a fuel and a combustible substance. LNG is a clear, colorless, and non-toxic liquid which forms when natural gas is cooled to -162ºC (-260ºF). LNG consists mainly of methane (CH_4), with minor amounts of other hydrocarbons (ethane, propane, butane, and pentane). During transport the temperature should be below the boiling point. Because LNG is extremely cold, it requires special cryogenic equipment, procedures, and training of the personnel involved. The cooling process shrinks the volume of the gas 600 times, making it easier and safer to store and ship. In its liquid state, LNG will not ignite. When LNG reaches its destination, it is turned back into a gas at regasification plants. It is then piped to homes, businesses, and industries where it is burned for heat, to generate electricity, and for other purposes. Currently, LNG is emerging as a cost-competitive and less environmentally harmful alternative to other fossil fuels. This is the case especially for shipping and heavy-duty road transport (Shell, 2017).

Fire hazard properties:

The gas is flammable in volume concentrations between 4.5% and 16.5% in air but auto-ignition only occurs at high temperatures.

Table 1 Fire hazard properties of LNG in comparison to other fuels

Properties		Petrol (100 Octane)	Diesel	Methane (LNG)	Propane (LPG)
Flash point (°C)		<-40	>62		
Flammability in air	**Lowest concentration in air (%)**	1.4	0.6	4.5	2.1
	Highest concentration in air (%)	7.6	7.5	16.5	9.5
Auto-ignition temperature (°C)		246-280	250-300	537	480

Source: https://hub.globalccsinstitute.com/publications/ccs-learning-lng-sector-report-global-ccs-institute/91-development-history-lng

LNG has been safely handled as an energy resource for many years. Although the LNG industry has recently developed quite rapidly, it is based on very old foundations. Some major developments during its history, according to the Global Carbon Capture and Storage (CSS) Institute (2017), are listed below:

- Michael Faraday liquefied methane in 1820
- Karl von Linde developed a compressor refrigeration machine in 1873
- First LNG plant built in 1912 in West Virginia, began operation in 1917
- First commercial liquefaction plant built in 1941 in Cleveland, Ohio
- First LNG disaster in 1944 in Cleveland, Ohio
- First LNG tanker, the Methane Pioneer, carried first cargo of 7,000 bbl. LNG in 1959 from Louisiana to UK
- First export / import trade in 1964 between Algeria and UK
- From the start of the international trade in the 1960s, LNG demand reached 50 MTPA in 1990, then 100 MTPA in 2000, and 240 MTPA in 2012
- Production is expected to approximately double between 2012 and 2030

Currently natural gas is an important element of the world's supply of energy. BP's Energy Outlook 2030 (Figure 1) shows that natural gas contributes to more than 20% of the global primary energy basket, and that it may rise over the next decades due to the increasing price of oil.

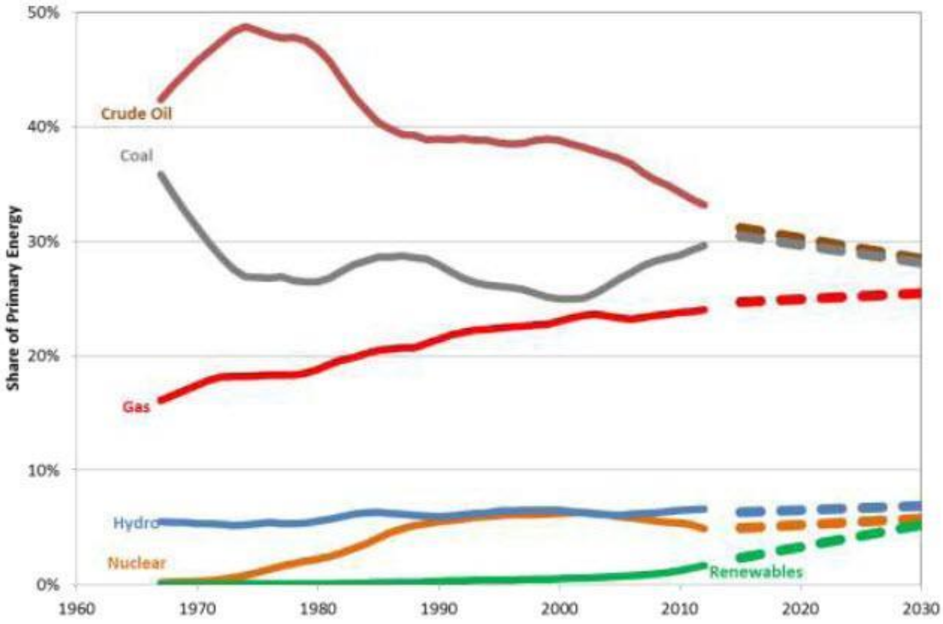

Figure 1. World Primary Energy Mix. Source: Developed from BP Energy Outlook 2030, January 2013

Natural gas is transferred and traded mainly by pipeline. However, LNG takes the share of more than 30% of transported natural gas movements. Figure 2 shows the major trade routes of LNG from supplying countries to five regional markets: namely North America, South America, Europe, India, and North Asia. New sources of LNG from identified gas resources in North America and the east coast of Africa, resulted in the increase in the portion of natural gas transported as LNG. Transportation of natural gas in the form of LNG gives flexibility in connecting suppliers and consumers all around the world.

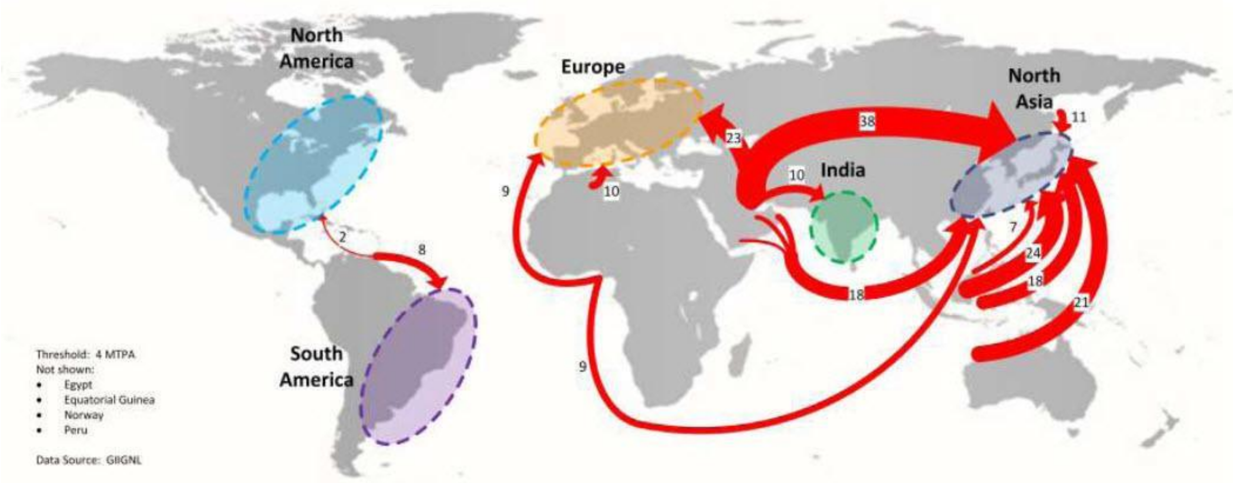

Figure 2. World Trade in Liquefied Natural Gas for 2012, (unit: MTPA). Source: Developed from GIIGNL report, "The LNG Industry in 2012".

There are two processes for liquefying natural gas in large quantities. The first is the cascade process in which the natural gas is cooled by another gas which in turn has been cooled by still another gas, hence named the "cascade" process. There are usually two cascade cycles prior to the liquid natural gas cycle. The other method is the Linde process, with a variation of the Linde process, called the Claude process, being sometimes used. In this process, the gas is cooled regeneratively by continually passing it through an orifice until it is cooled to temperatures at which it liquefies. The cooling of gas by expanding it through an orifice was developed by James Joule and William Thomson and is known as the Joule–Thomson effect. Lee Twomey used the cascade process for his patents (Global Carbon Capture and Storage Institute, 2017).

The LNG value chain includes the following:

- LNG adds value to Natural Gas by allowing efficient transportation over very long distances.
- Strict pre-treatment of feed gas is critical for LNG process performance. There are multiple technologies for the liquefaction process, with two of them dominating.
- LNG storage, marine facilities, and tanker fleets are major components of the value chain.
- LNG has been applied to conventional and unconventional gas sources and to onshore and offshore reservoirs (Global Carbon Capture and Storage Institute, 2017).

LNG as a fuel is a proven and available solution. Although in the near future, conventional oil-based fuels will be the main fuels for most existing vessels, the opportunities of LNG are interesting for many new build and conversion projects as LNG infrastructure is expanding rapidly (DNV GL, 2015). By the end of March 2017, the in-service and on-order fleet of LNG-powered seagoing ships had reached the 200 mark (See Fig.3). The LNG World Shipping exclusively lists the 97 LNG-fuelled ships on order, as of March 2017 (Corkhill, 2017).

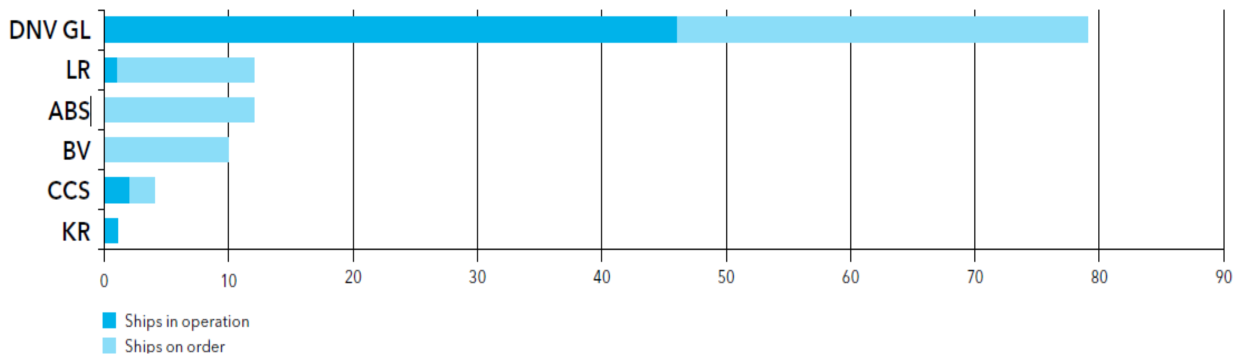

Figure 3. LNG-fuelled fleet. Source: DNV GL, (2016), https://www.dnvgl.com/maritime/lng/index.html.

Figure 4 shows emission restrictions being adopted for international shipping in the coming years. LNG is likely to become a key instrument in meeting restrictions in local air-pollution, as well as initial reductions in GHG emissions. Regulated air pollution emissions are comprised of SO_x, and NO_x. Particulate matter (PM) is an additional non-regulated pollutant that will be reduced significantly when switching to LNG. The potential for 99% removal of SO_x, and 95% of particle PM emissions and a notable reduction of up to 85% of NO_x (WinGD, 2018) emissions by consuming LNG allows it to comply with restrictions in Emission Control Areas (ECA). Methane slip is an issue which should be addressed in the future and either by direct regulation, or by incorporating it into its GHG potential and subtracting it from LNG's potential CO_2 emission advantage. Currently, CO_2 emission reductions by LNG are quoted to be 10-20% (DNV GL, 2018b).

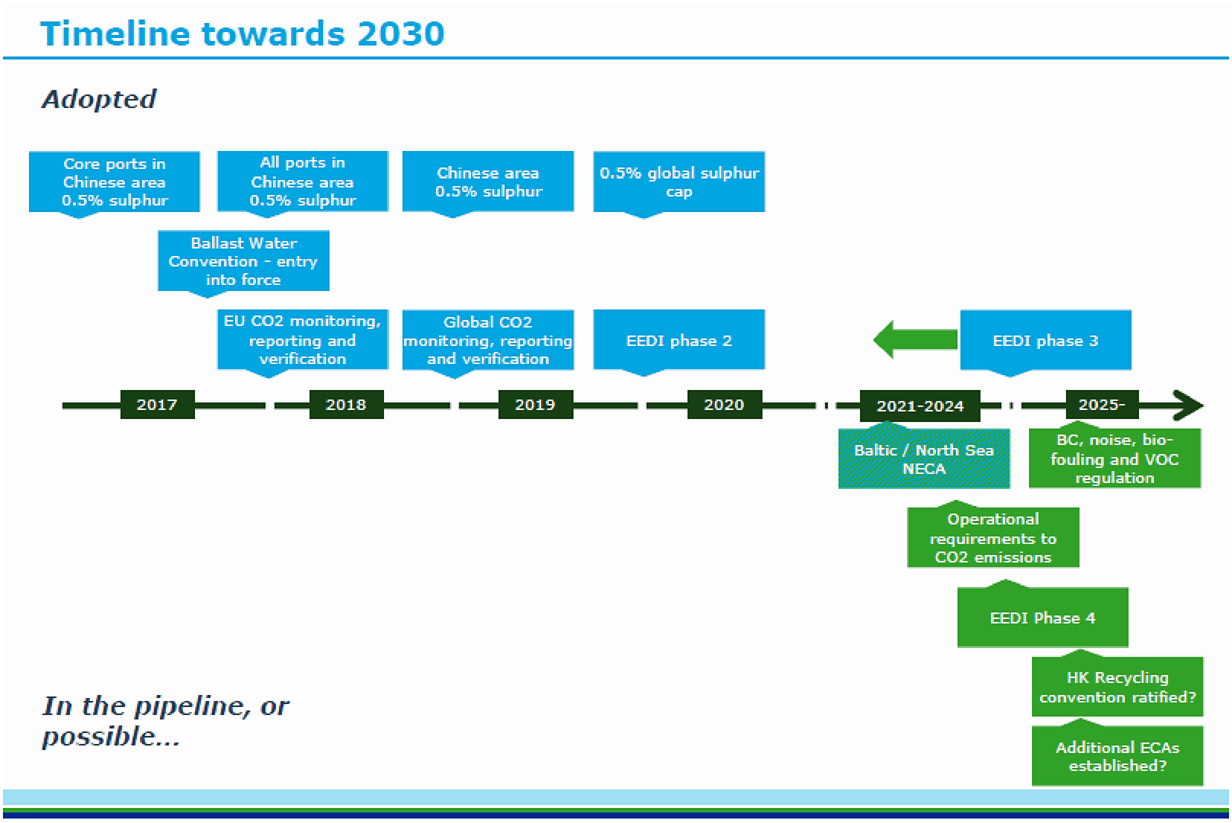

Figure 4. LNG International legal framework. Source: DNV GL, (2016), https://www.dnvgl.com/maritime/lng/index.html.

LNG is classified as a dangerous good according to the SOLAS Convention on Maritime Dangerous Goods Code (class 2 and class 3). Safety issues must be regulated by States Authorities on the basis mentioned in the Convention. All the BSR countries are SOLAS Convention members.

Nearly a decade of experience with small-scale LNG-driven ships has proven the reliability of the technology (Herdzik, 2011). Also, the distribution of LNG by sea has a good safety record; the Society of International Gas Tanker and Terminal Operators (SIGTTO) calculates that more than 80,000 LNG cargoes have been safely delivered with no loss of cargo tank containment and no on-board fatalities attributable to cargo operations. Since LNG is not carried under pressure but is natural gas that has been cooled until it has reached a liquid state, in the highly unlikely event of a loss of containment, LNG would return to a gaseous state and dissipate with no impact on water or land. For a fire to occur, there must simultaneously be a loss of containment, a narrow fuel-to-air ratio, and a source of ignition.

ISO (International Organization for Standardization)

The International Organization for Standardization (ISO) is a non-governmental organization and a network for national standard bodies developing standards for all kinds of industries on an international level. The ISO is also involved in the development of standards for the shipping industries and works closely with the IMO.
One important work done by the ISO related to the LNG supply chain is:

- Guidelines for systems and installations for supply of LNG as fuel to ships (currently under development in the ISO Technical Committee 67 WG) including requirements for safety, components and systems, and training.

The objectives of the document are defined as follows:

- Ensure safety to personnel (crew, bunkering operators, and 3rd party personnel).
- Eliminate or minimize the release of natural gas to the atmosphere.
- Promote standardization in equipment (connectors and instrumentation) and in procedures.
- Give functional requirements to explain principles and allow for future improvements and developments by not prescribing existing solutions based on current and limited experience.
- Allow for an effective review and permit process of simple and standardized solutions (IMO, 2016).

This document was published as *ISO/DTS 18683: Guidelines for Systems and Installations for Supply of LNG as Fuel to Ships*, on June 29th 2013. Another document from ISO is the *ISO 28460:2010 standard: Installation and Equipment for Liquefied Natural Gas – Ship to Shore Interface and Port*. ISO 28460:2010 which specifies the requirements for ship, terminal, and port service providers to ensure the safe transit of an LNG carrier through the port area and the safe and efficient transfer of its cargo. ISO 28460:2010 applies only to conventional onshore LNG terminals and to the handling of LNG cargos in international trade (IMO, 2016).

Classification Societies

Among all classification societies, DNV GL is the leading one for LNG. DNV introduced the first set of rules for gas-fueled ships in 2001, and these rules were used as input for the IMO Interim Guidelines issued in 2009. Since then, most IACS members, including ABS, LR, and NK have issued rules and guidelines related to the design and safety requirements for gas-fueled ship and onboard systems. In addition to the ship rules, classification societies are developing guidelines and standards related to bunkering operations and personnel certification. In April 2013, DNV issued a *Standard for Certification No. 3.325*, Competence Related to the Onboard Use of LNG as Fuel. The scope of the standard is to identify a suggested minimum level of knowledge and skills for people in various roles onboard a vessel using LNG as fuel (IMO, 2016).

1. DNV GL rules for gas as ship fuel:

   Part 6, Chapter 2, Propulsion, power generation, and auxiliary systems
   - Section 5 Gas-fueled ship installations – Gas-fueled
   - Section 6 Low flashpoint liquid-fueled engines - LFL fueled
   - Section 8 Gas ready ships - Gas ready

   Part 6, Chapter 5 Equipment and design features
   - Section 14: Gas bunker vessels - gas bunker

2. DNV GL Recommended Practice RP – G105 on the development and operation of LNG bunkering facilities.

DNV GL has been developing a Recommended Practice (RP) for LNG bunkering. In order to continue meeting and supporting the market in its growing demand for cleaner fuels and versatile LNG applications, DNV GL has updated its RP for Development and operation of LNG bunkering facilities (DNVGL-RP-G105). The RP now includes a section dedicated to determining LNG quantity and its properties. The objective is to assist operators in addressing the large spread in properties, density, and the calorific value among the available LNG sources globally (DNV-GL, 2015). The RP focuses on four main elements:

- Safe design and operation
- Safety management systems
- Risk assessments
- Gas quality and quantity metering.

The RP is in accordance with, but further elaborates on the ISO/TS 18683 Guidelines for systems and installations for supply of LNG as fuel to ships, with focus on bridging the gap between the rules for the receiving ship and the bunker supplier, such as national or port regulations and rules for LNG bunker vessels.

Industry Groups and Associations

The Society of International Gas Tanker & Terminal Operators (SIGTTO) is a non-profit organization representing the liquefied gas carrier operators and terminal industries. The purpose of the SIGTTO is to promote shipping and terminal operations for liquefied gases which are safe, environmentally responsible, and reliable. SIGTTO also publishes guidelines and reports for development of best operating practices. The guidelines describe the handling and transport of large quantities of LNG as cargo, handled by an experienced crew on gas carriers and LNG terminals, and has formed the basis for the development of current guidelines for the bunkering of LNG as ship fuel (IMO, 2016). The most important guidelines are:

- LNG Ship to Ship Transfer Guidelines including guidance for safety, communication, manoeuvring, mooring, and equipment for vessels undertaking side-by-side ship to ship transfer.
- Liquefied Gas Fire Hazard Management including the principles of liquefied gas fire prevention and fire-fighting.
- ESD Arrangements & linked ship/shore systems for liquefied gas carriers including guidance for functional requirements and associated safety systems for emergency shut-down (ESD) arrangements.
- Liquefied Gas Handling Principles on Ships and in Terminals including guidance for the handling of LNG, LPG, and chemical gases for serving ship's officers and terminal operational staff.
- LNG Operations in Port Areas including an overview of risk related to LNG handling within port areas (IMO, 2016).

SIGTTO announced in May 2013 the formation of a new organization for gas-fueled vessels: Society for Gas as a Marine Fuel (SGMF). One of the purposes of SGMF will be to develop advice and guidance for best industrial practices among its members and to develop best practice for the use of LNG as a marine fuel.

2.1.2 BUSINESS OPPORTUNITIES

Shifting from conventional fuel to LNG not only helps fulfill new stricter environmental policies and to ensure energy security and diversification, but also creates new business opportunities and benefits international cooperation. Regarding the deployment of LNG in the region, for the maritime industry the question is no longer if LNG could be a solution to complying with international emissions regulations, but rather how much of the energy and fuel market could be replaced by LNG and how-to market it effectively as the preferred fuel/source of energy. For the specific market to be fully exploited and become more financially viable, the number of sectors interacting with it needs to increase. In order to identify the prospects offered by the natural gas market, it is important to evaluate the current status of LNG use, as well as risks and opportunities.

Natural gas currently provides 22% of the energy used worldwide and represents almost a quarter of electricity production and plays a key industrial role as a raw material. (Source OECD / IEA, 2017). The number of operating LNG-fueled vessels is steadily increasing worldwide, with 102 of them already in operation, and 108 confirmed newbuildings until 2022 (DNV GL, 2016). Since not all planned LNG-driven ships are made public immediately (both in terms of newbuildings and planned retrofits), the actual number of planned LNG ships is likely to be greater than the above number. Of the confirmed new builds, 56% of the ships in operation are operating in Norway, 19% in the rest of Europe, 11% in America, and 8% in Asia and the Pacific. When it comes to the confirmed bookings (as of March 2018), 59% will be operating in Europe, 17% in America, 11% in Norway and 4% in Asia and the Pacific (DNV GL, 2018 a) (See Fig.5).

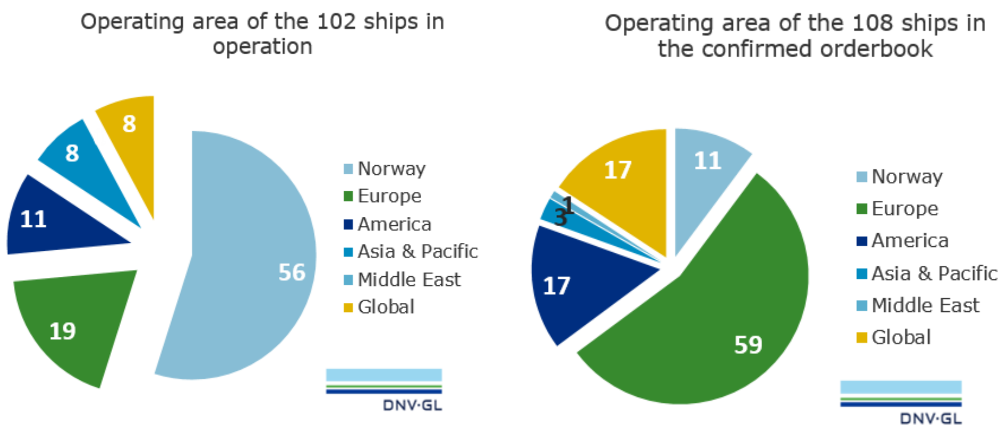

Figure 5. LNG ship operations by global areas. Source: Source: DNV GL, (2016)

From an economic point of view, LNG is seen by many as having the potential to decouple bunker prices from expected further increases in the cost of oil (EU Law and Publication, 2013). LNG can be sourced from a number of world regions and further distributed via existing and planned LNG import facilities to port based or mobile refueling stations. Globally known gas reserves are considerably larger than those of oil. According to the BP energy outlook 2035, global natural gas demand is expected to grow by 1.9% p.a., reaching around 490 Bcf/d by 2035 (BP stats, 2015), while a Shell outlook specifies that LNG is set to rise 4 to 5% until 2030 (Shell, 2017). Moreover, Europe's part in global LNG imports is believed to rise from 16% to 19% between 2013 and 2035 (BP stats, 2015). In other regions of the world, such as in China, Japan, South Korea, Singapore, and the US, plans to use LNG for shipping are also developing and emerging. The economic factors, once LNG becomes widely available in the SECAs, may also promote the use of the bunker in other areas across the EU (EU Law and Publication, 2013).

The preliminary ruling for the development of a natural gas market in the transport sector is represented by its competitiveness:

- with respect to other energy sources;
- to be evaluated with reference to the value chain as a whole.

In order to permit an adequate development of the LNG market at a global level, "market drivers" and "regulatory drivers" should be identified and used as tools to drive this development. The drivers of the market identify the environmental drivers represented by the growing decarbonization needs of the economy and the reduction of polluting emissions. Technical drivers may include, for example, the modularity and flexibility of what small scale LNG technologies allow. The economic drivers comprise the possibility of expansion and industrial development. LNG introduction is likely to start from the naval sector, which is currently experiencing a modernization of the fleet by retrofits, the construction of new ships, and pollution reduction from port areas.

The normative drivers (for example Nitrogen-oxides Emission Control Areas "-NECA and Sulphur Emission Control Areas - SECA) play a role of primary importance in allowing an adequate development of the whole System and LNG value chain.

2.1.3 Challenges

Ever since it was understood that the BSR would become an IMO SECA area, projects and research regarding LNG use in the region have started emerging. These projects and studies have been of various natures, e.g. some have been pure infrastructure projects (HEKLA – Helsingborg & Klaipeda LNG Infrastructure Facility Deployment), while others have had a softer approach including feasibility studies and the like (BSR Innoship, Cleanship, LNG in Baltic Sea Ports I & II, North European LNG Infrastructure Project, Martech LNG). The Go LNG project is a continuation of the Martech LNG project, which started mapping the LNG value chain development in the BSR. Go LNG is building on that knowledge, demonstrating the continued development of the region.

The type of challenges for the continuous development of LNG in the BSR has changed from an initial lack of planning for LNG infrastructure development or safety and public acceptance, to keeping up the pace and continuing the deployment of LNG in more areas. Another major task is managing the timeliness of LNG deployment from a climate perspective. It needs to be noted that while the use of LNG in shipping will help to reach environmental targets with regards to emissions of sulphur and particulate matters, with regards to CO_2 targets, the use of LNG will have to be complimented in the long run by more energy efficient engines and vessels. The potentials of non-fossil alternative shipping fuels (e.g. bio-LNG, synthetic LNG from renewable resources, renewable methanol, and renewable hydrogen), as well as energy efficiency and hybrid propulsion of ships, need to be implemented in order to meet greenhouse gas emissions in the medium term. One interesting option is the mixing of natural gas with biogas before liquefaction. By doing so, the fossil derived CO_2 emission of LNG can be reduced (Sperling, 2017). This is also a way of ensuring that LNG infrastructure will find applications in the medium and long term. The list below includes the main tasks for the LNG industry in the BSR:

- Ensure safe storage of LNG in main LNG import and small-scale LNG terminals on basis of "Safety First"
- Ensure safe transportation from main import and small-scale LNG terminals to LNG end users
- Promote use of LNG as a fuel in different transport modes (sea, road, railway, inland waterway transport)
- Promote the use of LNG as an energy resource in small and medium energy and heating plants
- Promote the use of LNG as an energy resource in industry
- Promote and create stationary and mobile LNG bunkering stations in BSR region, at locations close to the users
- Educate and train personnel who will work along the LNG supply chain
- Make sure the new infrastructure is sustainable and can be used for other purposes in the future (e.g. biofuels)
- Work for a progressive decarbonization of LNG, including biogas and synthetically produced methane from renewable resources in the gas mix
- Better understanding of LNG quality/gas composition and energy density, especially in the light of mixing natural and biogas
- Improve stakeholder relations management
- Improve the environmental performance of shipping in terms of local pollution, to prevent a major shift of transport from shipping to land routes.

The Go LNG project will focus on widening the use of LNG to encompass more than just the maritime sector. This will be done, in part by assisting stakeholders in finding relevant tools and regulations, education and networks, as well as discussing potentials for future sustainability.

2.1.4 Aim of Blue Corridor Strategy for the Baltic Sea Region

The aim of the Blue Corridor Strategy delineated in this report provides a road map for promoting LNG use as a fuel for transport and energy. A Blue Corridor shall be defined as an important axis for passenger and freight transport, which uses LNG as an initial step to improve its sustainability. The main objective of the Blue Corridor Strategy is to describe how the need for transport flows relate to the requirement for infrastructure development, business models, and government policies if the transport is to be powered by LNG in a cohesive and efficient LNG manner. The result is an infrastructure development plan and advice to policy makers, which could lead to increasingly environmentally friendly "Blue Transport Corridors" in the BSR. The strategy identifies the existing maritime LNG value chain of the region and describes the opportunities in expanding towards a wider value chain, incorporating not only shipping but other transport modalities and also land-based industries. It is envisioned that by disseminating information about LNG, the acceptance of LNG by the maritime industry will be facilitated, which in turn will create new business opportunities in energy, industry, port operations, and transportation sectors. During the course of the project, the Blue Corridor Strategy development will provide stakeholders in the LNG sector an up-to-date knowledge base on relevant technical information and standards as well as policies and regulations in the form of an online "tool box" and a bunkering map (Dalaklis et al., 2017).

Furthermore, it is anticipated that the region can demonstrate itself as a competence hub in the field of LNG. Several well-functioning LNG solutions and business models already present in the maritime transport sector of the region are identified and evaluated. Further, analyses on existing and potential efforts regarding education, business, infrastructure, and other challenges connected to a continued LNG advancement in the BSR are described.

In order to design a regional strategy with long-term aims, development patterns of LNG-related activities must be mapped, and capabilities regarding education, business, and infrastructure of some of the BSR countries (involved in the Go LNG project) must be analyzed. A full exploitation of LNG's potential requires not only the development of a well-functioning and favorable regulatory framework, but also a critical mass of investment in LNG infrastructure, as well as education and cooperation. Following that, the strategy suggests links that are missing or need to be developed further. Cooperation possibilities will be highlighted that could help achieve a greater effect on business development and a positive impact on the environment. In addition, the strategy includes methods on how to ensure the sustainability of LNG infrastructure and economic growth in the BSR coastal communities, such as by demonstrating the feasibility of LBG production and distribution in a municipality.

The Blue Corridor Strategy proposed in this document supports the general policy objectives of the EU in the field of transport and energy but also considers each country's specific challenges on introducing LNG to the market and aims to include the stakeholders' view on what is needed for a positive development of LNG use in the BSR.

2.2 POLICY AND LEGAL INSTRUMENTS

The UN and the EU as well as the BSR countries in general are moving towards green industries, by decreasing emissions from industrial processes, transport, and daily life by using cleaner energy sources, like LNG, LBG, and more renewable energy, like solar, wind, waves, and tidal energy.

In the BSR, tidal and wave energy is limited, because the Baltic Sea has very low tidal effects as well as limited wave energy due to relatively low waves. Solar energy is limited in the northern parts of the BSR, because solar days are relatively short and few. Wind energy is widely available, but the ability to store this energy still needs to be improved. In the short and medium terms, it is necessary to use other energy sources with the lowest environmental impact possible. The EU and BSR countries have identified LNG as an important part in the energy mix of the near future and have oriented their policies to supporting the use of LNG.

Before going into more details of continued LNG infrastructure deployment in the Baltic region, a brief background is presented on international policies and strategies that affect the introduction and continued deployment of LNG in the BSR. In order to understand how different parts of the LNG value chain are affected by policy and different legal instruments, it is necessary to gather existing information, both on the international level as well as national levels. Regulations and standards may be divided into two groups: those used internationally across many countries and those used by a specific country or region.

An important feature of the Blue Corridor Strategy is that it includes the use of LNG for the maritime sector as well as for road and rail. Below, we introduce some of the main international instruments that have played a major role in the development of LNG use in the BSR. These legal instruments have changed and will continue to change the shipping industry's demand for different fuels, which in turn affects the fuel prices and the cost-effective available technology and infrastructure. The collected policy documents, regulatory documents, standards and norms from all levels, are available at the GoLNG website, under the following link: http://www.golng.eu/en/standards-regulations-toolbox/. An overview of the international legal instruments connected to the use of LNG can be found in Table 2 below.

Table 2. International legal instruments connected to the use of LNG.

International legal instruments			**Application area** ***(may be blank if none apply or for general applicability)***			
Level	***Title***	***Type***	***Maritime***	***Inland H_20***	***Rail***	***Road***
IMO	International Convention for the Safety of Life at Sea (SOLAS)	Convention	X	X		
	International Convention for the Prevention of Pollution from Ships (MARPOL)	Convention	X	X		
	International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers	Convention	X	X		
	International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)	Code	X	X		

International legal instruments			Application area *(may be blank if none apply or for general applicability)*			
Level	***Title***	***Type***	***Maritime***	***Inland H_2O***	***Rail***	***Road***
	International Code of Safety for Ships Using Gases or Other Low-flashpoint Fuels (IGF Code)	Code	X	X		
	International Maritime Dangerous Goods Code (IMDG code)	Code	X	X		
	Interim Guidelines on Safety for Natural Gas-fuelled Engine Installations (MSC.285(86))	Guideline				
COTIF (Internationa l Rail Transport Committee)	Convention Concerning International Carriage by Rail, Appendix C: Regulations Concerning the International Carriage of Dangerous Goods by Rail	Convention			X	
EU -EC	On the establishment of criteria for use by LNG carriers of technological methods as an alternative to using low sulphur marine fuels http://register.consilium.europa.eu/doc/srv?l=EN&f=ST %2012022%202010%20INIT	Decision	X			
	Directive 2001/116/EC of December 20th 2001, on the classifications of vehicle category adapting to technical progress	Directive				X
	Council Directive 70/156/EEC on the approximation of the laws of the Member States relating to the type-approval of motor vehicles and their trailers	Directive				X
	Directive 2002/24/EC of the European Parliament and of the Council of March 18th 2002 relating to the type-approval of two or three-wheeled motor vehicles and repealing Council Directive 92/61/EEC					x
	2009/28/EC of the European Parliament and of the Council of April 23rd 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC	Directive	X	X	X	X

International legal instruments			***Application area*** *(may be blank if none apply or for general applicability)*			
Level	***Title***	***Type***	***Maritime***	***Inland H_20***	***Rail***	***Road***
	Target of 10 % of renewables in transport fuels					
	Inland transport of dangerous goods (2008/68/EC)	Directive		x	x	x
	Directive laying down technical requirements for inland waterway vessels (2006/87/EC)	Directive		x		
	Seveso II - Directive on the control of major-accident hazards involving dangerous substances (96/82/EC)	Directive				
	Environmental impact assessment directive (EIA) - on the assessment of the effects of certain public and private projects on the environment (2011/92/EU)	Directive				
	Industrial emissions directive (IED) - integrated pollution prevention control (IPPC) (2010/75/EU)	Directive				
	Pressure equipment directive (97/23/EC) (PED)	Directive				
	ATEX directive 94/92/EC (ATEX 95) (94/9/EC)	Directive				
	ATEX directive 99/92/EC (ATEX 137) (99/92/EC)	Directive				
	DIRECTIVE 2014/94/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of October 22nd 2014 on the deployment of alternative fuels infrastructure	Directive	X	X		X
	EU directive 2009/28/EF	Directive				X
	Directive 2008/68/EF Inland transport of dangerous goods	Directive			X	
	EU LNG Strategy	Strategy				
UNECE (United Nations Economic	ADR: “European Agreement Concerning the International Carriage of Dangerous Good by Road” LNG trucks have to be marked, only fill tank up to 90-95%	Agreement				X

International legal instruments			Application area *(may be blank if none apply or for general applicability)*			
Level	***Title***	***Type***	***Maritime***	***Inland H_2O***	***Rail***	***Road***
Commission for Europe)						
	ADR 2013 Dangerous Goods Guide/33/ Education of drivers transporting dangerous goods. Drivers transporting LNG must have an "ADR Certificate"/ Acquisition course TANK All equipment has to be approved according to ADR (trailer, truck, containers, etc.)	Agreement				X
	ADN - European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways	Agreement		x		
Organization for Cooperation of Railways	Agreement on International Goods Transport by Rail (SMGS) (Appendix II)	Agreement			X	
The Society of International Gas Tanker and Terminal Operators (SI GTTO)	LNG Transfer Ship to Ship	Guideline	x			
	LNG Transfer and Port Operations	Guideline	x			
ISO	ISO 28460:2010 Installation and equipment for liquefied natural gas – Ship-to-shore interface and port operations	Standard	X	X		
	ISO/TC 67	Standard	x			

International legal instruments			Application area *(may be blank if none apply or for general applicability)*			
Level	***Title***	***Type***	***Maritime***	***Inland H_2O***	***Rail***	***Road***
	Materials, equipment, and offshore structures for petroleum, petrochemical, and natural gas industries					
	ISO 20519[1] Ships and marine technology – Specification for bunkering of liquefied natural gas-fueled vessels The scope of the standard will cover shore-to-ship, truck-to-ship and ship-to-ship transfer.	Standard	x			
CEN (European Committee for Standardization)	CEN/TC 282 EN 12065:1997 Installations and equipment for liquefied natural gas - Testing of foam concentrates designed for generation of medium and high expansion foam and of extinguishing powders used on liquefied natural gas fires	Standard				
	CEN/TC 282 EN 12066:1997 Installations and equipment for liquefied natural gas - Testing of insulating linings for liquefied natural gas impounding areas	Standard				
	CEN/TC 282 EN 12838:2000 Installations and equipment for liquefied natural gas - Suitability testing of LNG sampling systems	Standard				
	CEN/TC 393 EN 13012:2012 Petrol filling stations - Construction and performance of automatic nozzles for use on fuel dispensers	Standard				x
	CEN/TC 393 EN 13617-1:2012	Standard				x

[1] Produced at the request of the International Maritime Organization (IMO), the European Commission and the Baltic and International Maritime Council (BIMCO), the world's largest international shipping association.

International legal instruments			Application area *(may be blank if none apply or for general applicability)*			
Level	***Title***	***Type***	***Maritime***	***Inland H_2O***	***Rail***	***Road***
	Petrol filling stations - Part 1: Safety requirements for construction and performance of metering pumps, dispensers, and remote pumping units					
	CEN/TC 393 EN 13617-2:2012 Petrol filling stations - Part 2: Safety requirements for construction and performance of safe breaks for use on metering pumps and dispensers	Standard				x
	CEN/TC 393 EN 13617-3:2012 Petrol filling stations - Part 3: Safety requirements for construction and performance of shear valves	Standard				x
	CEN/TC 393 EN 13617-4:2012 Petrol filling stations - Part 4: Safety requirements for construction and performance of swivels for use on metering pumps and dispensers	Standard				x
	CEN/TC 282 EN 13645:2001 Installations and equipment for liquefied natural gas - Design of onshore installations with a storage capacity between 5 t and 200 t	Standard				
	CEN/TC 218 EN 13766:2010 Thermoplastic multi-layer (non-vulcanized) hoses and hose assemblies for the transfer of liquid petroleum gas and liquefied natural gas - Specification	Standard				
	CEN/TC 265 EN 14620-1:2006 Design and manufacture of site built, vertical, cylindrical, flat-bottomed steel tanks for the storage of refrigerated, liquefied gases with operating temperatures between 0°C and -165°C - Part 1: General	Standard				

International legal instruments			Application area *(may be blank if none apply or for general applicability)*			
Level	***Title***	***Type***	***Maritime***	***Inland H_2O***	***Rail***	***Road***
	CEN/TC 282 EN 1473:2016 Installations and equipment for liquefied natural gas - Design of onshore installations	Standard				
	CEN/TC 282 EN 1474-2:2008 Installations and equipment for liquefied natural gas - Design and testing of marine transfer systems - Part 2: Design and testing of transfer hoses	Standard				
	CEN/TC 282 EN 1474-3:2008 Installations and equipment for liquefied natural gas - Design and testing of marine transfer systems - Part 3: Offshore transfer systems	Standard				
	CEN/TC 268 EN 1626:2008 Cryogenic vessels - Valves for cryogenic service	Standard				
	CEN/TC 234 EN 16348:2013 Gas infrastructure - Safety Management System (SMS) for gas transmission infrastructure and Pipeline Integrity Management System (PIMS) for gas transmission pipelines - Functional requirements					
	CEN/TC 408 EN 16723-2:2017 Natural gas and biomethane for use in transport and biomethane for injection in the natural gas network - Part 2: Automotive fuels specification	Standard				x
	CEN/TC 139 EN ISO 11127-6:2011 Preparation of steel substrates before application of paints and related products - Test methods for non-metallic blast-cleaning abrasives - Part 6: Determination of water-soluble contaminants by conductivity measurement (ISO 11127-6:2011)	Standard				

International legal instruments			**Application area** *(may be blank if none apply or for general applicability)*			
Level	***Title***	***Type***	***Maritime***	***Inland H_20***	***Rail***	***Road***
	CEN/TC 301 EN ISO 12617:2017 Road vehicles - Liquefied natural gas (LNG) refueling connector – 3.1 MPa connector (ISO 12617:2015, Corrected version 2016-01-15)	Standard				x
	CEN/TC 282 EN ISO 16903:2015 Petroleum and natural gas industries - Characteristics of LNG, influencing the design and material selection (ISO 16903:2015)	Standard				
	CEN/TC 282 EN ISO 16904:2016 Petroleum and natural gas industries - Design and testing of LNG marine transfer arms for conventional onshore terminals (ISO 16904:2016)	Standard				
	CEN/TC 326 EN ISO 16923:2018 Natural gas fueling stations - CNG stations for fueling vehicles (ISO 16923:2016)	Standard				x
	CEN/TC 326 EN ISO 16924:2018 Natural gas fueling stations - LNG stations for fueling vehicles (ISO 16924:2016)	Standard				x
	CEN/TC 282 EN ISO 20519:2017 Ships and marine technology - Specification for bunkering of liquefied natural gasfueled vessels (ISO 20519:2017)	Standard	x			
	CEN/TC 282 EN ISO 28460:2010 Petroleum and natural gas industries - Installations and equipment for liquefied natural gas - Ship-to-shore interface and port operations (ISO 28460:2010)	Standard				
British Standard	EN 1160: Installations and equipment for liquefied natural gas – General Characteristics of LNG	Standard				

International legal instruments			Application area *(may be blank if none apply or for general applicability)*			
Level	***Title***	***Type***	***Maritime***	***Inland H_2O***	***Rail***	***Road***
	EN 1473 Installations and equipment for LNG – Design of onshore installations, 2007	Standard				
	EN 13645 Installations and equipment for LNG – Design of onshore installations with a storage capacity between 5t and 200t	Standard				
Port of Helsinki	Safety manual on LNG bunkering procedures for the Port of Helsinki	Manual	X			

2.2.1 International Maritime Organization

Below, you can find a brief description of the most important IMO regulations with relevance to LNG.

The most relevant IMO regulations applicable to the use of LNG as a fuel for shipping, based on a feasibility study carried out by the IMO on 2016, are listed as below:

1. SOLAS convention including requirements for maritime fuels
2. STCW convention including training requirements for crews
3. International Code for Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code, referenced within SOLAS Chapter VII, Part C) including requirements for the construction and operation of LNG tanker
4. Interim Guidelines on Safety for Natural Gas-Fueled Engine Installations in Ships MSC.285(86)
5. International Code of Safety for Ships using Gases or Other Low-flashpoint Fuels (IGF Code, in development, will be referenced within SOLAS) including requirements for the construction and operation of gas-fueled ships (IMO, 2016).

2.2.1.1 International Convention for the Prevention of Pollution from Ships (MARPOL)

The most significant regulation driving the introduction and continued development of LNG in the BSR is the International Maritime Organization’s Convention on Prevention of Pollution by Ships (MARPOL) (IMO, 2010). Annex VI of the IMO MARPOL Convention represents the regulatory framework tackling exhaust gas emissions from ships. It prohibits deliberate emissions of ozone depleting substances and sets progressive reductions (tiers) in emissions of sulphur oxides (SO_X), nitrogen oxides (NO_X), and particulate matter (PM). It has also introduced designated emission control areas with more stringent standards for emissions of SO_X, NO_X, and PM. Today these areas are the Baltic Sea (SO_X only), the North Sea (SO_X only), the North American area (SO_X, NO_X, and PM), and the United States Caribbean Sea area (SO_X, NO_X, and PM). The ECAs have and will continue to change the shipping industry's demand for different fuels, which in turn affects the fuel prices and cost-effective available technology and infrastructure. Depending on which technologies/fuels will be demanded, the reduction of GHG will also be affected.

When it comes to GHG from shipping, amendments to MARPOL Annex VI in 2011 added Chapter 4 which introduces two mandatory mechanisms (which entered into force in January 2013), which are intended to ensure an energy efficiency standard for ships: (1) the Energy Efficiency Design Index (EEDI) for new ships and (2) the Ship Energy Efficiency Management Plan (SEEMP) for all ships.

- The EEDI is a performance-based mechanism that requires certain minimum energy efficiency in new ships. As long as the required energy efficiency level is attained, ship designers and builders are free to use the most cost-efficient solutions for the ship to comply with the regulations. The level is tightened incrementally every five years and EEDI is therefore expected to stimulate continued innovation and technical development of all the components influencing the fuel efficiency of a ship. The improvement target (%) of new ships increases in 2015, 2020 and 2025.
- The SEEMP establishes a mechanism for operators to improve the energy efficiency of ships. The Ship Energy Efficiency Management Plan (SEEMP) is an operational measure that establishes a mechanism to improve the energy efficiency of a ship in a cost-effective manner. The SEEMP also provides an approach for shipping companies to manage ship and fleet efficiency performance over time using, for example, the Energy Efficiency Operational Indicator (EEOI) as a monitoring tool. The guidance on the development of the SEEMP for new and existing ships incorporates best practices for fuel-efficient ship operation, as well as guidelines for voluntary use of the EEOI for new and existing ships (MEPC.1/Circ.684). The SEEMP allows companies and ships to monitor and improve performance with regard to various factors that may contribute to CO_2 emissions.

2.2.1.2 International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF code) and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code)

Important IMO instruments related to the use of LNG are the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels, the IGF code (amendments to the International Convention for the Safety of Life at Sea - SOLAS), which entered into force January 1st 2016, and the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code). The IGF code is set up to minimize the risk to the ship, its crew, and the environment, paying regard to the nature of the fuels involved. It therefore contains mandatory provisions for the arrangement, installation, control, and monitoring of machinery, equipment, and systems using low-flashpoint fuels, focusing initially on LNG. The purpose of the IGC Code is to provide an international standard to ensure the safety of gas carriers. The IGC focuses on LNG as a cargo, not as a fuel. The code includes prescriptions for the design and construction of the ships and onboard equipment in order to minimize the risks associated with LNG transport. This includes requirements for the materials of construction, ventilation, electric installations, and fire protection.

2.2.2 European Union

The European Union launched a ten year job and growth strategy in 2010 called Europe 2020. It is supposed to help create conditions for smart, sustainable, and inclusive growth. Five headline targets have been set for the EU to achieve by the end of 2020. These cover employment, research and development, climate/energy, education, social inclusion, and poverty reduction.

The EU is committed to supporting the development of common technical standards and regulations at the European and international levels, including filling stations, components for vehicles or stationary equipment, gas quality, and other important technical issues. NGVA Europe coordinates its activities at CEN, UNECE, or ISO level with other important stakeholders, such as the International Association for Natural Gas Vehicles, NGV Global.

2.2.2.1 Energy Strategy 2020

By 2020, the EU aims to reduce its greenhouse gas emissions by at least 20%, to increase the share of renewable energy by at least 20% of consumption, and to achieve energy savings of 20% or more. All EU countries must also achieve a 10% share of renewable energy in their transport sector. Through the attainment of these targets, the EU can help combat climate change and air pollution, decrease its dependence on foreign fossil fuels, and keep energy affordable for consumers and businesses. As part of the Energy Union strategy, the EU is committed to building missing links and energy infrastructures to ensure that each member state has access to several sources of gas. Integrating the BSR with the rest of the EU's gas system is one of the Commission's top priorities.

In order to meet the targets, the 2020 Energy Strategy (European Commission, 2011) sets out five priorities:

- Making Europe more energy efficient by accelerating investment into efficient buildings, products, and transport. This includes measures such as energy labeling schemes, renovation of public buildings, and eco-design requirements for energy intensive products.
- Building a pan-European energy market by constructing the necessary transmission lines, pipelines, LNG terminals, and other infrastructure. Financial schemes may be

provided to projects which have trouble obtaining public funding. By 2015, no EU country should be isolated from the internal market.

- Protecting consumer rights and achieving high safety standards in the energy sector. This includes allowing consumers to easily switch energy suppliers, monitor energy usage, and speedily resolve complaints.
- Implementing the Strategic Energy Technology Plan – the EU's strategy to accelerate the development and deployment of low carbon technologies such as solar power, smart grids, and carbon capture and storage.
- Pursuing good relations with the EU's external suppliers of energy and energy transit countries. Through the Energy Community, the EU also works to integrate neighboring countries into its internal energy market.

2.2.2.2 EU White Paper for Transport

The European Commission's EU White Paper for Transport (2011) has set a greenhouse gas reduction goal of at least 40% by 2050 (compared to 2005) in absolute terms for the shipping sector. This must take into account the expected substantial traffic increase during that period. The White Paper also states that shipping will need to further contribute to the reduction of local and global emissions (European Commission, 2018). In addition, the dependency on oil, a general risk factor for transport within the EU economy, requires looking for alternative fuels, in particularly for those which help to further reduce greenhouse gas emissions.

2.2.2.3 EU Directive on alternative fuels

In 2014 the EU approved EU Directive (2014/94/EU) (European Parliament, 2014), a common framework for the deployment of alternative fuels throughout the EU. The directive was accompanied by an action plan for the development of Liquefied Natural Gas (LNG) in shipping. Through the Directive 2014/94/EU, vital infrastructure in EU is being established, setting out minimum requirements for recharging points for electric vehicles and refueling points for natural gas (LNG and CNG) and hydrogen, to be implemented by Member States. It also sets out technical specifications and user information requirements. The framework is aimed at minimizing dependence on oil and mitigating the environmental impact of transport in the EU. For many member states, Directive 2014/94/EU marked the starting point for developing LNG infrastructure. In November 2016, according to Article 3.7 of the Directive, each EU country was supposed to hand in its own LNG national policy framework. Moreover, the directive spells out that each country must report the implementation status by November 18th 2019 and every following third year.

Such frameworks set national targets and objectives and support actions for the development of a market for alternative fuels. This includes the deployment of the necessary infrastructure to be put into place. Importantly, the frameworks must have been developed in close cooperation with regional and local authorities and with the industry concerned while also considering the needs of small and medium-sized enterprises. Where necessary, member states should cooperate with other neighboring member states at regional or macro- regional level. This is particularly important where continuity of alternative fuels infrastructure coverage across national borders or the construction of new infrastructure in the proximity of national borders is required, such as non-discriminatory access to recharging and refueling points. A need to rapidly establish a minimal infrastructure for LNG bunkering was identified, in order to kick-start the development. The availability of LNG bunkering infrastructure would increase the demand by ships, further decreasing prices for LNG technology and LNG itself. By November 2016, all member states were required to submit national policy frameworks for the implementation of the EU alternative fuels directive. The final Directive, as adopted by the European Parliament and the Council on September 29th 2014 following the inter-institutional negotiations:

- Requires Member States to develop national policy frameworks for the market development of alternative fuels and their infrastructure
- Foresees the use of common technical specifications for recharging and refuelling stations
- Paves the way for setting up appropriate consumer information on alternative fuels, including a clear and sound price comparison methodology

2.2.2.4 The TEN-T Core Network and Motorways of the Sea

The TEN-T Core Network shall be the basis for the deployment of LNG infrastructure as it covers the main traffic flows and allows for network benefits. Out of the nine corridors, three include the Baltic Sea Region (European Commission, 2013):

1. The Scandinavian-Mediterranean Corridor is a crucial north-south axis for the European economy. Crossing the Baltic Sea from Finland to Sweden and passing through Germany, the Alps, and Italy, it links the major urban centers and ports of Scandinavia and Northern Germany to continue to the industrialized high production centers of Southern Germany, Austria, and northern Italy, continuing further to the Italian ports and Valletta. The most important projects in this corridor are the fixed Fehmarnbelt crossing and Brenner base tunnel, including their access routes. It extends, across the sea, from southern Italy and Sicily to Malta.
2. The North Sea-Baltic Corridor connects the ports of the eastern shore of the Baltic Sea with the ports of the north sea. The corridor connects Finland with Estonia by ferry and provides modern road and rail transport links between the three Baltic states on the one hand and Poland, Germany, the Netherlands, and Belgium on the other. Between the Odra river and German, Dutch, and Belgian ports, it also includes inland waterways, such as the "Mittelland-Kanal". The most important project is "Rail Baltic", a European standard gauge railway between Tallinn, Riga, Kaunas, and North-Eastern Poland.
3. The Baltic-Adriatic Corridor is one of the most important trans-European road and railway axes. It connects the Baltic with the Adriatic Sea through industrialized areas between Southern Poland (Upper Silesia), Vienna, Bratislava, the Eastern Alpine

region and northern Italy. It comprises important railway projects such as Semmering base tunnel and Koralm railway in Austria and cross-border sections between Poland, Czechia, and Slovakia.

Core network corridors lead the way in implementing the new TEN-T dimension, as conceived with the 2013 guidelines. These corridors are strong means for the European Commission to boost investments and to advance the wider EU transport policy objectives. The ultimate aim of infrastructure development along these corridors – and for the core network as a whole – is to complete the seamless connections for the sake of efficient, future-oriented, and high-quality transport services for citizens and economic operators.

In EU countries, the TEN-T Core Network and Motorways of the Sea provides the basis for the deployment of LNG infrastructure, as these cover the main traffic flows and pave the way for more "network" benefits. Within the core network, ports that have been appointed as core ports will have to offer bunkering of LNG to its customers by the end of 2025 (see Table 3). For the development of LNG for road transport, Member States have to ensure a sufficient number of publicly accessible refueling points, with common standards, within the TEN-T core network (see IP/13/948), ideally every 400 km, to be built by the end of 2025.

Table 3. TEN-T Core Network timings of core ports to offer LNG bunkering to its customers. Source: European Commission, 2017.

	Coverage	**Timing**
LNG at maritime ports	Ports of the TEN-T core network	by end 2025
LNG at inland ports	Ports of the TEN-T core network	by end 2030
LNG for heavy-duty vehicles	Appropriate number of points along the TEN-T core network	by end 2025

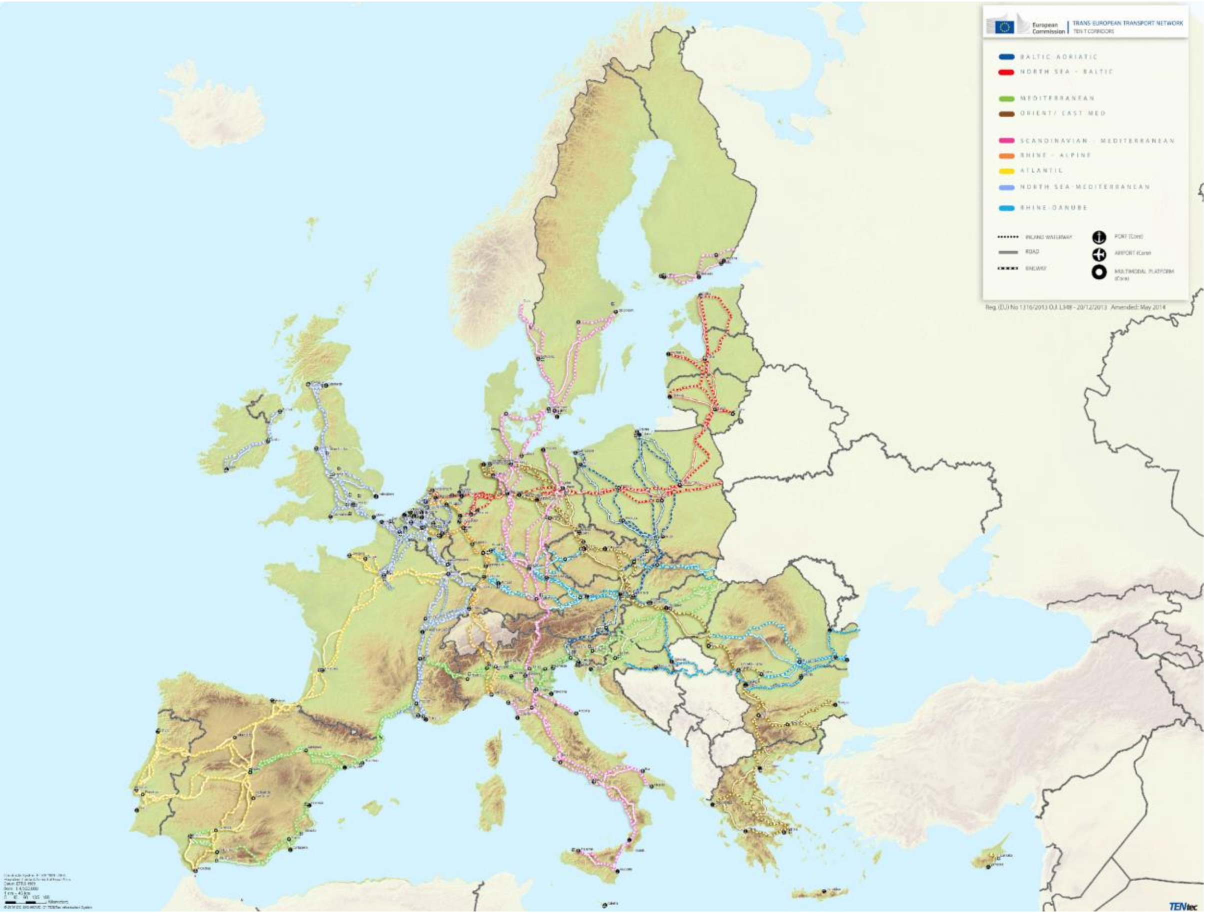

Figure 6. TEN/T corridors. Source: https://ec.europa.eu/transport/themes/infrastructure/ten-t-guidelines/corridors/maps_en.

2.2.2.5 EU LNG Strategy

In February 2016, the EU delivered an LNG Strategy, stressing geopolitical challenges linked to ensuring secure and resilient supplies of fossil fuels with the aim of exploiting the potential of liquefied natural gas (LNG) as gas storage. This was aimed at making the EU gas system more diverse and flexible, thus contributing to the key EU objective of a secure, resilient, and competitive gas supply (European Commission, 2016).

2.2.3 National level LEGAL instruments

Shipping is international and the IMO and other international bodies, such as the European Maritime Safety Agency, largely develop regulations for ships. At the same time, regulations and standards oriented on shore side LNG terminals and facilities are different in each country and different ministries or administrations are responsible for safety issues. In Table 5, national legal instruments of BSR countries involved in the Go LNG project are shown and in Table 6, responsible authorities are listed.

Table 4. National legal instruments of BSR countries involved in the Go LNG project.

Country	National legal instruments	Scope	LNG sector
Denmark	Lovbekendtgørelse nr. 996 af 13. oktober 2011, med de ændringer, der følger af § 2 i lov nr. 575 af 18. juni 2012, § 3 i lov nr. 576 af 18. juni 2012, § 2 i lov nr. 1352 af 21. december 2012 og § 2 i lov nr. 642 af 12. juni 2013	National natural gas supply directive	General
	BEK 726 af 3. July 2008 (+ later updates)	Security in tunnels	Road
	In Denmark, part of BEK 2008/68/EF af 24, September 2008, applies to national transport of dangerous goods by rail. (EU)	Dangerous goods	Rail
	Convention concerning International Carriage by Rail (COTIF), Appendix C: Regulations concerning the International Carriage of Dangerous Goods by Rail	Dangerous goods	Rail
	BEK 9484 af 15. February 2005	Transport of explosives in tunnels	Rail and Road
	EN 1160: Installations and equipment for liquefied natural gas – General Characteristics of LNG	Standard	General
	EN 1473 Installations and equipment for LNG – Design of onshore installations, 2007	Standard	Maritime
	EN 13645 Installations and equipment for LNG – Design of onshore installations with a storage capacity between 5t and 200t	Standard	Maritime
	BEK nr 788 af 27/06/2013	in line with the international ADR – transport and handling of dangerous goods	Road
	Temavejiledning om omtapping av farlig stoff (DSB 2011). (revised in 2013)	Guideline - The guideline is from Norway and addresses the demands on bunkering stations. It has been applied in DK in connection with Fjordline. It permits – amongst other things – that passengers may stay on board during bunkering.	Maritime
	Anvisningar för flytande naturgas, LNGA 2010	LNG bunkering	General
Germany	Ship Safety Law (Schiffssicherheitsgesetz) (SchSG)	Interim guidelines on safety for natural gas-fueled engine installations in ships (MSC.285(86))	Maritime

Country	National legal instruments	Scope	LNG sector
	Inland Water Vessel Investigation Ordinance (Binnenschiffsuntersuchungsordnung) (BinSchUO)	Directive laying down technical requirements for inland waterway vessels (2006/87/EC) Rhine Vessel Inspection Regulations (RVIR)	Inland Water
	Inland Waterway Ordinance (Binnenchifffahrtsstrassenordnung) (BinSchStrO)		Inland water
	Gefahrgutverordnung Straße, Eisenbahn und Binnenschifffahrt (GGVSEB)	EU directive inland transport of dangerous goods (2008/68/EC) European agreement concerning international carriage of dangerous goods by inland waterways (ADN) European agreement concerning international carriage of dangerous goods by road (ADR)	Inland water
	Environmental Impact Assessment Act (Gesetz über die Umweltverträglichkeitsprüfung) (UVPG)	Environmental Impact Assessment Directive (EIA) - on the assessment of the effects of certain public and private projects on the environment (2011/92/EU)	Onshore
	Federal Emission Protection Law (Bundesemissionschutzgesetz) (BlmSchG), Major Accident Ordinance (Störfallverordnung)	Seveso II - Directive on the control of major-accident hazards involving dangerous substances (96/82/EC)	Onshore
Lithuania	Lietuvos Respublikos suskystintų gamtinių dujų terminalo įstatymas. (Republic of Lithuania, the Liquefied Natural Gas Terminal Law).	Scope of LNG usage in Lithuania	General
	Lietuvos Respublikos Vyriausybės nutarimas „Dėl Lietuvos Respublikos suskystintų gamtinių dujų terminalo įstatymo įgyvendinimo“ (Lithuanian Government Decree "Regulations for Use of the Liquefied Natural Gas Terminal in the Republic of Lithuania"	Scope of LNG implementation	General
	Gamtinių dujų tiekimo diversifikavimo tvarkos aprašas (Natural Gas Supply Diversification Procedure)	Ministry act for the LNG receivers	Main LNG receivers in Lithuania

Country	National legal instruments	Scope	LNG sector
	Suskystintų gamtinių dujų, atgabenamų į suskystintų gamtinių dujų terminalą, pirkimo tvarkos aprašas (Liquefied natural gas, transported in liquefied natural gas terminal, purchasing procedure)	LNG terminal and market procedures	LNG terminal and main LNG users
	Naudojimosi suskystintų gamtinių dujų terminalu taisyklės (Terminal rules for the use of a liquefied natural gas)	LNG terminal safety	LNG terminal, LNG suppliers, and users
	Nutarimas dėl suskystintų gamtinių dujų perkrovos paslaugos kainos 2015–2019 metams (Decree on liquefied natural gas service rates overload for the years 2015-2019). Link: www.gov.lt	LNG business model	LNG terminal and users
Norway	Greenhouse Gas Emission Trading Act issued by the Norwegian Environment Agency	"Tradable permit for greenhouse gas emissions"	General
	Fire and Explosion Prevention Act and its regulations		LNG terminals, facilities for LNG bunkering
	Regulations on the handling of hazardous substances		
	The Pressure Equipment Directive		
Poland	Ustawa o przewozie towarów niebezpiecznych	Act of Parliament regarding dangerous goods transportation	Inland, Road, Rail
	Rozporządzenie Ministra Transportu, Budownictwa i Gospodarki Morskiej w sprawie formularza listy kontrolnej i formularza protokołu kontroli	Regulation by Ministry of Transport, Construction, and Maritime Economy regarding checklist and control protocol form	Inland, Road, Rail
	Rozporządzenie Ministra Transportu, Budownictwa i Gospodarki Morskiej w sprawie formularza rocznego sprawozdania z działalności w zakresie przewozu towarów niebezpiecznych oraz sposobu jego wypełniania	Regulation by Ministry of Transport, Construction, and Maritime Economy regarding the form of the annual report on the activities in the transport of dangerous goods and filling procedure	
	Rozporządzenie Ministra Gospodarki w sprawie warunków technicznych, jakim powinny odpowiadać bazy i stacje paliw płynnych, rurociągi przesyłowe	Regulation by Ministry of Economy regarding technical conditions to be met by fuel depots stations, and far-reaching	

Country	National legal instruments	Scope	LNG sector
	dalekosiężne służące do transportu ropy naftowej i produktów naftowych i ich usytuowanie	liquid fuel pipelines for the transport of crude oil and petroleum products and their location	
	PN-EN 1473_2016-09	Installations and equipment for liquefied natural gas, design of onshore installations	Industry
	PN-EN 1474-2_2010	Installations and equipment for liquefied natural gas, design and testing of marine transfer systems, design and testing of transfer arms	Maritime
	PN-EN 12308_2007	Installations and equipment for LNG, suitability testing of gaskets designed for flanged joints used on LNG piping	Industry
	PN-EN 12567_2004	Industrial valves, isolating valves for LNG, specification for suitability and appropriate verification tests	Industry
	PN-EN 12838_2008	Installations and equipment for liquefied natural gas, suitability testing of LNG sampling systems	Industry
	PN-EN ISO 16903_2015-10	Petroleum and natural gas industries, characteristics of LNG, influencing the design, and material selection	Industry
	PN-EN ISO 16904_2016-07	Petroleum and natural gas industries - Design and testing of LNG marine transfer arms for conventional onshore terminals	Industry, Maritime
	PN-EN ISO 28460_2011	Petroleum and natural gas industries - Installations and equipment for liquefied natural gas - Ship-to-shore interface and port operations	Port, Maritime, Industry
	PN-ISO 10976_2015-03	Refrigerated light hydrocarbon fluids - Measurement of cargoes onboard LNG carriers	
	Decyzja Prezesa Urzędu Regulacji Energetyki w sprawie koncesji na skraplanie gazu ziemnego i regazyfikację skroplonego gazu ziemnego	Decision by President of Energy Regulatory Office regarding concession for liquefaction and regasification of LNG	

Country	National legal instruments	Scope	LNG sector
	Decyzja Prezesa Urzędu Regulacji Energetyki w sprawie wyznaczenia Polskiego LNG S.A. operatorem systemu skraplania gazu ziemnego	Decision by President of Energy Regulatory Office regarding appointment of Polskie LNG as operator of regasification system	
	Instrukcja Eksploatacji Terminalu – Morskie Procedury Eksploatacyjne i Bezpiecznego Postoju Zbiornikowca LNG	(Terminal Operational Instruction) – Marine procedures for handling and safe berthing of LNG tanker	
	Procedura autoryzacji zbiornikowca zawijającego do Terminalu LNG w Świnoujściu	Procedure of authorization for LNG Tanker entering Świnoujście LNG Terminal	
	Instruction of LNG Terminal in Świnoujście		
Sweden	Lagen (2016:915) om krav på installationer för alternativa drivmedel	Regulation by Agency for Contingency Planning, in force since Nov. 18th 2016	General
	Förordningen (2016:917) om krav på installationer för alternativa drivmedel, jfr prop. 2015/16:189	In force since Nov. 18th 2016	General
	Sjösäkerhetslagen		Maritime
	Lagen om brandfarliga och explosiva varor	Onshore. Regulation by Agency for Contingency Planning	General
	Lagen om transport av farligt gods	Onshore. Regulation by Agency for Contingency Planning	General
	Miljöbalken (Swedish Environmental Code)		General

Table 5. National and regional authorities of BSR countries involved in the Go LNG project.

Country	LNG Sector	Regional authority	National authority
Denmark	Shipping		
	Ferry		Danish Maritime Authority
	License for LNG activity		Danish Energy Agency
	Safety - installations above 10 tons		Danish Emergency Management Agency
	Risk Approval Legislation on Emergency Preparedness		Danish Working Environment Authority
	Construction license	Municipality- construction unit	
	Safety - installations above and below 10 tons Risk Approval	Municipality – emergency preparedness	

Country	LNG Sector	Regional authority	National authority
	Legislation on Emergency Preparedness		
	Environmental Impact Assessment Screening – installations above 50 tons Environmental Impact Assessment Screening – installations above 200 tons Environmental Risk Approval Construction License	Municipality – environmental unit	
	Environmental Impact Assessment Screening – installations above 200 tons, addition to municipal development plan, local development plan	Municipality – planning unit	
Germany	LNG Bunkering	Federal states ministries for economics, transport, and energy and Port Authorities	
	LNG Safety	Fire prevention and rescue authorities	
	LNG road transportation – refueling stations	Regional Authorities for environment, energy safety	
Lithuania	Shipping (offshore)		Transport Ministry
	Port	Port Authorities	
	Port	Klaipeda oil terminal	
	Shipping (onshore)		Environmental Ministry
	General		Energy Ministry
	Rail		Lithuanian Rail Administration
	Road		Lithuanian Transport and Road Administration
	Other industry application		Lithuanian Energy Inspection
	Energy/electricity generation		Lithuanian Energy Inspection
	Energy/electricity generation		Lithuanian Energy Price Regulative Commission

Country	LNG Sector	Regional authority	National authority
Norway	Shipping (offshore)		Norwegian Maritime Directorate and Norwegian Coastal Administration
	Shipping (onshore)		Agency for Civil Protection and Emergency Planning
	Rail		Ministry of Transport and Communications
	Road		Ministry of Transport and Communications
	Oil exploration (offshore)		Ministry of Petroleum and Energy
Poland	Shipping (offshore)	Polskie LNG, Maritime Office in Szczecin	Ministry of Infrastructure and Construction, Polish Committee for Standardization
	Shipping (onshore)		Ministry of Infrastructure and Construction, Polish Committee for Standardization
	Rail		Ministry of Infrastructure and Construction, Polish Committee for Standardization
	Road		Ministry of Infrastructure and Construction, Polish Committee for Standardization
	Multimodal applications		Polish Committee for Standardization
	Other industry application	Polskie LNG	Polish Committee for Standardization, Energy Regulatory Office
	Energy/electricity generation		Polish Committee for Standardization, Energy Regulatory Office
Sweden	Shipping (offshore)		Swedish Transport Administration (Transportstyrelsen)
	Shipping (onshore)		Agency for Contingency Planning (Myndigheten för samhällsskydd och beredskap)
	Permissions	County Administrative Boards (permissions) and municipalities	
	Rail		
	Road		
	Multimodal applications		
	Other industry application		
	Energy/electricity generation		

2.2.3.1 DENMARK

With reference to the legal aspects of LNG, “The Act on Infrastructure for Alternative Fuels” was presented in October 2017 in the Danish Parliament authorizing the Minister to establish a number of standards for implementing the Directive 2014/94 / EU.

In regards to the operational legal framework (bunkering with passengers on board, LNG standards, etc.), it should be noted that many previous legal restrictions have been resolved while other aspects of LNG legislation still need to be addressed such as standardization of LNG bunkering facilities/equipment and permissions to perform ship-to-ship LNG bunkering (with passengers onboard), just as the limited number of core and comprehensive ports seems to present a challenge.

The Danish NPF identified the ports of Frederikshavn and Hirtshals (being part of the TEN-T Comprehensive Network) as candidates for LNG refueling stations for shipping and concluded that the LNG production plants planned for the Ports of Hirtshals and Frederikshavn would be sufficient for supplying the Danish Shipping Industry with LNG (or LBG). However, in 2018, both projects in Frederikshavn and Hirtshals were deemed ineligible to receive EU funding due to their status as comprehensive ports only.
The ports of Copenhagen and Aarhus, are the only ports in Denmark belonging to the TEN-T Core Network, therefore making them the only locations eligible to receive EU funding to establish LNG intrastructure. Both Core Ports in Denmark have completed financial sustainability studies for LNG infrastructure with EU funds but no plans to establish LNG infrastructure in the ports are currently on the table. However, being EU Core ports, both ports have to offer bunkering of LNG to its customers by the end of 2025.

Policy measures targeting LNG in the Danish maritime ports, will have to be further improved to stimulate the deployment of LNG infrastructure. The availability and density of LNG refueling and bunkering possibilities need to be located and provided for in a sufficient and effective manner. The Danish government highlighted the key roles of market forces in this sector and is considering two feasible solutions: in the short-run, truck-to-ship LNG bunkering; in the long run, ship-to-ship. If the market demand will be sufficient, the government will investigate how the mobility on the TEN-T corridors can be strengthened.

2.2.3.2 GERMANY

A midsize LNG terminal in the Hamburg region for Germany to import natural gas is planned by Dutch natural gas company Gasunie.

2.2.3.3 LITHUANIA

Lithuania has established a Floating Storage and Regasification Unit (FSRU) LNG terminal in Klaipeda, which became operational on the December 3rd 2014 as part of the country's long term policy to invest in LNG. The main reason for the political support for LNG is to diversify the gas supply and open it up to competition. The law "Lietuvos Respublikos suskystintų gamtinių dujų terminalo įstatymas". (Republic of Lithuania, The Liquefied Natural Gas Terminal Law) was designed to provide suitable legislation for the establishment of the FSRU terminal. The government decree "Lietuvos Respublikos Vyriausybės nutarimas „Dėl Lietuvos Respublikos suskystintų gamtinių dujų terminalo įstatymo įgyvendinimo" ("Regulations for the Use of the Liquefied Natural Gas Terminal in the Republic of Lithuania"), "Gamtinių dujų tiekimo diversifikavimo tvarkos aprašas" (Natural Gas Supply Diversification Procedure), Suskystintų gamtinių dujų, atgabenamų į suskystintų gamtinių dujų terminalą, pirkimo tvarkos aprašas" (Description of the procedure for purchase of liquefied natural gas arriving at the liquefied natural gas terminal), "Naudojimosi suskystintų gamtinių dujų terminalu taisyklės" (Rules for the use of a liquefied natural gas terminal), "Nutarimas dėl suskystintų gamtinių dujų perkrovos paslaugos kainos 2015–2019 metams" (Decree on liquefied natural gas service rates overload for the years 2015-2019) all provide the legal framework for the establishment of the FSRU at Klaipeda.

2.2.3.4 NORWAY

In Norway, several regulatory and administrative authorities cover the use of LNG as fuel for ships. Onshore facilities are subject to the laws and regulations administered by the Norwegian Directorate for Civil Protection and Emergency Planning, while plants onboard ships are subject to laws and regulations managed by the Norwegian Maritime Directorate. For activities in ports and shipping channels, the Norwegian Coastal Administration is the responsible authority.

For passenger ships, the Norwegian Maritime Directorate shall approve bunkering procedures for LNG. For cargo ships, the classification society must approve bunkering procedures. New procedures for improved safety and handling of LNG are identified and adopted by the Norwegian Maritime Directorate. The Fire and Explosion Prevention Act and its regulations regulate LNG terminals and other facilities for bunkering of LNG ships. This law prescribes the central and local management of fire and explosion prevention measures. It also requires accident and injury prevention duties to be implemented, in connection with the safe handling of hazardous substances and the carriage of dangerous goods on land. This is also a legal requirement for emergency preparedness and a planned response to accidents. The local fire department has an obligation to support such emergency response plans.

Norway has acted as an international coordinator for the efforts that resulted in the IMO IGF Code and has also been active in contributing to its content. In 2007, Norway adopted a preliminary guideline for gas-fueled ships, which may in future also be adopted by other countries.

2.2.3.5 POLAND

On the national level, Poland usually adopts international regulations, standards, and norms into national legislation. At the regional and local levels, regulations, standards, and norms are both adopted or introduced on their own. There is no single law covering the infrastructure for alternative fuels. Trade with natural gas is subject to the Act of April 10th 1997 Energy Law. There are currently initiatives on changing the law, with the aim of abolishing the statutory obligation to submit tariffs for approval, including for the trading of CNG and LNG. While trading of natural gas is regulated in detail in the Polish legislation, there are no regulations for trading of LNG in ports, including transshipment. Currently, single cases of bunkering must be individually agreed with the Maritime Authority, the Port Authority, and the local operators, in agreement with the local guidelines for handling of dangerous goods.

2.2.3.6 SWEDEN

In Sweden, the international legal instruments regarding shipping (IMO) are included in the Swedish Maritime Administration's Code (Sjöfartsverkets författningssamling) and can therefore be considered a part of Swedish law. Generally, Sweden prefers going through the IMO to perform changes rather than setting up differing national regulations. The Swedish Civil Contingency Agency is responsible for onshore issues, while the Transport Administration is responsible for the offshore side (vessel and connected infrastructure). Since bunkering of LNG is performed right on the border, a continuous dialogue between these authorities is needed in order to make sure which parts of a bunkering operation are covered by which authority, and what considerations have to be taken between them.

The acts and ordinance upon which regulations pertaining to environmental protection are based are the following: Act (1980:424) issued by the Swedish Maritime Administration on Prevention of Pollution from Ships, and Ordinance (1980:789) on Prevention of Pollution from Ships. These form part of the regulations issued by the Swedish Maritime Administration (TSFS 2010:96) General Advice on the prevention of pollution from ships. Other regulations pertaining to environmental pollution include the regulations of the Swedish Maritime Administration (SJÖFS 2001:12) General Advice on reception of waste from ships and the regulations of the Swedish Maritime Administration (SJÖFS 2001:13) on reception of waste from recreational craft.

When it comes to the supervision of infrastructure in ports, it may be either the local county's administrative board or the municipality that are responsible, depending on the scale of the structures (stipulated in the Swedish Environmental Code, i.e. 'Miljöbalken').

2.2.4 HARMONIZATION OF REGULATIONS AND STANDARDS ON INTERNATIONAL AND NATIONAL LEVELS?

There have been several efforts in harmonizing offshore standards for LNG safety and operation of infrastructure, as well as for LNG handling procedures such as bunkering and transfer. However, regulations and standards applying to onshore LNG facilities are different in each country, making harmonization incomplete. Moreover, in the BSR countries, different administrations are responsible for safety and permission issues. As can be seen from Tables 5 and 6, there are several national regulations to be taken into account. Also, the responsible agencies differ from country to country. Given that the use of LNG in the BSR is relatively novel, it is expected that harmonization will take some time. It is important to remember that each risk assessment is done for a specific facility, meaning that international standards will have to have a large variety of terminal or bunkering facilities.

Bunkering of LNG differs on many aspects from the bunkering of conventional marine fuels, meaning that standards are not easily derived from existing ones. As the use of LNG-fueled vessels spreads and an increasing number of parties become involved in LNG infrastructure and handling, there is a clear need to standardize LNG bunkering operations on an international level. At the request of IMO, the European Commission, and the Baltic and International Maritime Council (BIMCO), the world's largest international shipping association, the new standard ISO 20519:2017 was produced. It contains requirements not covered by the IGF code, setting requirements for LNG bunkering transfer systems and equipment used to bunker LNG-fueled vessels. However, there is still no requirement regarding a standard coupling, for which a new working group had been established (ISO, 2017).

The EU is committed to supporting the development of common technical standards and regulations at European and international levels, including those applicable to filling stations, components for natural gas-powered vehicles, stationary equipment, gas quality, and other important technical issues. The Natural & Bio Gas Vehicle Association (NGVA Europe) coordinates activities for the standardization of natural gas-powered vehicles and ships at CEN, UNECE, or ISO level with other important stakeholders, such as the international association for natural gas vehicles, NGV Global.

2.2.5 SECURITY ASPECTS

LNG terminals at seaports may be attacked physically or by other means. Some LNG facilities might also be disrupted indirectly by "cyberattacks" or attacks on local electricity grids and communications networks, which could result in malfunction of the LNG control and safety systems.

In order to address terrorist attacks to LNG carriers and port terminals in the context of international maritime transport, the International Ship and Port Facility Security Code (ISPS Code) developed by the IMO, should be applied. It is a comprehensive set of measures to enhance the security of ships and port facilities, developed in response to the perceived threats to ships and port after the 9/11 attacks in the United States. The ISPS Code is implemented through chapter XI-2 Special Measures to Improve Maritime Security in the International Convention for the Safety of Life at Sea (SOLAS). In essence, the code takes the approach that ensuring the security of ships and port facilities is a risk management activity and that, to determine what security measures are appropriate, an assessment of the risks must be made in each particular case (IMO, 2018).

The purpose of the ISPS Code is to prevent and suppress terrorism against ships, improve security aboard ships and ashore, reduce risks to people (including passengers, crew, and port personnel on board ships and in port areas), and to reduce risks to vessels and cargoes. It provides a standardized, consistent framework for evaluating risk for ships and port facilities. It is designed to enable governments to determine security levels and to offset increased threats by increasing ships and port security via appropriate measures. Cargo vessels of 300 gross tons and above, including all LNG vessels, as well as ports servicing those regulated vessels, are required to implement these IMO and SOLAS standards. The ISPS Code is part of SOLAS, so compliance with it is mandatory for the 148 Contracting Governments to SOLAS, including all countries around the Baltic Sea. The different security levels defined by the ISPS Code are:

Security level 1: normal, the level at which the ship or port facility normally operates.
Security level 2: heightened, the level applying for as long as there is a heightened risk of a security incident.
Security level 3: exceptional, the level applying for the period of time when there is the probable or imminent risk of a security incident (IMO, 2018)**.**

According to the International Group of Liquefied Natural Gas Importers, the ISPS Code requirements for ships may be summarized by the following non-exhaustive list:

- Ships must develop security plans and have a ship security officer;
- Ships must be provided with a ship-security alert system able to transmit ship-to-shore security alerts to a competent authority designated by the administration.
- Ships must have a comprehensive security plan for international port facilities, focusing on areas having direct contact with ships.
- Ships also may have certain equipment onboard to help maintain or enhance the physical security of the ship.

For port facilities (including LNG facilities inside a port area), IMO requirements include the following:

- Port facility security plan
- Facility Security Officer

- Certain security equipment may be required to maintain or enhance the physical security of the facility.

For both ships and ports, security plans must address the following issues:

- Monitoring and controlling access of people
- Monitoring the activities of people and cargo
- Ensuring the efficiency and availability of security communications, procedures, and systems
- Completing a Declaration of Security

Security plans also address issues such as: port of origin, port of destination, control of ship movements, cooperation with shipping authorities, and appropriate internal and external communications. In addition to the security measures listed above, in the United States, the US Coast Guard (USCG) requires additional security measures based on a location-specific risk assessment of LNG shipping. These include:

- Inspection of security and carrier loading at the port of origin
- Onboard escorting to the destination terminal by USCG "sea marshals"
- Ninety-six-hour advance notice of arrival (NOA) of a LNG carrier (International Group of Liquefied Natural Gas Importers, ND)

2.2.5.1 CYBERSECURITY

Since almost all industries are now directly or indirectly dependent upon electronic information and communication systems, there is vital need for Cybersecurity and maritime transport is no exception. In this context, protection of data and electronic E-navigation must be considered the highest priority. Further recommendations are:

- Having navigation systems connected via the internet, to allow push or pull updates
- Keeping navigation-critical chart information displayed, despite it possibly being partially corrupted
- Taking precautions for the possibility that satellite-based positioning systems may be spoofed resulting in a plausible but misleading position for the ship
- Taking precautions for the possibility that satellite-based positioning systems may fail either deliberately or through a fault, and the resultant loss of timing may seriously degrade the integrity of other automated time-dependent systems, such as Automatic Identification Systems (AIS) (IMO, 2016).

The prevention of cyber attacks, for security and economic reasons is fundamental for companies and for society as a whole; companies should try to make their systems more “resilient” in order to guarantee their operability.

LNG tankers and LNG onshore facilities are sensitive targets for terrorists who could attack them with the intent to destroy their cargo or seize them to use as weapons against targets on the coast. Furthermore, they could be subjected to a "cyber attack" which could occur simultaneously with a "physical" attack. It is important to note that as a result of the above mentioned attacks, cascade effects could be created throughout the supply chain, as LNG is a fuel for domestic heating, for power stations, etc. and if, for example, shipment or storage were interrupted, the risks would spread "downstream" of the supply chain.

Cybersecurity attacks are increasing: for example, a real case recently occurred affecting the shipping company BW Group (which represents one of the largest owners of gas carriers in the world) in July 2017. The company suffered a cyber attack where the hackers were able to access their computer systems, causing their computers to crash and go offline. (LNG World Shipping, 2017)

2.3 EDUCATION & TRAINING IN THE BALTIC SEA REGION

In order to facilitate a fast and safe deployment of LNG in the shipping sector, not only regulations and respective responses from the industry must be on track but also sufficient the education and training of those people working with LNG in various respects as well. Mapping the available education and training LNG portfolio in the BSR may help pinpoint areas of common interest as well as weak points. Collaboration between science, technology, and business institutions is of major importance for new technologies and decisions to become effectively implemented. Cross-sectional and cross-border collaboration is further supported by the EU (European Commission, 2018). Two other main outputs of the Go LNG project are the BSR LNG Competence Center and the BSR LNG Cluster. The Competence Center was set up, tested, and evaluated during the project period, to be fully established once the project ends in the summer of 2019. The establishment of an expert cluster is aimed at assisting BSR countries to achieve continued successful technological implementation of LNG, as well as promote LNG industrial growth and ensuring conformity with legal restrictions.

Most universities in the BSR offer education on energy, sustainability, logistics, business, and transport. Some are broad while others are more specialized, such as towards shipping. Apart from the universities, there is a plethora of institutes that perform research in the field of maritime energy as well as consultancy companies offering both training as well as consulting. The tables below give a hint on what aspects of LNG are considered as important in the different countries.

Table 6. Relevant higher education institutions in the BSR, including training and capacity building institutions.

Country	University/College/Institution	Area of competence/LNG sector	Projects
Denmark	Aarhus School of Marine and Technical Engineering		
	Aalborg University	Aalborg University has taken part in some general clean shipping studies in 2012, which have touched upon LNG.	Study on the potential for Frederikshavn in connection with maritime clean tech development.
	Copenhagen School of Marine Engineering and Technology Management		
	Marstal Navigationsskole	Offers all kinds of maritime training and education and specializes in supplementary training courses such as advanced tanker courses and other STCW courses – also when it comes to LNG.	
	DTU, Technical University of Denmark	Substantial research on various aspects of LNG – ranging from LNG market analysis to combustion technology and propulsion.	Machinery for high-speed ferries Inno +: Shore-based small-scale LNG/LBG liquefaction unit
	University of Southern Denmark	In regard to LNG, the SDU touches upon LNG in its Bachelor of Engineering courses where studies on the cooling effect and use of LNG have been examined.	Biogas 2020
	MARTEC – Maritime and Polytechnic College	In regard to LNG, MarTec offers STCW courses on firefighting.	
	MAN ES Primeserv Academy	Two stroke marine gas engines and fuel injection systems	
	SIMAC (Svendborg International Maritime Academy)		
	FORCE Technology	Metrology, LNG Ship2Ship operations, Aerodynamics (incl. LNG terminals and floating platforms), Tug operations, Ship performance, etc. FORCE Technology also offers a range of LNG relevant courses, for example: Training in LNG Ship-to-Ship Aerodynamic assessment of floating platforms	Metrology for LNG 2
	Lloyd's register	While Lloyd's Register's main competence is classification, it is worth noticing that LR also has a vast catalog of courses, incl. several relevant in connection with LNG: Liquefied Natural Gas Ships Introduction to LNG	
	Danish Gas Technology Centre	DGC participates in Danish and international research projects,	DGC is participating in various projects – currently no LNG relevant projects are in the pipeline.

Country	University/College/Institution	Area of competence/LNG sector	Projects
		thereby continually updating its knowledge and methods. While the main part of DGC's services revolves around consulting on various aspects of gas, the company also offer some courses and certification on general gas usage, security, combustion, and environmental impacts from gas use.	However, DGC has very useful studies on LNG on topics like: Security and Authorities for LNG distribution for ship(bunkering) usage LNG-driven ships in the EU LNG status in Denmark
	Nordjysk Brand og Redningsskole	Primarily offers security courses for the maritime sector and firefighting courses in general. The school has specialized courses on LNG devolved according to Resolution MSC.285(86): LNG A: Basic security for all crewmembers. No beforehand knowledge or specific knowledge of the onboard technical installations are necessary. LNG ABC: For officers and key personnel familiar with the technical installations onboard the vessel. Prior to this course, detailed technical specifications of the ships technical installations have to be developed as part of the simulation exercises. The Danish and Norwegian Maritime Authorities certify teachers giving this course.	
	NORDIC MARITIME HUB	Consortium of Port of Frederikshavn, Kosan Crisplant and Stena Line that will meet the demands of the modern maritime sector by improving the port access facilities, establishing shore-side power supply to be used by Stena Line's ferries, and by establishing bunkering facilities for alternative fuels.	The Nordic Maritime Hub project was in June 2015 awarded TEN-T funding from EU's Connecting Europe Facility, which is a funding instrument established to realize the European transport infrastructure policy.
Northern Germany	Hochschule Wismar, University of Applied Sciences: Technology, Business and Design	Maritime simulation center	Martech
	Hamburg University	Institute for the Law of the Sea and for Maritime Law	
	FGW – Forschungs-GmbH Wismar (part of Wismar University of Applied Sciences)		

Country	University/College/Institution	Area of competence/LNG sector	Projects
	Association for Promotion of the Hanseatic Institute for Entrepreneurship and Regional Development at the University of Rostock	TRAIN LNG- training new competencies in LNG for cross-border growth, Seed Money Project 2017, South Baltic Programme 2014-2020	
	Navigation School Rostock-Warnemünde	LNG transportation and competence building	
	European Cruise Academy, Rostock	LNG competence building	
	Institute for Safety Engineering and Ship Safety e. V. Warnemünde (ISV)		
	ISL Institute for Maritime Transport and Logistics Bremen	LNG transportation and marketing	LNG market development and demand analysis
	University of Applied Sciences Emden / Leer	LNG technology	Testing of LNG Methane Catalyst
	Mariko GmbH	LNG marketing	
Lithuania	Klaipeda University	LNG terminals engineering (bachelor degree) (since 2016) Navigation (master degree) (until 2016)	
	Klaipeda Shipping Research Centre	Navigation safety, LNG and ports development	MT- LNG Klaipeda LNG terminal navigation study
	Lithuanian Maritime Academy	Maritime personnel for LNG powered ships, LNG tankers, LNG custody transfer ship-to-terminal. Training simulators.	
	Lithuanian LNG cluster	LNG applications technology and management. FSRU technology and project management backed by physical infrastructure. LNG for transport, environmental, and economic aspects. LNG safety to be planned. LNG SS terminal management technological aspects backed by simulator. To be operated in 2018.	Lithuanian LNG cluster established in April 2016 is a coordinating institution that gathers all the major Lithuanian LNG stakeholders with the aim to develop LNG competence and capacity in Lithuania. To establish Lithuania as an LNG knowledge hub and to better utilize LNG terminal as a hub for the BSR.
	Coastal Research and Planning Institute	Coastal Research and Planning Institute has performed an environmental impact study for Klaipeda terminal, gathering specific knowledge that can be distributed.	Environmental impact study for Klaipeda LNG terminal.
Norway	University College of Southeast Norway	Master of Maritime Management	
	Norwegian University of Science and Technology	Maritime education and training Marine engineering and technology education Gas processing and LNG	
	Maritime Academy Norway	DNV GL courses	
	DNV GL	While DNV GL's main competence is classification, it is worth noticing that DNV GL also has a vast catalog of courses, incl. several relevant in connection with LNG:	

Country	University/College/Institution	Area of competence/LNG sector	Projects
		FLNG Systems FLNG Hull	
Poland	Maritime University of Szczecin	Higher maritime education	MARTECH LNG
	Gdynia Maritime University	Higher maritime education	
	Gdynia Maritime University Officer Training Centre Ltd	- Liquefied gas tanker familiarization - Advanced liquefied gas tanker operations - Liquefied gas carrier cargo & ballast handling simulator training - LPG/LNG bunkering safety	
	Gdynia Maritime School	Maritime training courses: - Liquefied gas tanker familiarization - Advanced liquefied gas tanker operations - Liquefied gas carrier cargo & ballast handling simulator training - LPG/LNG bunkering safety	
	Bernhard Schulte Ship Management	Maritime training, ship management, crew service. Potential for LNG education.	
	Oil and Gas Institute	National research institute covering all aspects dealing with crude oil and natural gas, including the exploration and exploitation of hydrocarbon reservoirs, the underground storage, transport, distribution, and utilization of natural gas, crude oil, and petroleum products, and the development and improvement of liquid fuel production technology.	Partially founding and taking general care over LNG terminal in Swinoujscie
Sweden	Chalmers University of Technology	Environmental impact, emissions, alternative fuels, hull fouling, energy system modeling, marine technology	Decision support for choosing renewable fuel Environmental assessment EfficenSea2 Customer and agent initiated intermodal transport chains Energy efficient and low environmental impact marine traffic modeling Prospects for renewable marine fuels
	Kalmar Maritime Academy	Environmental impact, risk management, energy efficiency	
	IIEEE – The International Institute for Industrial Environmental Economics (Lund University)	Transition to low-carbon and resource efficient economies, assessing governance and management processes, evaluating policy instruments and business models, and exploring visions and scenarios for sustainable futures	F3 - Swedish Knowledge Centre for Renewable Transportation Fuels
	Lund University	Thermal power engineering (gas turbine technology)	

Country	University/College/Institution	Area of competence/LNG sector	Projects
		Internal combustion engines	
	Royal Institute of Technology, Stockholm	Cost-benefit analysis, sustainable transport systems, transport modeling, simulation, financing and organization, interactions between the transport system and the regional economy, and travellers' behavior and valuations	Centre for Transport Studies
	World Maritime University	Maritime master education including specialization on energy management	On the MoS Way Network Go LNG
	IVL Swedish Environmental Research Institute	Air pollution from shipping, alternative fuels in shipping	
	Lighthouse	Triple-Helix collaboration between industry, society, academia, and institutes for research, development and innovation within the maritime sector	
	F3 center	- provides a broad, scientifically based source of knowledge for industry, governments, and public authorities for short-term actions to reach long-term visions - system oriented research related to the entire renewable fuels value chain - national platform for international collaborative processes	
	Zero Vision Tool	Cooperation between industry, society, and academy, 160 organizations in active change process to more green transport by sea.	

In 2016, an LNG dedicated study program called "LNG terminal engineering" was launched by the Klaipeda University. Now, it is the first and only study program in the Baltic Sea Region that prepares professionals in this field. In the same year, the LNG Competence Center was opened in the Klaipeda University business incubator to "serve the LNG terminal engineering students, as well as the specialists from Lithuania and abroad working in the field" (Klaipeda University, 2018). A significant competence in that area and along each segment of LNG value has been reached.

2.4 EXISTING LNG INFRASTRUCTURE IN THE BALTIC SEA REGION

In order to foresee and plan the development of LNG in the BSR, the following chapter will describe what LNG infrastructure has already been developed or planned. This includes LNG infrastructure for the maritime sector, as well as for land-based industries and transportation.

As previously specified, the EU has produced a master plan on where LNG bunkering possibilities must be available. However, national energy strategies as well as the needs of private industry may result in LNG infrastructure being developed elsewhere as well. By describing available and planned infrastructure developments in the BSR, this chapter will highlight the needs to connect LNG terminals, bunkering facilities, and industry through the creation of LNG-powered transport corridors (Blue Corridors) with intermodal possibilities. Although not a BSR country, information on Norway was included in this analysis, because it is a close-by supplier of LNG and provides useful examples of existing infrastructure in Europe.

2.4.1 TERMINALS AND BUNKERING FACILITIES FOR MARITIME APPLICATIONS AND ROAD VEHICLES

During the last decade, there has been a progressive development of LNG terminals and bunkering facilities. Political, economic, logistical, and environmental reasons have affected the development pattern in the BSR. A descriptive summary of the available
and planned LNG infrastructure in the BSR is shown in Table 7. The geographic distribution of these facilities is illustrated on an infrastructure map of the BSR, shown in Figure 7.

Table 7. Terminal and bunkering infrastructure in BSR. Grey text = planned facility.

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
LNG export terminals							
Norway	Risavika	LNG is loaded from a storage tank onboard ships or tank lorries for further transport.	300,000 tons/year. Storage tank is designed for up to 28,000 m^3			Skangas	
	Melkøya (Snøhvit, Hammerfest)	LNG exported in custom-built LNG ships	4.3 million tons/year			Statoil	
	Snurrevarden (Karmøy)		0.0210 million tons/year			GASNOR	
	Kollsnes 1		0.410 million tons/year			GASNOR	
	Kollsnes 2		0.0810 million tons/year			GASNOR	
Russia	St Petersburg (2018/19)	Three non-self-propelled barges and three 700 m^3 bunkering vessels. Will be fed by a 12 km pipeline	Each barge with a production capacity of 656 mln m3 (approx. 1.26 mln tn of LNG/year)	Gazprom	LNG-Gorskaya	LNG-Gorskaya	
	Yamal Energy, Yamal Peninsula		Current: 5.5 106 t/year By 2018: 11 106 t/year By 2019: 16.5 106 t/year		NOVATEK		
	Arctic LNG-2 (Gydan) FPU, Yamal Peninsula Start-up: (2022/2023)		16.5 *106 t/year		NOVATEK		
	Ust-Luga Baltic Sea Start-up : (2022/2023)		$10 \cdot 10^6$ t/year		GAZPROM		
	Shtokman-Teriberka FPU, Barents Sea	Floating Production Unit	$7.5 \cdot 10^6$ t/year		GAZPROM		

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
	Cyprus, Vassilikos Start-up: ------						
Denmark	Frederikshavn liquefaction plant (status currently unknown)	small scale, with LNG bunkering and filling station	$0.05 \cdot 10^6$ t/year		NORDLIQ		
Denmark	Hirtshals						
LNG import terminals							
Lithuania	Klaipeda	Floating Storage and Regasication Unit (FSRU) *Independence* will provide gas to the national gas grid and will be used for bunkering of vessels	maximum hourly capacity: 460,000 m^3(n)/h . nominal annual capacity: 4.00 billion m^3(n)/year	Statoil (Norway)	Klaipedos Nafta	Klaipedos Nafta	Cost of FSRU tanker: Ca. $330,000,000 USD
Poland	Świnoujście	Trucks and containers - used for gas grid too. Possibility of loading LNG on truck and containers 95,000 tons/y	320,000 of m^3. The plant capacity will be increased from 5-7.5 bcm/year	Qatar, Norway (June 2016), Cheniere Energy (US, May 2017)	PGNiG	Gaz-System's Polskie LNG (owned by state).	Inland waterways (potential - designed in plans).
Estonia	Paldiski (2020)	large-scale facility onshore	Nominal annual capacity:2,50 billion m^3(n)/year				
	Muuga (Tallinn) (2018)	large-scale facility onshore	Nominal annual capacity: 2.00 billion m^3(n)/year		Vopak		
Germany	Brunsbüttel start-up:-----	large-scale facility onshore	Nominal annual capacity 3.00 – 4.00 billion m^3(n)/year		Oil tanking Vopak Gasunie		
Small scale LNG terminals							
Finland	Pori	LNG tank, loading docks, process units (compressor and vaporizers), flare torch, three loading docks for road tankers, a transformer	30,000 m^3	Norway	Skangas	Gasum, Skangas	81 million Euros. The Finnish government supported 23 million Euros.

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
		building, and a heat production unit. 12 km natural gas pipeline that connects the terminal to the local Industrial park					
	Rauma (2017)		10,000 m3			Oy Ab AGA	
	Hamina Kotka (2018)	LNG storage capacity	30.000 m3			Haminan Energia Oy	
	Torneå (2018)	Industrial processes (steel by Outokumpu), energy production, and shipping. Trucks, tankers, and even a possible pipeline to local SME's	50,000 m3				
	Turku						
Germany	Brunnsbüttel					Bomin Linde LNG	
Lithuania	Klaipeda (2017)	Ships, tank container (from FSRU terminal)	5000 m3	Norway	Klaipedos Nafta, Bomin Linde	Klaipedos Nafta	
Norway	Øra (near Fredrikstad)	Nearby industry supplied by natural gas pipeline grid. For industries that exist outside of the pipeline grid, trucks supply them with LNG. 15-20 safe truck loadings every day	Nine tanks with a combined storage capacity of 6,400 m3.			Skangas, Manga LNG	
	Mosjoen LNG terminal	small-scale facility Start-up 2007	LNG storage capacity 6,500 m3 LNG			GASNOR	
Russia	Kaliningrad (2017)	FSRU LNG import, storage and regasification terminal.	The FSRU have LNG storage of max capacity 174,100 cbm		Gazprom	Gazprom	Adapted for handling small-scale LNG vessels bunkering

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
Sweden	Nynäshamn	The main customer is Nynäs refinery but LNG is also delivered to the bunkering vessel Seagas (by truck)	20,000 m3	Norway	AGA	AGA	
	Lysekil	Import and storage of LNG. Established to deliver gas to the refineries of the region. Preem receives its natural gas directly by pipe from the terminal. Every week, specially designed trucks carrying LNG travel the 420 km distance from Lysekil to Borlänge and SSAB. Planned: a loading arm for ships to bunker LNG directly from the terminal (project run on the unique collaboration platform Zero Vision Tool)	30,000 m3. Annual capacity 250,000 tons	Norway	Skangas	Skangas, AS/Preem	Investment: nearly 700 million NOK. Railways (potential - designed in plans).
	Gävle (2018)	To serve industries of mid-Sweden	500,000 tons LNG/y. Storage capacity 30,000 m3		Skangas AS	Skangas AS	
	Gothenburg (2018)	An open access terminal for anyone who wishes to supply LNG to the Swedish market. Storage in cisterns before being transferred to road tankers and rail trucks for onward distribution. Ships will also be able to bunker			Swedegas and VOPAK		

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
		LNG. In time, the LNG Terminal will also have the capacity to supply the existing gas grid with natural gas					
Small scale LNG bunkering facility							
Denmark	Hov (Samsö)	Specific ferry	40m^3 Single tank LNG truck trailer as a semi-permanent storage tank (exchanged every 3-4 days) connected to a permanent pumping facility. The pumping facility is connected to the vessel with a vacuum insulated pipe system	Q8	Q8	Kosan Krisplant A/S	
	Hirtshals	Bunkering for Fjordline's M/S Bergensfjord and M/S Stavangerfjord that sail between Bergen, Stavanger, and Hirtshals, and between Langesund and Hirtshals	500 m^3 tank, planning for a storage of 10,000m^3	Skangas (Norway)	Skangas	Fjordline, Liquiline	Plan: expand terminal to offer LNG to other ships. Reception of EU financing of 1,305,374 euro through TEN-T (50% of total cost).
	Grenaa (2019)	MoU between Port of Grenaa and Estonian company LNG Gorskaya Overseas OU	Floating storage up to 10,000 m^3	Russia (LNG Gorskaya)	LNG Gorskaya Overseas OU		
	Copenhagen/Malmö (2025)	Core Port					Has to provide LNG bunker by 2025

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
	Frederikshavn		To be scaled in accordance with costumer demand		UniOil and Bunker Holding		(status currently unknown)
Estonia	Mõntu (2018)	MoU with Estonian LNG Gorskaya Overseas		Russia (LNG Gorskaya)	LNG Gorskaya Overseas OU		
	Pärnu (2019)	LNG Gorskaya Overseas signed a letter of intent with Port of Pärnu to establish an LNG center. It will consist of LNG floating storage, a specialized pier, and other port equipment necessary for storage and bunkering of vessels	Floating storage. Maximum capacity of 5,500-cbm. The bunkering vessel with tanks of 1,300-cbm.				Plan includes gas station for trucks and use of LNG for municipal purposes .
	Tallinn (2025)						
Finland	Helsinki	The Tallink ferry Megastar bunkers in Helsinki's West Harbour. Skangas delivers LNG flexibly from the LNG import terminal at Tahkoluoto, Pori		Gasum			2.65 million euros in EU funding. The four terminals are intended to reduce Finland's dependence on Russia for gas.
	Hamin Kotka (2019)			Russia (LNG Gorskaya)	LNG Gorskaya Overseas OU		
	Turku (2025)	Maritime transport and industry	Maximum 30,000 m3.				
Germany	Lübeck (2018)	Memorandum of understanding signed with Estonian company LNG Gorskaya Overseas		Russia (LNG Gorskaya)			

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
	Cologne (2018)	Inland waterways, part of a Connecting Europe Facility project "Breakthrough LNG Deployment in Inland Waterway Transport"					
	Hamburg (2025)						
	Rostock (2025)	Bunkered a Chemical Tanker (Furetank AB) in Rostock on February 2nd. First successful trial bunkering of the Norwegian boat M.V. Greenland on February 27th 2016. Port of Rostock will likely bunker more ships by truck in the future. The Port of Rostock is completely "Quayside Ready" for LNG.		Gazprom (Russia)	Bomin Linde		
Latvia	Liepaja (2019)	Memorandum of understanding signed with Estonian company LNG Gorskaya Overseas		Russia (LNG Gorskaya)			
	Riga (2025)						
	Ventspils (2025)						
Norway							
	Risavika (Stavanger)	Solution for Fjord Line's 2 LNG ferries. Ro-Pax, product tankers and general cargo ships will be able to bunker LNG	35,000 tons			Skangas	First ever shore-side bunkering station in the Nordics, Loading arm
	Halhjem fergekai						
	Florø - Saga Fjordbase				Saga Fjordbase		
	Kristiansund Vestbase				Vestbase, Barents Naturgass		

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
	Lødingen Rødholmen						
	Moskenes				Barents Naturgass		
	Bjugn				Marine Harvest		
	Hammerfest Polar base				Barents Naturgass		
	Ågotnes Coastal center base				Gasnor		
	Os/Haljem				Gasnor		
	Drammen				Skagerak Naturgass		
	Bodø – Burøya	Industry terminal ready for bunkering			Barents Naturgass		
	Mosjøen/Elkem	Industry terminal ready for bunkering			Gasnor		
	Stord	Industry terminal ready for bunkering			SKL Naturgass		
	Lista	Industry terminal ready for bunkering			Gasnor		
	Porsgrunn	Industry terminal ready for bunkering			Skagerak Naturgass		
	Sandefjord	Industry terminal ready for bunkering			Skagerak Naturgass		
	Husnes	Industry terminal ready for bunkering			Gasnor		
	Høyanger	Hydro Høyanger Metallverk, ready for bunkering			Gasnor		
	Sunndalsøra	Hydro, ready for bunkering			Gasnor		
	Oslo (2025)						
Poland	Gdynia Gdansk (2025)						
	Swinoujscie Szczecin (2025)						
Sweden	Gothenburg	M/T Ternsund bunkered natural gas at the entrance to the port from the Dutch bunkering vessel Coral Energy. This is the first		Skangas (Norway)	Skangas	Swedega s	

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
		example for Sweden of a tanker bunkered LNG					
	Piteå (2019)	Memorandum of understanding signed with Estonian company LNG Gorskaya Overseas		LNG Gorskaya (Russia)	LNG Gorskaya Overseas OU		
	Stockholm (2025)	Bunkering vessel Seagas already bunkers the cruise ship Viking Grace. Transported by truck from AGA LNG terminal in Nynäshamn	60 ton LNG per filling	Norway	AGA	AGA	
	Trelleborg (2025)						
Liquefaction plant							
Denmark	Frederikshavn	Also planning for LBG. Intended to upgrade the maritime links between the ports of Frederikshavn and Gothenburg and Oslo. Hoping to produce LNG for the maritime sectors in Denmark and Sweden	150-300 tons/day	Nature Energy	Bunker Holding (Unioil Supply) and Kosan Krisplant		(status currently unknown)
	Hirtshals (2019)	Also planning for LBG. Maritime, industry and road sector			HMN, Koch industries, Skangas		TBC
Finland	Porvoo	The plant has the potential to produce liquefied bio-gas (LBG)	20,000 tons/y, storage capacity 2100m3	Receives feed gas from the Finnish pipeline grid	Skangas	Skangas	Two truck-loading stations are part of the facilities
Norway	Bergen (Kollsnes)	Small-scale liquefaction plant. LNG transported to customers by road tanker and an LNG vessel (Pioneer Knutsen)	Tank volume: 2 x 250 m3				

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
	Karmøy				Gasnor		
	Tjeldbergodden				Statoil	Statoil, AGA, Conco Philips	
	Nes (near Oslo)	EGE Biogas plant. 50,000 tons of food waste a year. 135 Oslo region buses will be able to run on biogas. As a result, CO_2 emissions will be reduced by some 10,000 tons a year and particle emissions will also be significantly lowered.	Around 14,000 Nm3 per day of bio methane.	Pipeline gas. Inlet pressure 120-150 bar	Wärtsilä Oil & Gas Systems	Norwegian Cambi AS	
	Melkøya						
	Trondheim (Skogn)	LBG plant-will spare the environment annual emissions of about 30 000 tons of CO_2 from fossil fuels. Waste water from Norske Skog's pulp mill in Skogn and waste from the fish farming industry in the area. Provide fuel for buses mainly in Norway	125 GWh per year (25 tons/day)	Biokraft AS	Purac Puregas AB, Wärtsilä		With a contract value of over 300 million.
Russia	Kaliningrad (2018)	174,100 cbm FSRU. Will be linked to the existing gas pipeline near the local underground gas storage facility, which will allow for delivery of gas to local consumers as well as pump it into storage	Maximum 2.4 million tons LNG/y				

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
		reservoirs. The FSRU will be subsequently replaced by the Baltic LNG project (Ust-Luga)					
	Ust-Luga (2022/23)	Target markets for the project include countries in the Atlantic region, Middle East, and South Asia, as well as small-scale LNG markets in the areas of the Baltic and North Seas. Gazprom and Shell signed a memorandum of understanding in June 2016	10 million tons/y	Gazprom			
Sweden	Lidköping	LBG plant. Buses are the current main customers. Will spare the environment annual emissions of about 16,000 tons of CO_2 from fossil fuels	Maximum 60 GWh/y	Gasum	Air Liquide	Air Liquide	
Regasification plant							
Lithuania	Klaipeda		Up to 10,244, 300 m^3 natural gas/ day		Klaipedos Nafta	Klaipedos Nafta	
Poland	Świnoujście	Regasification facilities, National and pan-European gas connector to the terminal	Capacity: 5 bln m3 natural gas/y		PGNiG		
Latvia	Skulte LNG termin (2019)	Floating Regasification Unit	Nominal annual capacity 5.00 billion m3(n)/year		As "Skulte LNG Terminal"		
Poland	FSRU Polish Baltic Sea Coast (2023)	Floating Storage and Regasication Unit	Nominal annual capacity 4.10 – 8.20		GAZ system		

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
			billion $m^3(n)$/year				
Russia	Kaliningrad (2018)	A floating regasification plant	Maximum send out 500 mmscf/day	Gazprom	Gazprom		
LNG bunkering infrastructure of heavy vehicles							
Denmark							
Finland	Turku	For heavy-duty vehicles			Gasum		
	Porvoo	2 truck-loading stations			Skangas		
	Jyväskylä (2017)	For heavy-duty vehicles			Gasum		
	Vantaa (2017)	For heavy-duty vehicles			Gasum		
Germany	Ulm				Uniper (LIQVIS) and IVECO		
	Berlin	Publicly available			IVECO and Mayer Logistics		
	Rhine/Ruhr	2 stations, for 200 trucks			IVECO and Uniper (LIQVIS)		
Norway							
Poland		3 tank stations planned					
		LNG fuel loading on roads: There are three filling stations, one is public (LCNG) and two are private. In Poland, there are also 46 LNG bus cities in two cities, cost of one is around 200,000 EUR. There is no foreign direct investment.					
Sweden	Helsingborg	Only biogas. ICA, retailer with a focus on food and health, has		Biogas from Lidköpin	Öresundskraft		

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
		its goods terminal in Helsingborg. Between 400 - 500 trucks/day, which is expected to grow to 1000/day		g LBG plant			
	Göteborg	50 % biogas		Biogas from Lidköpin g LBG plant	Fordonsgas		
	Jönköping	50 % biogas. 20-25 cars refuel (e.g. DHL, post, Schenker, Bring Frigo, and Götene Kyltransporter). These cars have been awarded 175,000 SEK/car by the Swedish Energy Agency. Cargo owners that use BiGreen are ICA (food retailer), Coca-Cola, and IKEA, with the food industry having the most cars/trucks		Biogas from Lidköpin g LBG plant	Fordonsgas		
	Järna			AGA	Circle K		
	Älvsjö			AGA	Circle K		
	Örebro			AGA	Circle K		
	Högbytorp (Stockholm)	Part of the EU GREAT project			e.On		
	Munkedal	Part of the EU GREAT project			Fordonsgas		
	Malmö	Part of the EU GREAT project			e.On		

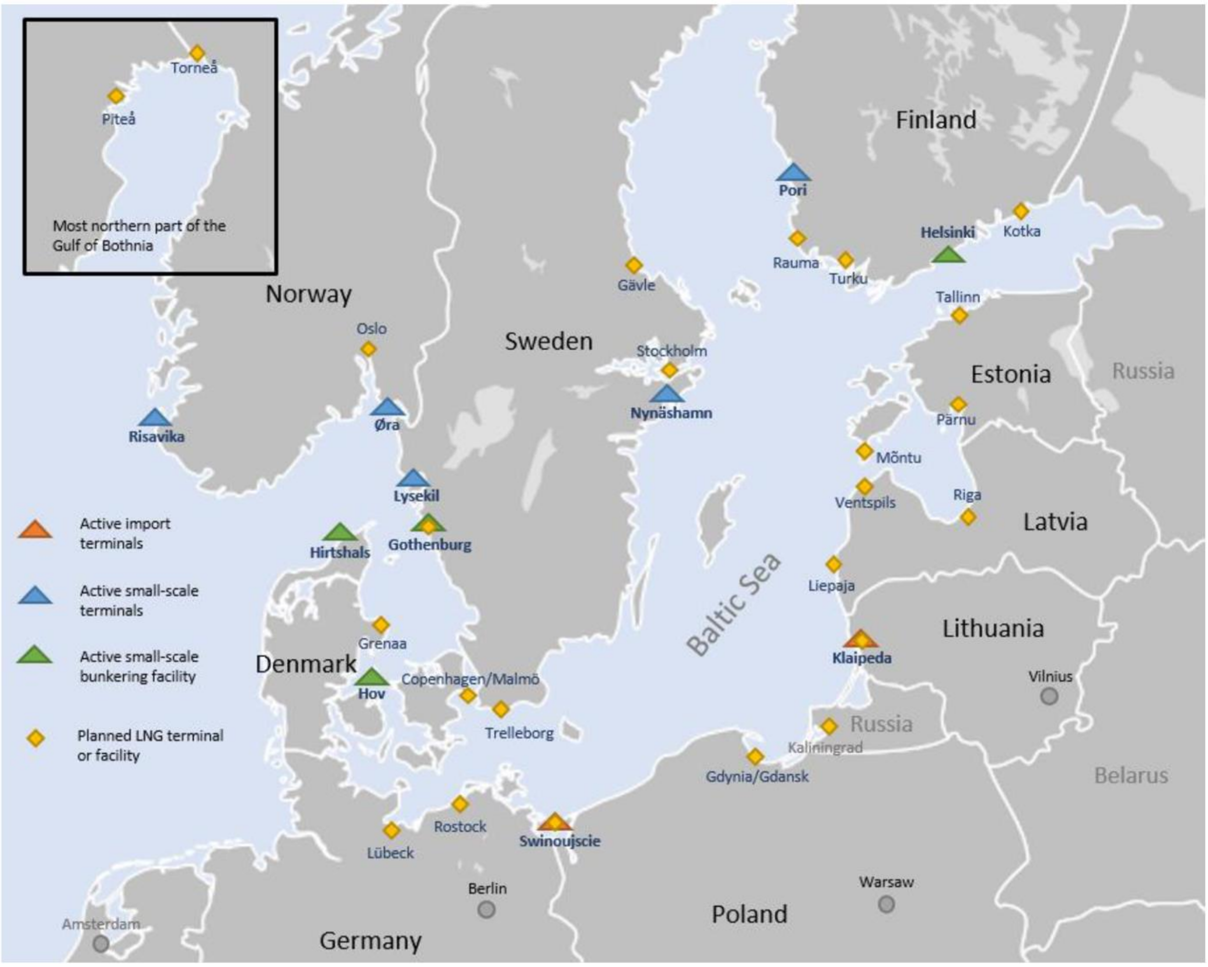

Figure 7. Map of LNG facilities in Baltic Sea Region. Source: http://www.golng.eu/en/bsr-lng-infrastructure-map/

Figure 7 shows active LNG terminals as red triangles. There are two large scale import terminals, one at Swinoujscie and one at Klaipeda (Table 7). Small scale terminals are shown by blue triangles, five of which are currently active. Small scale bunkering facilities are shown by green triangles, two of which are currently active. A larger number of planned LNG terminals are currently being planned or are under construction. These are shown as yellow squares in Figure 7. The number of LNG infrastructure facilities is expected to almost double from today's 40 (including Norway, excluding stations for trucks) to 77 by 2025. It should also be mentioned that one-off bunkering events have already taken place at ports that have no fixed infrastructure, e.g. in Denmark (port of Esbjerg) and Germany (port of Lübeck and port of Bremerhaven).

Norway is by far the country with the most developed LNG infrastructure, at least in the maritime domain. It is also the only country of the region that currently liquefies natural gas for export. One large LBG plant has been built and one more is planned; however, these plants will mainly serve the national trucking industry (Ölçer et al, 2018).

The only two large-scale LNG import terminals of BSR are situated in Poland and Lithuania. From these terminals, LNG is not only redistributed to bunkering stations but also regasified for the national gas grid. Moreover, both facilities have the possibility to sell and distribute LNG in the BSR. In Poland, the terminal is owned by state Gaz-System, and PGNiG was awarded the contract for storage and distribution of LNG. In the close future, Gaz-System is planning to distribute LNG on a spot market basis. Small companies are importing LNG from other countries, using mostly EU LNG import terminals. Poland will also have to offer small scale bunkering at the port of Gdansk/Gdynia and the Port of Swinoujscie/Szczecin. When it comes to Lithuania, the large-scale FSRU is now functioning, and from there LNG will be transported to the Port of Klaipeda's planned bunkering facility. Afterward, it will be regasified and fed into the national gas grid. No other maritime LNG facilities are currently planned.

Sweden has two LNG terminals from which gas is transported by truck either to ports for small scale bunkering or to nearby industries that use LNG as their major energy source. In Nynäshamn near Stockholm, Sweden, Linde has designed and constructed a mid-scale LNG terminal, selling and distributing LNG to various municipalities without direct access to the gas grid in the Eastern parts of Sweden. The LNG terminal, which is fully owned and operated by AGA, a subsidiary of Linde, commenced operations in March 2011 and is the first of its kind in the Baltic Sea region. In addition to supplying the gas grid of Stockholm and industrial facilities, the terminal also provides LNG as fuel for natural gas vehicles in the region. The terminal offers LNG possibilities within a radius of 300-500 km. The Port of Gävle is planning to have a small-scale LNG terminal ready by 2018 (Skangas), which will serve the industries of mid-Sweden. The aim for the terminal is to process 500,000 tons LNG/year and have the same storage capacity as the terminal in Lysekil (30,000 m^3).

Germany does not have any LNG import terminal due to an already functioning supply chain from large-scale facilities in neighboring countries (e.g. Netherlands and Poland). The national value chain is based on import-orientated small scale LNG with the main focus on the maritime sector (Shell, 2013). However, a terminal is now planned for the Port of Brunsbüttel, situated by the German North Sea coast. German Baltic ports are planning for small scale bunkering.

Denmark, being a country that ships have to pass on their way in and out of the Baltic Sea, is strategically planning for several liquefaction plants and LNG terminals as well as small scale bunkering facilities. The two planned liquefaction plants plan to liquefy both natural gas and biogas. The Port of Esbjerg on the west coast of Denmark performed a one-off truck-to-ship bunkering (TTS) of an LNG supply vessel in 2015. The LNG was brought by three trailers from the Port of Rotterdam.

Russia is planning for two large-scale LNG production facilities in the BSR, where state-owned Gazprom is building a FSRU in Kaliningrad, while the private company LNG

Gorskaya is building one in Saint Petersburg. The one in Kaliningrad is later to be superseded by a larger plant planned for Ust-Luga (2023).

2.4.2 TRANSPORT MODES IN THE EU AND LNG

With more than 37,000 kilometers of inland waterways, the European Union (EU) has one of the longest networks of this type in the world, bridging 20 member states and connecting hundreds of cities. Inland waterways are important for transporting goods from major seaports to their hinterland (Figure 8). With respect to energy-efficiency of mass transported over a given distance, water transport is preferable over road transport. However, inland waterways have confronted many difficulties like lack of infrastructure integration with other modes of transport, overcapacity, skills shortages, and fragmentation of its labor force, all of which have prevented it from increasing its modal share in Europe during the past decade (European Parliament Research Service, 2014)

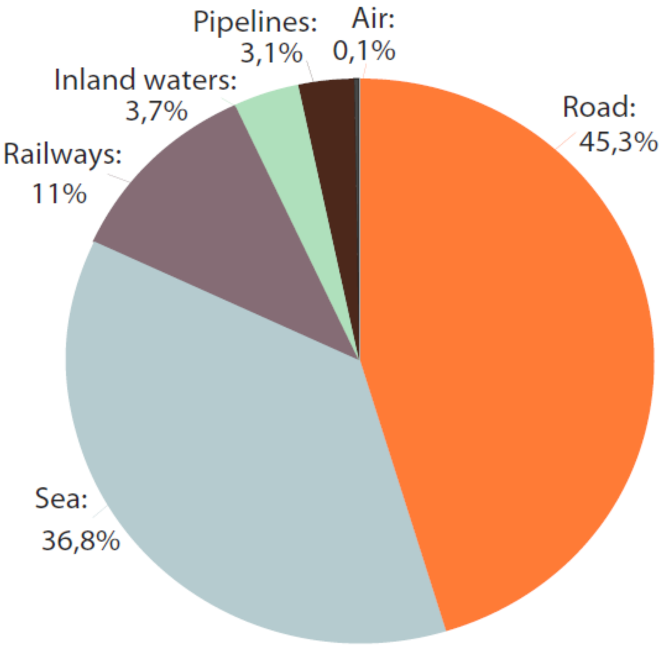

Figure 8. Freight transport, performance by mode (EU 27). Source: EU Commission, Transport in figures (2013), https://ec.europa.eu/transport/sites/transport/files/facts-fundings/statistics/doc/2013/pocketbook2013.pdf.

The European Commission encourages more companies to use the Inland waterways mode of transport. The related EU policy for Inland Waterway Transportation is encapsulated in the NAIADES Action Programme. The implementation of NAIADES is supported by the implementation platform PLATINA. The NAIADES Action Programme includes numerous actions, mechanisms, and measures to enhance transport on EU inland waterways. The program timeframe is operational until 2020 and is being monitored by The European Commission to ensure proper implementation. The NAIADES is to be implemented by the European

Commission, the member states, and the industry itself. Carriage of goods by inland waterways is more energy-efficient than road transport. It can significantly contribute toward more sustainable transportation in Europe, while relieving heavily used road transport corridors. The European Commission is also promoting inland waterway transport through various funding and financing programs, such as the Connecting Europe Facility, Horizon 2020, the European Fund for Strategic Investments, and through the Cohesion policy. A funding database provides an overview of available public funding for inland waterway transport (European Commission, 2018). Table 8 shows the other LNG infrastructures in the BSR for different segments such as waterways, road, and rail transport. This is to highlight the possible synergy between land-based and maritime infrastructure. The list is not exhaustive, but provides salient examples of land-based infrastructure.

Table 8. Other LNG infrastructure in the BSR.

LNG segment	Type	Ship name	Flag	
Denmark				
LNG-fueled ships	Ferry	Princess Isabella		Samsö municipality
		MS Stavangerfjord and MS Bergensfjord		Fjord Line
	Tanker	Ternsund		Terntank
		Fure West		Furetank
Rail	-			
Road	Currently no vehicles or trucks are running on LNG	Frode Laursen A / S owns gas trucks (CNG) and has purchased one truck at Iveco, capable of running on LNG		
	79 smaller trucks, 73 busses, and 91 trucks, on CNG			
Germany				
LNG-fueled ships	Retrofitted ferry	MS Ostfriesland	MS Ostfriesland is the first ferry in Europe using LNG as a dual-fuel propulsion system	LNG-supplier is Bomin Linde LNG GmbH
	LNG barge	Hummel	To supply cruise ships in ports with electric power	Becker Marine

LNG segment	Type	Ship name	Flag	
				Systems GmbH & Co. KG
	Container ship	Wes Amelie	World's first container ship to be converted from heavy fuel oil to LNG. Operating on the feeder routes between the North Sea and the Baltic Sea	Wessels Rederei
	Research vessel	Atair II	Expected to begin operations in 2020.	Federal Maritime and Hydrographic Agency
Rail	Rail tank car for transporting LNG		In cooperation with project partners, Chart Ferox and Waggonbau Graaf	VTG Deutschland GmbH
Road	LNG trucks	20 ordered, 400HP Iveco Stralis LNG trucks.	Used for fresh food distribution in the Berlin area. The Federal Ministry of Transport and Infrastructure (BMVI) encouraged the purchase of the LNG truck fleet for 360,000 euros	Uniper (LIQVIS), Mayer Logistics and IVECO
	At the moment, there are 900 refueling stations for compressed natural gas (CNG) in operation. By 2025 there will be a basic network of LNG refueling stations (liquid natural gas) for heavy goods vehicles along the TEN-V core network			
		Lithuania		
LNG-fueled ships	Bunkering vessel		Planned	
Rail	Planned: LNG use for rail in port terminals		LNG cluster project on LNG for rail	
Road	Planned 2 bunkering stations for 2018			
		Norway		

LNG segment	Type	Ship name	Flag	
LNG-fueled ships	Ferry	MS Stavangerfjord and MS Bergensfjord	MS Stavangerfjord - the world's first and largest cruise ferry with single LNG engine	Fjord Line
			4 operating ferries serving Lofoten	Torghatten Nord
	Supply vessel	Viking Princess	Serving oilrigs. LNG-powered Wärtsilä engines will be updated with batteries to a hybrid system in Sept. 2017. May cut CO_2-emissions by 13-18%/year with this system.	Eidesvik Offshore
	Bunkering vessel	Coralius	LNG Bunkering services for Skangas in North Sea and Baltic Sea. Ship-to-ship bunkering from July 2017. Co-funded by EU under TEN-T and part of the Zero Vision Tool platform	Sirius Shipping and Anthony Veder
	LNG carrier	Coral Energy	Bunkered by Coralius	Anthony Veders
		Pioneer Knutsen	Operates for Gasnor	Knutsen OAS Shipping
				Höeg LNG
				Golar LNG
				BW Gas
		WilForce and WilPride	Intended for international trade	Awilco LNG
Rail	-			
Road				
		Poland		
LNG ships	Bunkering vessel		Planned for 2022	
Rail				
Road				
		Sweden		
LNG-fueled ships	Cruise ship	Viking Grace	Bunkered by Seagas.	Viking Line
	Ferry	Visborg and Thjelvar	Among the world's most powerful and fastest LNG-fueled RoPax-ferries, will service the route between Nynäshamn and Visby, Gotland (Sweden). OSK-ShipTech A/S (DK) naval architects	Rederi AB Gotland
	Bunkering vessel	Seagas		Sirius Shipping
	Cargo ship	Ternsund	Operates along North Sea-Baltic Sea	Terntank
	LNG carrier	Stena Blue Sky, Stena Clear Sky, and	Transportation of LNG around the world	Stena Bulk

LNG segment	Type	Ship name	Flag	
		Stena Crystal Sky		
	Small bulk/dry cargo vessel	LNG Sea River	The joint industry project LNG Sea River is an EU TEN-T financed project and collaboration between the Erik Thun Group, Ferus Smit, and Lloyd's Register	Erik Thun AB
	Tanker	Fure West		Furetank
		Bit Viking	First product tanker in the world to use LNG as fuel, in 2011	Tarbit Shipping
Rail	-			
Road	Truck	Volvo FM MetanDiesel	BiMe Trucks project with AGA	Volvo
			6 trucks	Scania

2.4.2.1 POLICY: DANUBE STRATEGY WITH MASTERPLAN

At the behest of the European Commission, transport ministers of the riparian states of the Danube agreed to a declaration reasserting existing obligations to maintain the fairway to a good standard. This included finding solutions for problems like low water or ice and to coordinate actions through the structures of the Danube Strategy and the Trans-European Transport Network Coordinator for Inland Waterways. As a result, an EU master plan for the rehabilitation and maintenance of the river Danube and its tributaries has been put into place from 2015, for coordinated national and cross-border actions to respond to the challenges and to re-establish optimal and safe navigation conditions in the Danube (European Commission, 2018).

LNG Masterplan for Rhine-Main-Danube

A key player toward the success of this masterplan goal is the transition of the Danube fleet from gasoil to other low-carbon fuel alternatives, such as LNG. Additionally, LNG transport through the Danube could remarkably increase transport in terms of volumes and result in energy savings for related industries in the region. The LNG Masterplan is a thorough plan which covers not only areas like market and regulatory assessment, feasibility studies, technical concepts, education, and training materials, but is also a comprehensive strategy for deployment of LNG in inland waterway transport. It puts forward a recommendation for actions for the extensive deployment of LNG in inland water transport (European Regional Development Fund, 2017). The LNG Masterplan aims to achieve the following objectives:

- to coordinate and facilitate development of a regulatory framework and to motivate public-private investments
- to explore and analyse costs and benefits of using LNG as a fuel and as cargo for the European inland fleet

- to identify barriers to cooperation between public authorities and industry, while recommending mechanisms for overcoming these obstacles
- to assess the potential of LNG markets in the hinterland of river ports
- to improve know-how from Northern Europe & the maritime sector to the inland navigation sector in general and particularly to Central / South Eastern Europe
- to make LNG available as an environmentally friendly and alternative fuel for inland waterway transportation
- to ease the application of the waterborne LNG chains - through building-up of pilot LNG infrastructure in ports and pilot LNG-fueled vessel(s), either newly built or retrofitted, (European Regional Development Fund, 2017).

Another driver of the Inland Waterway Transportation in Europe is the European Clean Power Directive, which requires all larger sea ports and Trans-European Transport Networks (TEN-T) core inland ports to have LNG-bunkering facilities by 2025 (Ministry of Infrastructure and the Environment, 2014). LNG growth is predicted to experience a rapid rise in the next 5-10 years. Initially, LNG is expected to be deployed on relatively small ships operating in local areas, along with the developed of gas bunkering infrastructure, where LNG prices are competitive with respect to Heavy Fuel Oil prices. A number of large LNG import terminals already exist in Europe, some of them are on the way to having an export facility, which is a crucial step towards small-scale LNG distribution in the region (European Commission, 2016).

Relevant stakeholders in the inland waterway infrastructure

Different stakeholders are engaged in the LNG industry for Inland Waterways Transportation (IWT) and the key players are the policy makers, the shipping owners, and mainly the gas companies who are the LNG bunkering facilities operators (Figure 9). Policy makers have aimed at facilitating investments in LNG infrastructure. Financial investments in LNG infrastructure come predominantly from shipping companies and gas companies. Eventually, operators of the LNG bunkering facilities will be making profits out of trading LNG (Karaarslan, 2014). In the following scheme, the most relevant parties involved in the LNG market for IWT are illustrated:

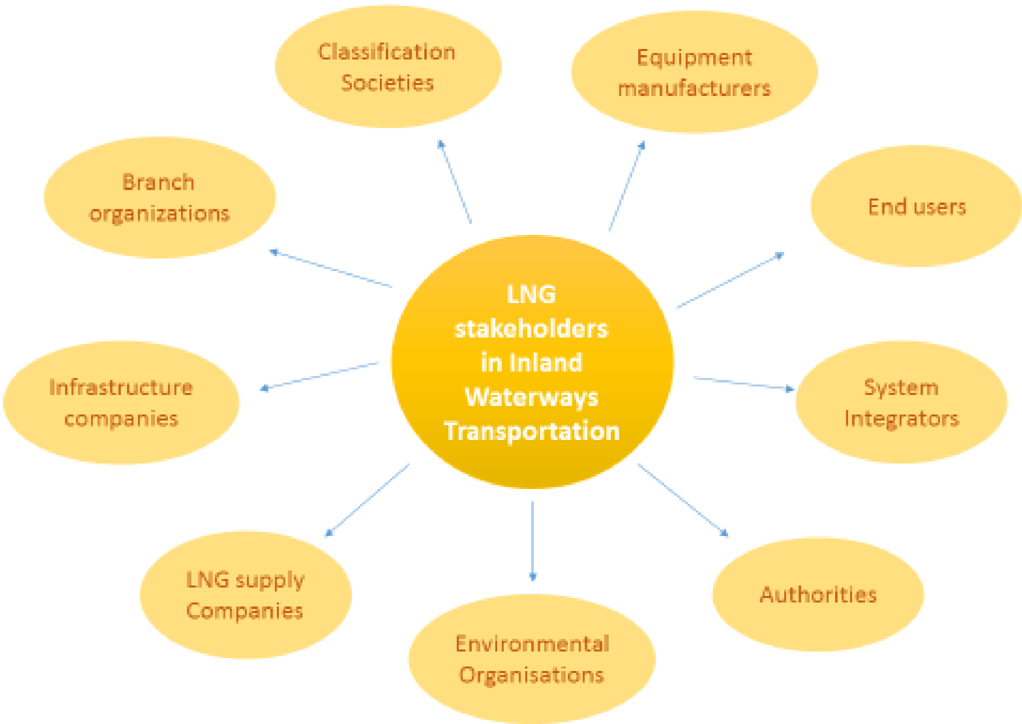

Figure 9. LNG stakeholders in Inland Waterways Transportation. Source: Recaptured and reproduced by the author from Karaarslan, 2014.

Rotterdam as LNG hub for inland waterway transportation (IWT)

In 2013, a report on EU transport was published on behalf of the European Commission’s Directorate-General. It was aimed at investigating the impact of measures taken to reduce emissions from IWT. According to the report, local air pollution and its resulting external costs on people’s health is the main problem of IWT in Europe. Despite this disadvantage of IWT, the report recognized that in terms of CO_2 emissions, IWT had an important advantage over road transportation. LNG offers the possibility of reducing local pollution, whilst making use of the CO_2 advantage which IWT offers. Karaarslan (2014), reported that the use of LNG can lead to a significant reduction of NO_X and PM emissions from IWT.

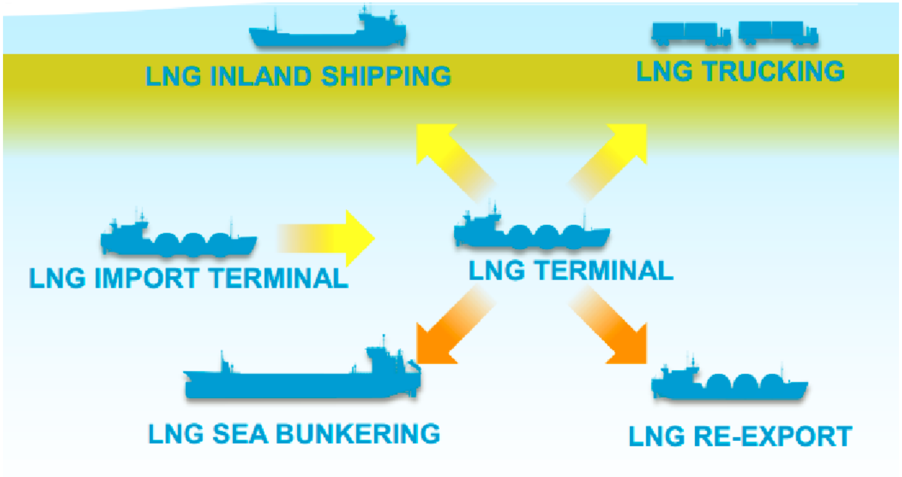

Figure 10. Port of Rotterdam as an LNG Hub. Source: Karaarslan, 2014.

The port of Rotterdam is in transition to becoming a hub of the LNG industry (Figure 10). The National LNG Platform plays a crucial role and is introducing LNG as an alternative fuel for the transportation sector in the Netherlands. The goal of the National LNG Platform for 2015 was for a minimum number of 50 inland waterway vessels to run on LNG. To reach this goal, there was a focus on investments in the LNG logistics chain by relevant stakeholders of IWT.

Important bottlenecks in LNG application in Inland Waterways Transportation (IWT)

Currently, there are some bottlenecks for the implementation of LNG as an alternative fuel in inland waterway transports. These comprise conducting a market analysis, overcoming legal issues, selecting the optimum location, organizing the investment capital, and resolving technical issues. Some of the challenges faced during the planning, construction, and commissioning of LNG infrastructure in European ports has been listed by Wang & Notteboom (2014) (Figure 11).

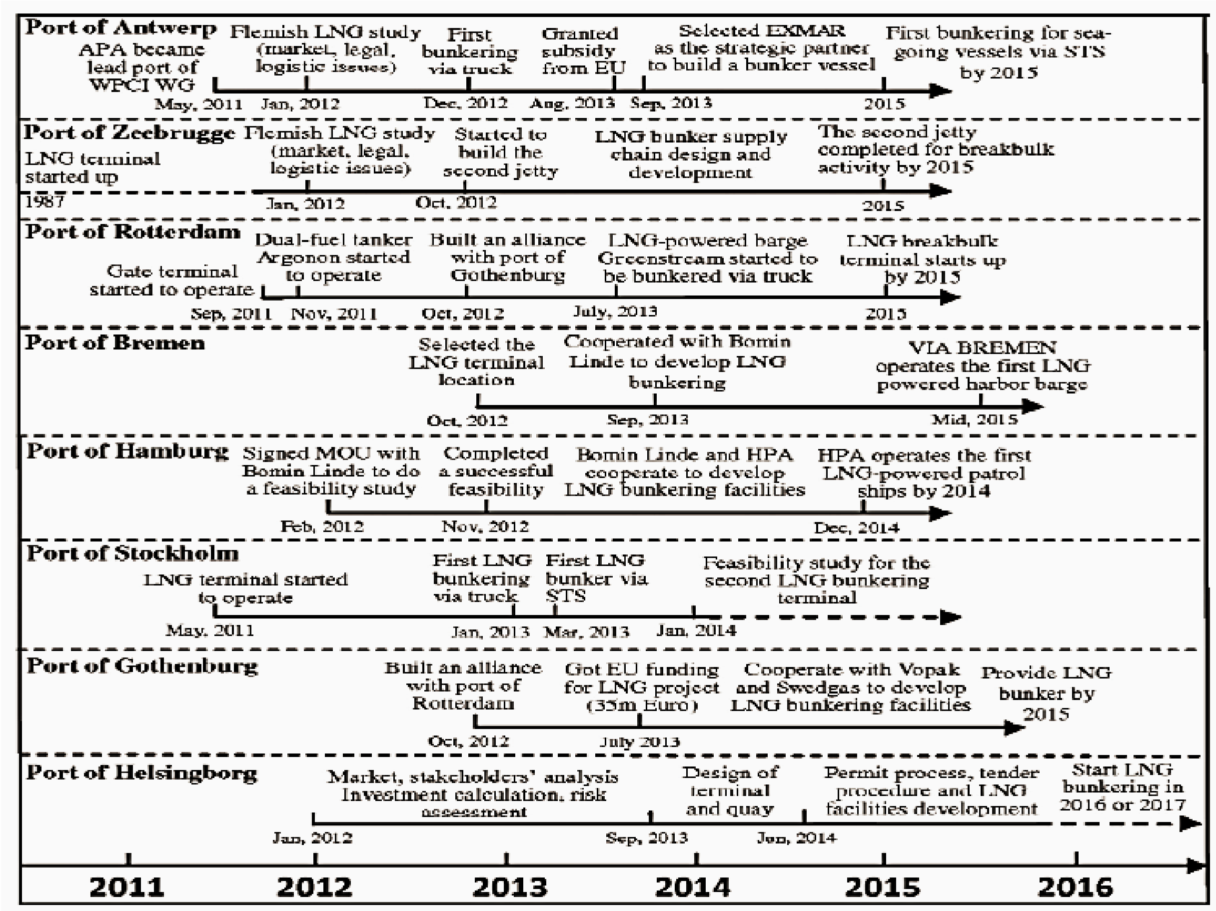

Figure 11. Overview LNG infrastructure in several EU Ports. Source: Port Economics ,2014.

Another major challenge can be the lack of knowledge about the use of LNG in IWT. Vessel owners are often not familiar with the use of LNG and its technology. This lack of knowledge among stakeholders of IWT can create a reluctant attitude towards the introduction of LNG as a fuel.

2.5 OTHER LNG INFRASTRUCTURE

Apart from fixed maritime related LNG infrastructure, the countries of the BSR have other LNG infrastructure, including vessels, trucks, and rail wagons. Again, Norway is leading in the maritime sector with different types of vessels including ferries, supply vessels, bunkering vessels, and LNG carriers (Table 8). However, Sweden is also an operator of several types of vessels and of LNG trucks (in 2016, there were about 70 trucks from which 10 are used in the southernmost region of Scania (Skåne)). In Sweden, there were 174 public CNG refueling stations as of November 2018. There were six public LNG bunkering stations for road vehicles (Table 8).

Indeed, when it comes to use of gas for rail and road, it is compressed natural gas (CNG) that is most commonly used for mobility solutions. However, this fuel only offers limited range for trucking and is thus ill-suited for long haul transport. It has been evaluated that to keep the same level of autonomy and energy efficiency, 1.8 liters of LNG are needed compared to 1 liter of diesel, and the increased volume tank could still be easily fitted on the heavy road truck. This translates to 1,000 kilometers on a tank of LNG, compared with just 250 to 300 kilometers on a tank of CNG (European Commission, 2014). Therefore, LNG could be a better alternative for medium and long distance road transport.

The first German retrofitted ferry that used LNG as a main fuel was MS Ostfriesland. LNG is imported via large-scale facilities, e.g. Rotterdam port, and then transported via truck to the consumer (Dual Fuel Ferry MS Ostfriesland) and transferred at the berthside. The ferries route is from Emden to Borkum (North Sea) and one route takes 6 hours. MS Ostfriesland is the first ferry in Europe using LNG as a dual-fuel propulsion system. The LNG-supplier is Bomin Linde LNG GmbH (Logistik-Initiative Hamburg 2015).

Becker Marine Systems GmbH & Co. KG developed a LNG barge called "Hummel" in 2014/15. The barge is used to supply cruise ships in ports with electric power with a frequency of 60 Hz. No transformer is needed which is usually necessary for a landside power plant. The barge has a power supply of 6 MW and an operation of a maximum 10 hours (Logistik-ibid, 43ff.). Becker Marine Systems also developed the LNG PowerPac system. The PowerPac system is a solution for supplying power to container ships at ports. (Becker Marine Systems, 2016). The barge is now no longer in service, and the company was dissolved.

VTG's objective of developing the LNG rail tank car is to create a means of transport for the first time in Europe that provides the possibility to transport larger quantities of liquefied natural gas by rail in an environmentally friendly manner. This LNG rail tank car makes the distribution of LNG in Europe possible beyond the sea-lanes, road transport networks, and corresponding pipeline networks currently used. Technically, this had not been possible previously. In cooperation with its project partners, Chart Ferox and Waggonbau Graaf, VTG Deutschland GmbH has developed, designed, and built a rail tank car for transporting liquefied natural gas (LNG). Until now, LNG has always been transported by sea, truck, and tank container. The LNG rail tank car - which is unique in Europe - has brought a means of transport onto the market that scores twice when it comes to environmental friendliness: environmentally friendly liquefied natural gas is transported by rail, which is also environmentally friendly (Logistik-Initiative Hamburg 2015.).

In June 2016, the first LNG filling station was built in Ulm. This project was realized and initiated by IVECO and Uniper (Verkehrsrundschau 2016).

The agreement signed in 2016, between Uniper subsidiary LIQVIS and truck manufacturer Iveco will help further expand infrastructure allowing LNG to be used as a truck fuel. The plan was for approximately 200 vehicles by 2020 in the Rhine Ruhr region. LIQVIS is planning – alone or with a partner – to build two LNG filling stations in this region. LIQVIS is also planning the installation of mobile filling stations at the facilities of suitable customers (LIQVIS, 2016).

Concerning the development of an LNG filling station in Berlin, this will be located in the SoNoR Corridor, which runs from Spain to Sweden. LNG is likely to be viewed initially as a complementary fuel to diesel fuel, but it is hoped that it will eventually develop into an adequate replacement.

The SECA regulations are expected to bring substantial socioeconomic benefits (e.g. Ballini and Bozzo, 2015), but in the short-term they generate additional costs to end-users of maritime transport and investments for ship owners and other related industries in the BSR (e.g. Bachér and Albrecht, 2013). SECA regulations will soon apply to other regions of the world, requiring functioning examples and solutions from the BSR that can be applied elsewhere in the world. An important part of the Go LNG project is to showcase the solutions found by the maritime industry in the BSR into examples that can be applied by the shipping industry elsewhere. In addition to this, the GoLNG project aims to show how additional benefits generated by complying with environmental regulations can become a source for development and innovation, subsequently resulting in new business activities, new jobs, and economic growth. The current level of progress on the deployment of LNG has been associated with the infamous "chicken-and-egg" problem, where bunker suppliers and shipowners have both followed a "wait and see" approach (Wang and Notteboom, 2013, Gerlitz and Paulauskas, 2015). In a report performed by Baltic SO2lution LNG (Dalaklis et al., 2017), it was shown that the investment dilemma is still a prevailing obstacle for a timely development of LNG. For example, the actual LNG demand from ship owners is currently much lower than the demand of LNG from local energy firms or industry. As a result, participation of the local industry and the energy sector is indispensable for initiating investments in LNG infrastructure (Semolinos et al. 2013, Adamchak 2013). In addition, the lack of crystal clear technical and operational standards together with the intensive capital cost and the associated risks of investment, have deterred potential stakeholders, including shipowners, and bunkering operators from early investment. Technical standards for LNG infrastructure in the BSR are likely to improve predictability of deployed LNG technology and are expected to be beneficial for private investments in LNG.

Figure 12. FRSU Independence. Source: Shutterstock (accessed 06-03-2019)

As the BSR countries are taking their first steps in LNG business operation, such as that of the Klaidea FSRU (Figure 12), there are many business opportunities in various areas for companies to become involved in. The technological requirements of LNG bunkering and transport will raise the demand for designs of innovative transportation technologies and require their construction and continuous development. This applies, for example, to the design and manufacture of cryogenic tanks and associated fuel systems and components. The technical supervision of infrastructure or production is another area likely to generate demand for technical consultancies. Another area expected to create local revenue and jobs is the design, construction, and operation of an LNG feeder distribution system for refueling of ships. There are three different methods on how ships can be refueled: The first option is to refuel ships directly from an onshore LNG storage tank. In this case, refueling takes place at the jetty with the vessel getting the LNG straight from an onshore tank. This requires a suitable onshore fuel system with pumps, electrical earthing, LNG supply, and vapor return pipes to the LNG tank. The second option is to refuel ships using mobile LNG trucks. This option is attractive if LNG must be transported a long distance from the onshore LNG tank. This will require the existence of suitable LNG trucks with onboard power and pumps as well as suitable transfer piping. The third option is to use feeder vessels that take the LNG from the storage tank and then refill the ships. This option is likely to be the most viable in many locations due to its flexibility to access sites where jetties are not installed or at ports where LNG bunkering sites are not installed yet. An overview of various LNG uses and transport options is shown in Figure 13.

Figure 13. Various uses of LNG. Source: [GoLNG website: http://www.golng.eu/en/bsr-blue-corridor-strategy/].

Indeed, the construction and operation of bunkering stations, refueling stations, development of trucks, engines, and retrofitting of vessels to LNG is expected to result in new business activities, jobs, and assist economic growth in Europe. The interest of private parties in LNG deployment in Road, Maritime Transport, and IWT underlines this.

As part of the GoLNG project, a study on the emerging LNG value chain of the BSR was conducted, as will be presented in section 2.6. An assessment of the logical number of LNG trading hubs in the BSR was conducted to estimate chances for further successful development of infrastructure and service. This may lead to an increase for short to long-term LNG supply contracts between trading hubs and transport/intermediate supply companies as well as an increase in logistic/intermediate services.

2.6.1 Main LNG players in the Baltic Sea Region

The most important companies involved in the development of LNG infrastructure in the BSR are listed in Table 9 below.

Table 9. Main players in the BSR per country and LNG field.

Country	Player
Denmark	
Bunkering*	Fjord Line
	Kosan Krisplant
	Q8 Denmark
	Bunker Holding (future provider)
	UniOil (future provider)
	HMN Naturgas (future provider)
	Primagaz
Storage	Unioil
	Kosan Krisplant
	AGA
	Nærenergi
	Primagaz
Distribution	Evergas Leading first class operator within the transportation of petrochemical gases and natural gas liquids. Latest addition to its fleet is the 4th ‘dragon class’ 27,500 m^3 multi-gas LNG carrier in a series of eight. The ‘dragon class’ vessels are the largest, most flexible, and most advanced multi-gas carriers built to date.
	J. Lauritzen International shipping company. Lauritzen Kosan focuses on liquefied gases.
	Svitzer World’s largest LNG towage provider.
	Nature Energy Nature Energy wants to deliver green and sustainable solutions and is currently involved in the establishment of several Biogas plants all over Denmark. Will supply the project in Port of Frederikshavn with biogas to be liquefied into LBG.
	Monjasa (potential player) Expects to be able to provide LNG within the next few years and has now actively begun work (expects to be able to provide LNG within the next few years and has now actively begun work).
	Maersk Tankers (potential player)

Country	Player
	Fleet of fully and semi-refrigerated gas carriers offers a comprehensive set of flexible solutions for transporting liquefied petroleum gas (LPG), ammonia, and petrochemical gasses.
End-user technologies	**Shipowners** **Fjord Line** **Samsø Shipping** **Terntank** **Furetank** **Unifeeder**
Shipbuilding and repair	OSK-ShipTech
	Knud E. Hansen A/S
	NIRAS
	Odense Maritime Technology (OMT)
	FAYARD A/S
	MAN Energy Solutions Supplier of ME-GI high-pressure gas injection engines powered by LNG, Ethane, LPG, or Methanol, including cryogenic compressors for LNG. MAN Cryo - MAN Diesel & Turbo's marine LNG fuel-gas-system supplier Cryogenic equipment for marine fuel-gas systems, offshore and onshore bunkering systems, including cryogenic tanks and fuel systems.
	Wärtsilä (Denmark)
	Rolls-Royce Marine
	LR Marine A/S
	ABB
Classification	DNV GL
	Lloyd's Register Group Limited (LR)
	Bureau Veritas
	RINA SERVICES
Consultants (economy, environment, risk, safety and security)	The Danish Technological Institute (DTI) Assists companies to boost their development within areas such as sustainable transportation
	Rambøll Rambøll's work with LNG in the Baltic Region includes everything from economic market studies to technical concepts for import of LNG, including risk assessment, preliminary process, and layout studies.
	COWI

Country	Player
	Carries out assignments at all stages of the project, ranging from studies at an early stage to the start-up of LNG terminals. Our breadth of knowledge in various fields includes risk and permit management, land preparation and project planning, and construction of LNG installations.
	LITEHAUZ Part of the project group completing the project "Natural gas as propulsion for the shipping sector in Denmark" back in 2010 - logistical, technical, and economic feasibility for using Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG) as fuel for ship propulsion and the supply of LNG or CNG to Danish ports from existing natural gas lines, trucks, or by ship.
	OSK ShipTech A/S Risk assessment
	DNV GL Technical and financial decision-making support for switching to LNG as ship fuel and assist with compliance (LNG ready).
	Lloyd's Register Helping ensure that internationally recognized safety and environmental standards are maintained at every stage of a ship's life.
	NIRAS In regards to LNG, Niras can assist with risk assessment and environmental assessments (such as VVM).
	NTU International Port of Frederikshavn collaborated with NTU International, an Aalborg-based Danish consultancy company, on the LNG bunkering facility project.
Associations and organizations	**GOLNG Denmark Network**
LNG in other industry	Arla Foods Potential player. Currently working on a project to establish a biogas plant at Videbæk, Denmark. It remains to be seen if this could also include LNG, but it is therefore within reason to think that Arla Foods is also considering LNG/LBG in the Baltic Sea Region.
	Aalborg Portland (Cementer Group) Potential player. Focused on minimizing energy used in production and on reducing environmentally harmful emissions. Have used the LNG driven cement carrier MV Greenland for shipping of their products and could have an interest in LNG driven bulk carriers as part of their environmental strategy.

Country	Player
	Nordic Sugar Potential player. A study on "Feasibility of producing Bio-fuel Nordic in sugar factory Nykøbing, from their biological residues environmental and economic impacts on the factory and Guldborgsund municipality energy system" which is now serving as baseline for the project task concerning Guldborgsund Havne in the project Dual Ports.
	De Danske Gærfabrikker Potential player. Producing yeast and could be a potential user of LNG – especially in light of the location in Grenå.
Germany	
Bunkering	Nauticor (formerly Bomin Linde LNG)
Storage	
Distribution	Bomin Linde LNG GmbH
	E.on.
	Uniper (LIQVIS) Energy company
End-user technologies	Becker Marine Systems Has developed the LNG PowerPac system which is a solution for supplying power to container ships at ports. The LNG PowerPac is a unit consisting of two 40-foot containers, combining a gas-powered generator with an output of 1.5 MW and an LNG tank in a limited amount of space. Once a container ship is moored, the LNG PowerPac is brought onboard via the port terminal's locally standard loading equipment. The unit then provides energy to the onboard power supply during the vessels layover in the port (Becker Marine Systems 2016).
	Meyer Logistics Food industry
Shipbuilding and repair	Becker Marine Systems
	MAN Energy Solutions and German Dry Docks in Bremerhaven LNG engine conversion of the containership Wes Amelie.
Classification	DNV GL
Consultants (economy, environment, risk, safety and security)	ATI Küste GmbH
Associations and organizations	Maritime LNG Plattform e.V. GOLNG Network
	LNG-Initiative Nordwest

Country	Player
	Deutscher Verband Flüssiggas e.V.
LNG in other industries/modalities	VTG Deutschland GmbH (rail)
	IVECO Utility vehicle manufacturer, LNG trucks
Lithuania	
Bunkering	Klaipedos Nafta
	Bomin Linde
Storage	Klaipedos Nafta
Distribution	Klaipeda LNG import terminal via Lithuania gas grid and Klaipeda small scale terminal (should start operation in 2017) distribute LNG to local (Lithuania, Latvia, Poland, Belarus) users
End-user technologies	Emerson
Shipbuilding and repair	Western Shipyard Built LNG-powered ferries for Norwegian customer Upgrading production to be able to produce LNG tanks and containers
Classification	DNV GL
	BV
	SGS
Consultants (economy, environment, risk, safety and security)	Klaipeda University CORPI, NPPE Klaipeda Shipping Research Center
	DNV GL
	JC Klaipedos Nafta LNG terminal management FSRU Operations and project management- backed by physical infrastructure. Design and build in 2010 – 2014 LNG offshore terminal (in operation since 2014), 6. Design and build small scale LNG terminal (should start operation in 2017)
Associations and organizations	Lithuania LNG cluster GOLNG Network
LNG in other industries	Planned: 2019 LNG cooling energy for cold storage
Norway	
Bunkering	Höeg LNG Leading provider in the FSRU market.
	Golar LNG

Country	Player
	Leading provider in the FSRU market.
Storage	Gasnor It is Norway's leading downstream natural gas company with an extensive pipeline network, some CNG distribution, and LNG distribution from three separate production plants. Gasnor owns 16 LNG trailers, 22 LNG terminals, and has 2 LNG vessels at its disposal. Skangas AGA Statoil Barents Naturgass
Distribution	Gasnor It is Norway's leading downstream natural gas company with an extensive pipeline network, some CNG distribution, and LNG distribution from three separate production plants. Gasnor owns 16 LNG trailers, 22 LNG terminals, and has 2 LNG vessels at its disposal.
	Kanfer Shipping
End-user technologies	
Shipbuilding and repair	
Classification	DNV GL
Consultants (economy, environment, risk, safety and security)	DNV GL Maritime Advisory Aker Solutions Global provider of engineering, design, production systems, and services to the oil and gas industry
Associations and organizations	Norsk Gassforum **GOLNG Network**
	Norsk Havneforening
	Short Sea Promotion Center
	Fraktefartøyenes Rederiforening
	Norges Lastebileier-Forbund
LNG in other industries	
Poland	
Bunkering	PGNiG (trial)

Country	Player
	Polskie LNG (trial)
	LOTOS Asfalt (potential player)
	LOTOS Kolej, Ltd. (potential player)
Storage	BUDNAFT
	Energiobaltic Sp. Z o.o.
	PETROLINVEST
	PGNiG
	POLSKIE LNG
	LNG-Silesia Sp. z o.o.
	VAK-POL&GAZ sp. z o.o
	CHEMET SA
	LOTOS Kolej Ltd.
	Blue Line Engineering Inc.
	Wärtsilä Polska Sp. z o.o. Components for LNG storage
	Witzenmann Polska Sp. z o.o.Tech Gas S.C. Components for LNG storage
	Nowoczesne Technologie Gazowe Components for LNG storage
	ABB Sp. z o.o. Components for LNG storage
	Air Products Sp. z o.o. Components for LNG storage
	Lady-w mgr inż. Maria Witkoś Components for LNG storage
Distribution	ENERGOBALTIC Sp. z o.o.
	GAZ-SYSTEM
	PETROLINVEST
	PGNiG
	LNG-Silesia Sp. z o.o.
	KRIOSYSTEM Sp. z o.o.
	Shell Polska Sp. z o.o. (potential player)
	DUON Group, Ltd.
	LOTOS Kolej, Ltd.
	Blue Line Engineering, Inc.

Country	Player
	Blue Gaz Ltd. (potential player)
End-user technologies	PETROLINVEST
	PGNiG
	Zakłady Aparatury Chemicznej CHEMET SA
	Lider Trading Sp. z o.o.
	BEST Systemy Grzewcze Ltd.
	Blue Line Engineering Inc.
	PNEUMATECH - GAZ TECHNIKA Ltd.
	Tech Gas S.C.
	Nowoczesne Technologie Gazowe
	Ticon Sp. z o.o
	Witzenmann Polska Sp. z o.o.
	ABB Sp. z o.o.
	Air Products Sp. z o.o.
	Lady-w mgr inż. Maria Witkoś
	Ceres Components for LNG Transport
	Iveco Poland Sp. z o.o. Components for LNG Transport
	1. ELPIGAZ Sp. z o.o. Components for LNG Transport
Shipbuilding and repair	GDANSK SHIPREPAIR YARD REMONTOWA
	REMONTOWA LNG SYSTEMS Sp. z o.o.
	Pipe Welding Service Jarosław Spławski
	Morska Stocznia Remontowa "Gryfia" S.A.
	Remontowa Shipbuilding SA
	Wärtsilä Polska Sp. z o.o., ABB Sp. z o.o.
	Remontowa Marine Design
Classification	POLISH REGISTER OF SHIPS (potential player)
	DNV GL POLAND (potential player)
Consultants (economy, environment, risk, safety and security)	PWC, Ltd. Risk assessment
	PWC, Ltd. Economic impact

Country	Player
	OBLC POLSKA Independent Consulting Company specialized in the management of pre-studies, negotiation and awarding process, engineering and construction of Gas Treatment Facilities and LNG Terminals. Port onshore infrastructure. LNG terminal in Swinoujscie, Poland, for PGNiG, Polskie LNG. Ref: ilf.com/pl/wybrane-referencje/ropa-i-gaz/terminale-naftowe-i-lng LNG terminal in Odessa, Ukraine for State Agency for Investment and National Projects of Ukraine. Ref: ilf.com/pl/wybrane-referencje/ropa-i-gaz/terminale-naftowe-i-lng
	PWC Polska Ltd. LNG market consultancy, economic impact, and risk assessment. Świnoujście LNG Terminal Project Consultancy, 2006 – 2007, lead partner: PGNiG S.A., funding instrument: own resources, location of project implementation: Świnoujście, Poland, Outer Port of Świnoujście. http://www.pb.pl/1394101,93731,pgnig-wybralo-konsorcjum-z-pwc-ws-projektu-lng Krku LNG Terminal Project Consultancy, March 2015, lead partner: Terminal LNG Adria, monetary value: 17,300,000 KUN, funding instrument: own resources, location of project implementation: Krku, Croatia. www: http://biznesalert.pl/pwc-skonsultuje-projekt-gazoportu-na-wyspie-krk/
	TDT-Transportation Technical Supervision Authorized transport technical supervision, provide technical inspection of tanks for liquefied or compressed gas, used to power internal combustion engines in vehicles, i.e.: tanks LPG, CNG, and LNG

	ILF Consulting Engineers Polska Sp. z o.o
	
	● provides design, project management, consulting, and investment supervision
	● services engineering and consulting companies and provides top quality services in the following areas:
	  ● Oil & gas
	  ● Energy & climate protection
	  ● Water & environment
	  ● Transport & structures
	
	● Complex services for:
	Upstream facilities of LNG, pipeline systems, underground storage facilities, tank farms & LNG terminals, refineries and, petrochemical plants
	LNG terminal in Swinoujscie, Poland, for PGNiG, Polskie LNG
	Ref: ilf.com/pl/wybrane-referencje/ropa-i-gaz/terminale-naftowe-i-lng
	
	LNG terminal in Odessa, Ukraine for State Agency for Investment and National Projects of Ukraine

Country	Player
	Ref: ilf.com/pl/wybrane-referencje/ropa-i-gaz/terminale-naftowe-i-lng
	Blue Line Engineering, Inc. Poland Gas Market Consultancy Liquefied gas distribution Liquefied gas shipping Liquefied gas onshore infrastructure Liquefied gas storage Gasification of the left bank of Wielun (Gazyfikacja lewobrzeżnej części Wielenia); 2013, project details are corporation confidential information
	DNV Poland DNV Maritime and Business Assurance office
	TDT-Transportation Technical Supervision
	OIL AND GAS INSTITUTE
Associations and organizations	**GOLNG Network**
LNG in other industries	Przedsiębiorstwo Gospodarki Komunalnej w Śremie Spółka z o.o
	SOLBUS, Ltd.
	BEST Systemy Grzewcze Ltd.
	PNEUMATECH - GAZ TECHNIKA, Ltd. (potential player)
	Iveco Poland Sp. z o.o.
	ELPIGAZ Sp. z o.o.
LNG fuel station	Przedsiębiorstwo Gospodarki Komunalnej w Śremie Spółka z o.o
	LOTOS Asfalt (potential player)
Sweden	
Bunkering	Skangas
	AGA Gas
Storage	AGA Gas
Distribution	Swedegas
	AXPO
	E.on.
	Barents Naturgass Sverige
End-user technologies	Alfa Laval
	Emerson

Country	Player
	MAN Diesel & Turbo Sverige
	MannTek (Mann Teknik AB)
Shipbuilding and repair	Swedish ship designer FKAB
	Oresund Drydocks
Classification	
Consultants (economy, environment, risk, safety and security)	SSPA Sweden AB Acts as a bridge between research and maritime industry implementation. LNG specific: terminal layout, port operations, risk analysis, bunkering operations, and infrastructure development. Developing a more effective infrastructure for access to LNG for the maritime market. The aim is to identify potential locations of new maritime terminals for import of LNG to Swedish ports. LNG in Baltic Sea Ports
	SWECO
	Ramböll
	ÅF
	COWI
Associations and organizations	Energigas Sverige (Swedish Gas Association) Member-funded, industry association dedicated to promoting a greater use of gas energy. GOLNG Network
	Svenskt Gastekniskt Center AB /Energiforsk Energiforsk is a non-profit corporation owned by Svensk Energi, Svensk Fjärrvärme, Svenska kraftnät, Energigas Sverige, and Swedegas
	Maritimt Forum An association of around 100 fee paying members. These members are companies, organizations, and authorities related to the shipping industry
	Svenskt Marintekniskt Forum (SMTF) Representatives of the maritime technology industry. Emission and greenhouse gas reduction from ships, using studies to reveal the status of air quality in ports and surrounding areas. Projects: CNSS-Clean North Sea Shipping and Go LNG
	Föreningen Svensk Sjöfart
	Sveriges Hamnar
	Sveriges Skeppsmäklareförening

Country	Player
LNG in other industries	SSAB Potential player. Uses natural gas for steel industry in Borlänge. By switching to LNG, the company reduces its CO_2 emissions by 40,000 tons/y, NOX-emissions by 300 tons/y and all SO_x emissions (400tons/y).
	LKAB Europe's biggest iron ore producer. Barents Naturgass delivers LNG with 11 trailers from Hammerfest, Norway, to Sweden
	Uddeholm
	Nynäs refinery
	ICA - grocery retail About a third of the dual-fuel vehicles made by Volvo in Sweden are in operation for ICA.
	PREEM refinery

2.6.2 DENMARK

Most of the existing LNG infrastructure in Denmark was created following the IMO SECA regulation. Infrastructure that is currently under development, has received either EU-funding (TNT, others), national funding such as the Norwegian NO_x-fund (where it can be applied), or are reliant on seaway and port dues reductions (where applicable), alongside the commercial aspect, to present a coherent business case. An exception is the Samsø bunkering system which was established without investment support. It is expected, however, that the future LBG liquefaction unit on Samsø will require some kind of support.

The Danish authorities want the continuous development of LNG infrastructure to be market-driven, but stakeholders still consider economic incentives for LNG or other types of cleaner shipping in Denmark or Europe to be important in supporting the market driven developments. Such incentives include the NO_x Fund in Norway, port fairway due for non-LNG-powered ships, or port reductions for LNG-powered vessels, a "clean shipping index" or similar financial incentives (not just for LNG but for clean shipping in general). Subsequently, EU funding dedicated to LNG infrastructure development and the financing schemes such as the CEF (Connecting Europe Facility) offered by INEA / EU are still considered to be important tools in LNG infrastructure development.

As of today, the marine industry / shipowners who represent the primary end user of the LNG infrastructure in Denmark play a major (though not exclusive) role in the development of

Danish LNG infrastructure. Danish shipowners are able to demonstrate that the ship operating cost for LNG is typically lower than that for MGO. However, they are not willing to share the exact costs or numbers. The Danish stakeholders don't currently foresee LNG use on a large scale but put to the service of marine activity, for heavy road transport, and for industry.

With regards to road transport, there are currently no LNG-powered vehicles in Denmark, but it is expected that LNG heavy trucks will enter the Danish transport market in the near future, especially new LNG trucks with 450 HP able to cover up to 600 km on a single tank of LNG. From the point of view of energy supply, Denmark has a very well developed natural gas network, thus reducing the need for LNG for industry or food production and distribution purposes.

The LNG infrastructure in Denmark has several ownership structures. The initiatives in Denmark are all focused on shipowners. Fjordline, Unifeeder, Furetank, and Terntank are private companies, while the municipality of Samsø with its Samsø Rederi and bunkering infrastructure in Port of Hov are publicly owned. Fjordline, which traffics the port of Hirtshals, owns the LNG infrastructure at the port.

The planned liquefaction plant at Hirtshals has a private ownership structure, involving four investors, including foreign direct investment by an American company (unknown split). The ownership of the planned bunkering infrastructure in Port of Frederikshavn has not yet been completed but will certainly involve private stakeholders. The status of both projects is currently unknown.

It is estimated that the LNG production plants planned for the Ports of Hirtshals and Frederikshavn – if built - will be sufficient for supplying the Danish shipping industry with LNG (LBG).

2.6.3 Germany

In Germany, information about national private investments is not publicly available and there is no information about foreign direct investment (FDI). It is clear, however, that there have not been any noteworthy FDIs in LNG infrastructure. There are different types of cooperation between the stakeholders. Business cooperation is quite common in the private sector, e.g. between the Port of Brunsbüttel and VTG Rail Europe to develop business opportunities in the LNG supply chain. There are also several networks, platforms, and associations regarding LNG on regional and national levels, e.g. Maritime LNG Plattform e.V., LNG-Initiative Nordwest, Deutscher Verband Flüssiggas e.V. These networks keep regular exchange and consultations with the public authorities.

Becker Marine Systems LNG developed an LNG barge for the Port of Rotterdam. The company is in direct talks with other port authorities to set up similar barges (Maritime Journal 2015). Becker Marine System's newly developed power generating barges (PowerPacs) seem to be important for the development of LNG (Ehrmann, 2016). VTG Deutschland GmbH as a rail wagon renting company is lending its cars throughout Europe. Several talks have been led with companies in Spain and Scandinavia. The current status of these talks is pending.

At the moment, there are 22 planned projects that are to be realized in the maritime sector: 17 new build ships and 5 retrofitted ships shall get LNG propulsion technology. Germany subsidizes these projects with a total value of 154 Mio. € (Approx. 7 Mio. € per ship) (Ehrmann, 2016). Data relating to current LNG business models are not available. As mentioned above, the current German federal policy relies on giving incentives to developing new technologies or to subsidizing the realization of planned projects. On the basis of these incentives, it is expected that a growing demand for LNG-based business models will develop. A number of initiatives have been established over recent years to support the thematic development on a political level.

In 2015, a so-called "LNG task force" was established and organized by the "Initiative Erdgasmobilität" to support all gas related topics on a ministerial level (including the development of national funding programs) and to develop recommendations. The task force consists of private companies (e.g. Volkswagen, BP, Shell etc.) as well as public organizations (e.g. maritime LNG platform, Deutsche Energieagentur (dena) et al.). A monthly exchange between the task force and the Federal Ministry of Transport and Digital Infrastructure was established (Deutsche Energieagentur, 2016).

There are different initiatives with members as ports, shippers, and companies which are engaged in the maritime sector to promote the use of LNG in the coastal parts of Germany (e.g. Maritime LNG platform, LNG Initiative Nord-West).

Ownership

There are actually no publicly owned facilities in Germany. The cooperation on national level consists of consulting services between companies, organizations, and federal ministries.

Germany is promoting the use of LNG as marine fuel with a new stimulus program announced by the country's Federal Ministry for Transport and Digital Infrastructure. The aim of the program is to promote the use of LNG within German maritime shipping (LNG World News, 2017).

The conversion of containership Wes Amelie was supported by the German Federal Ministry of Transport and Digital Infrastructure and will likely be extended to other ships in the fleet.

2.6.4 NORWAY

In developing the market for LNG, the commodity owner, i.e. the person who buys the transport order, has a great significance. Commodity owners were essential for the early development of LNG in Norway, by preferring tenders for LNG-powered ferry operations. Some commodity owners emphasized the environmental aspect and chose LNG-powered transportation. For a brief period, Statoil had a requirement for the LNG operation of their supply ships, but this has now been dropped in their procurement processes and expects the market to solve the issue of fuel choice. Further examples of commodity owners supporting LNG-powered transport are the fish feed producers Marine Harvest and Skretting who helped pave the way for the use of LNG vessels transporting fish feed.

Incentives, subsidies, and especially the NO_x Fund, have been very important sources of funding for the introduction of LNG-fueled ships in Norway. There is still a challenging profitability in the LNG value chain, but it presents good opportunities for improved profitability by increasing the number of users and volume traded. The NO_x-fund is based on efforts both from the private and the public sector. Shipping (and other industries) are exempted from state NO_x-tax and instead pay a lower fee into the NO_x-fund (owned by the business sector itself). In return, the fund is strictly committed to the authorities to achieve significant emission reductions. All funds are thus redistributed back to the associated enterprises as investment support (max 80%) for NO_x reducing measures.

Small-scale LNG production facilities are privately owned in Norway. Statoil had the first small-scale LNG production facility through its manufacturing plant at Tjeldbergodden, but this facility was sold to AGA and Statoil has pulled out of small-scale LNG.

There is an ongoing project called “LNG infrastructure” in Norway, which was planned and initiated by Energigass Norge. The project brings aims to bring together suppliers, consumers, transporters, equipment manufacturers, and service providers to improve their collaboration.

Involved partners are:
• Barents Naturgass
• Skagerak Naturgass
• Gasnor
• Skangas
• Short Sea Promotion Center
Norsk Gassforum, Norsk Havneforening, and Energigass Norge are the working group.

2.6.5 LITHUANIA

Lithuania has established a Floating Storage and Regasification Unit (FSRU) LNG terminal in Klaipeda, which became operational on the December 3rd 2014. This Klaipeda LNG terminal is state-owned to about 56% with about 44 % being owned by private investors in JC Klaipedos Nafta. Similar portions exist for Klaipeda LNG import and small-scale LNG terminals. The group comprises the following companies: Lietuvos Energijos Gamyba, AB, an electricity and heat generation company, AB Energijos Skirstymo Operatorius (ESO), an electricity and gas distribution operator, UAB Energetikos Paslaugų ir Rangos Organizacija (EnePRO), UAB NT Valdos, UAB Energijos tiekimas, UAB LITGAS, UAB VAE SPB, UAB Duomenų logistikos centras, UAB Technologijų ir inovacijų centras, UAB Verslo aptarnavimo centras, VŠĮ Energetikų mokymo centras, UAB Energijos sprendimų centras, UAB Elektroninių mokėjimų agentūra, UAB Vilniaus kogeneracinė jėgainė, UAB Kauno kogeneracinė jėgainė, UAB EURAKRAS, Tuulueenergia OU, SIA Geton Energy, and OU Geton Energy. Cooperation in LNG distribution exists between Lithuania, Latvia, and Estonia as well as the Russian Federation.
The Klaipeda LNG import terminal has a capacity of about 4.5 bcm. The total demand of the natural gas in Lithuania is about 2.2 bcm, 0.9 bcm in Latvia, and 0.5 bcm in Estonia. Belarus also has an interest in receiving some natural gas via Klaipeda LNG import terminal. Lithuania and Estonia both had contracts with the Russian gas company Gazprom until 2015. Latvia has a contract with Gazprom which runs until 2020. Part of the natural gas destined for use in Lithuania will continue to be received from Gazprom, but the increased supply improves flexibility in supply and means that about 20 – 40% of the Klaipeda import LNG terminal could be used for delivering gas to Belarus.

LNG regas –energy business model. In order to improve its energy security strategy, Lithuania invested in the FSRU project to improve competition in the market. The break bulk business model is applicable for the FSRU, since it has a transshipment possibility. A joint venture between Klaipedos Nafta (KN) and Bomin Linde has been established to charter LNG bunkering vessels. From now on, the supply to smaller terminals in the Baltics can be organized via the Klaipeda FSRU.

Internationalization
KN has a consulting contract for the implementation of an FSRU in Colombia. One of the major competitive points for this potential terminal could be KN's experience in open access infrastructure. When capacity allocation is done on a transparent public basis, this allows competition in supply to keep LNG prices low.

A Lithuanian LNG cluster has been established to enable new LNG business models with the aim of addressing LNG distribution as well as the deployment of LNG for use in energy and transport systems. The FSRU infrastructure is owned by private a company of which the Lithuanian government has a 70 percent ownership. The infrastructure is mainly utilized 50/50 by a government energy company and the private sector. The terminal capacity is operated on open access basis so that any stakeholders are allowed to use it.

Value of business models

FSRU terminal 350 mln. Onshore station 25 mln

The Klaipeda LNG import terminal based on FSRU technology has shown that LNG terminals could be created in many ports or places close to the shore. An FSRU requires a relatively small investment and can influence a country's gas market significantly. As an example of the FSRU's success, Figure 14 shows the gas prices for the BSR countries before the LNG terminal creation, during construction, and during the LNG import terminal's operation.

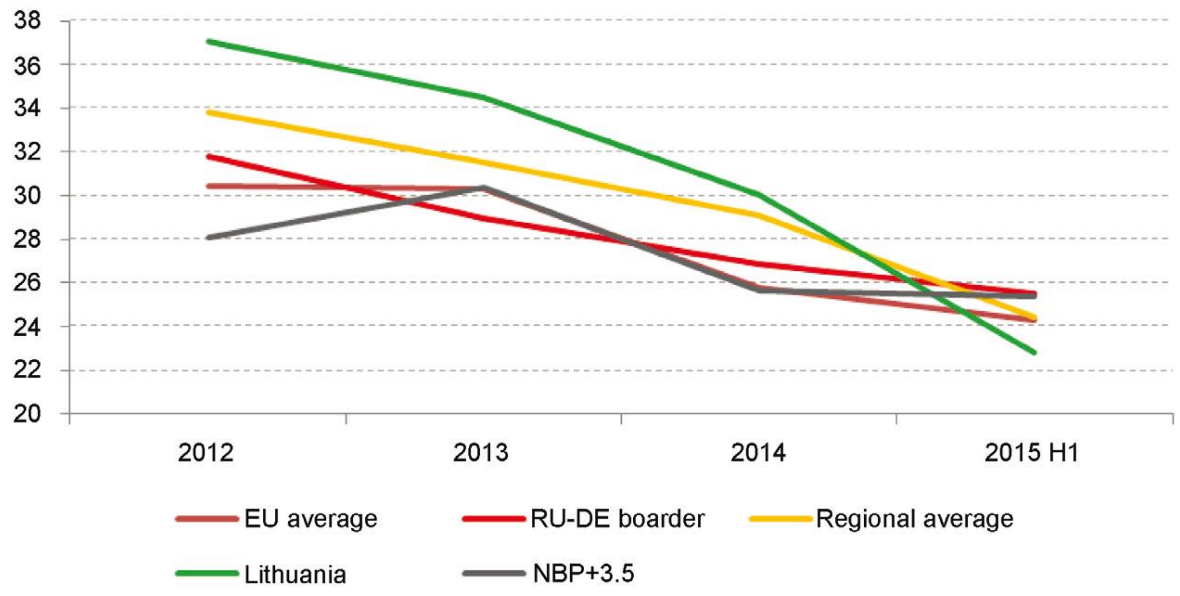

Figure 14. Natural gas import price changes as influence of the Klaipeda LNG terminal (comparison with neighboring countries). Source:[ ]

Figure 14 shows that the establishment of Klaipeda's LNG terminal was successful in reducing the price for natural gas in Lithuania by improving competition.

2.6.6 POLAND

In Poland, it is mainly the public sector and responsible authorities who are accountable for business models and strategies for investments in LNG infrastructure. There are no examples of private-public ownership and cooperation. However, there are a few examples of privately owned investments. The LNG Terminal in Swinoujscie is owned by the Polish state. The property and the infrastructure is owned by the port, the municipalities, and the forest district. The construction cost of the LNG terminal was about 700 – 800 million EUR. The investor of the project was "Polish LNG" - a company established to build and operate the LNG terminal. The company began operations in May 2007 and is owned by the Gas Transmission Operator GAZ-SYSTEM SA (100% owned by Polish Ministry of Treasury).

There exists two LNG liquefaction plants in Poland, and both are privately owned. There are 35 satellite storage sites for LNG, and all of these are privately owned. The costs of building CNG refueling stations for road transport (there are no published LNG stations, and most of the companies are strategizing for CNG stations) are in the range of 100,000 EUR to 250,000 EUR. These costs only reflect the equipment (or the construction) of the stations with the technical equipment necessary for the CNG sales. These amounts do not include the cost of the lease (redemption) for suitable land and the costs for building additional infrastructure, such as shops, cafes, or connecting CNG refilling stations to the electricity or water grids.

2.6.7 SWEDEN

Sweden is a sparsely populated country (9.9 million inhabitants) with about 85% of the population residing in the southern ⅓ of the country. This uneven population distribution also leads to less logistics infrastructure existing in the northern parts. In the Swedish national program for alternative fuels, prepared following EU Directive 2014/94/EU, it is stated that the transition to alternative fuels is a means of reaching several different future goalsregarding climate, energy, transport, regional development, as well as business and consumer economics. This program describes the development of the market for alternative fuels and associated infrastructure. It further defines these alternative fuels or sources of energy that, at least partly, function as a replacement for fossil fuels for energy and transport which can contribute to the phasing out of fossil fuels.

As with Denmark, the existing LNG infrastructure has only been created as a result of the IMO SECA regulation and has been driven by the market. All available business models – existing or planned - are dependent either on EU-funding (TEN-T) or national funding.

The introduction of natural gas in Sweden dates back to 1985 with an expansion of the Danish natural gas network to south Sweden transported by an oil pipeline from Dragør, near Copenhagen, to Klagshamn, on the outskirts of Malmö. In fact, natural gas imports from Denmark guarantee coverage of national needs. In south-west Sweden the interconnected Swedish natural gas network is set up which starts in Trelleborg in the south continuing along the west coast and ends in Stenungsund, north of Gothenburg. With about 290 Swedish municipalities, around 30 can access that gas network. In Sweden, There is no commercial production of natural gas, but about 2.4% (2014) of the gas in the gas network is from the domestic production of biogas.

The western Swedish natural gas system is small in comparison to the gas networks of other European countries. The western Swedish natural gas network is made up of about 600 km of transmission pipeline and about 3,000 km of distribution pipeline with a catchment area of about 35,000 customers represented by the main industries and cogeneration plants comprising around 30,200 households. It is understood that natural gas represents a relatively small share of total energy use in Sweden.

The Swedish market oversees the presence of a few actors, very often involved in both distribution and gas procurement operations, through separate companies. In fact, for preventing cross-subsidization situations between companies operating different types of natural gas activities, functional distinctions are required: from this it follows that companies operating in the transmission, gasification, or storage of natural gas cannot trade it.

In the Swedish market, six owners of gas distribution networks can be identified for the period 2015-2018: E.ON Gas Sverige AB, Gothenburg Energi Gasnät AB, Kraftringen Nät AB, Gasnätet Stockholm AB, Varberg Energi AB, and Öresundskraft AB.
The natural gas supply market is open and subject to competition. In fact, the natural gas market was deregulated in July 2007.

Gas suppliers and wholesalers in the Swedish market import gas from a gas producer or other gas operators, generally following bilateral agreements, and sell it to Swedish users. Regarding gas price, no regulation is envisaged and therefore gas prices are established on the basis of agreements between the supplier and the user.
The Danish natural gas exchange takes place on the Danish gas exchange named Gaspoint Nordic. Through the Pan-European Gas platform (PEGAS), contracts with various timelines are offered to producers, retail operators, energy companies, sales representatives, and large consumers.
PEGAS provides a market to producers, retailers, energy companies, and representatives and Gaspoint Nordic organizes the physical trade of natural gas. The exchange is a market for producers, suppliers of natural gas, energy companies, and larger consumers. Starting from July 2016, the owner of Gaspoint Nordic is Powernext SA.

Consequently, the structure of the Swedish network involves a natural gas market closely linked to the Danish market. From this, it follows that competition, prices, and transparency are largely dependent on the Danish market. Regarding the transmission of gas, Swedgas (owned by Enágas and Spanish Fluxys) owns the Western Swedish natural gas network, being responsible for its operation and maintenance.

In 2012, the company Swedegas AB was certified as transmission system operator and since 2013, under the designation of the government, has been handed the role of administrator of the balancing system for the gas network. This means that Swedgas is not limited to managing only the operation and maintenance of transmission pipelines but is responsible for maintaining the short-term balance between the input and output of natural gas.

Regarding operational LNG plants, there are currently two in Sweden (not connected to the gas network). The first LNG terminal, belonging to the AGA AB company, which is part of the

German group Linde, has been active since 2011 and is located in Nynäshamn, 58 km south of Stockholm. This terminal receives natural gas from production plants and terminals in northern Europe. It acts as a transit deposit for LNG, which is distributed to customers by truck or pipe to Nynas AB's refinery adjacent to the terminal.

The second terminal, located in Lysekil, on the west coast of Sweden, has been active since 2014 and is located near one of the oil refineries of the Preem oil company, the main recipient of LNG deliveries, but a distribution share is carried out by truck to other Swedish users. Skangas Terminal AB, a company of the Finnish Gasum Corporation owns the Lysekil terminal.

The port of Gothenburg is planning an LNG terminal. It is the largest port in Scandinavia and represents a strategic hub for Sweden and the Scandinavian countries. The LNG terminal is to be funded by Swedgas. It is expected that the LNG may be distributed inland using LNG trucks or railway carriages. Ships will have the possibility of using LNG as a bunker fuel. In addition to this, the LNG terminal could supply gas into the existing natural gas pipe network.

3 METHODOLOGY

3.1 CLUSTER ANALYSIS OF LNG VALUE CHAIN IN THE BSR METHODOLOGY

The Cluster Analysis of the Blue Corridor Strategy adopts a structure called a Methodological Pyramid as outlined in Figure 15. The following levels form part of the pyramid: The framework is the basis from which Methods are applied, which is called Methodology in order to help build a model from which testing can be conducted. Following the Model stage, the next step is Analysis, from which evaluations are conducted. Results and understanding of the model are obtained from the Analysis phase that is employed in the design of a suitable Strategy. The framework considered is known as the Michael Porters Cluster Theory (Porter, 1998).

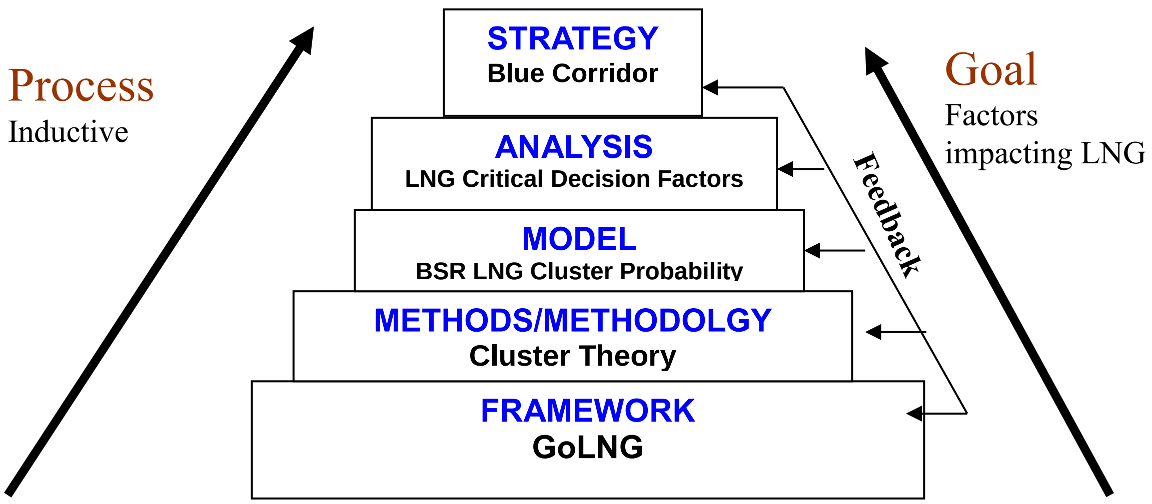

Figure 15. Methodological Pyramid

Much has been written on the subject of local and regional economic development policy, but it is Michael Porter's cluster theory, above all others, which has been the dominating theory (Porter 2003). Various international, regional, national, and local governments have used the cluster concept theory that is outlined by Porter, i.e. the OECD –Organisation of Economic Co-operation and Development, and the EU. In addition, dozens of countries have published reports or studies pertaining to national economic growth strategies. In the scope of LNG in the BSR, the aim is to apply a robust methodology to understanding the factors leading to the successful implementation of LNG development for this region.

In the framework of GoLNG, there are many organizations and institutions that stand to benefit from LNG development in the BSR; the argument is supported by the fact that there are geographic concentrations of interconnected companies and institutions in this particular field(Porter, 1998). Furthermore, the concept of clusters and how they are related to the examples from the GoLNG project are presented in Table 10 below:

Table 10. Cluster criteria and examples

Cluster Criteria	GoLNG Examples
Regional economic activity located at all levels: community, geographic area, global	BSR : DE, DK, LT, PL, and SE
it is limited to a specific industry	LNG and Maritime Industries
includes both vertical links as supplier-manufacture-dealer-customer chain or horizontal production links as in sectors of the same industry	Ship Yards, Shipping lines, LNG Terminals, Ports, Suppliers, or LNG Technologies, etc.
companies have identical or interrelated business areas	Examples are Emerson, ABB, and PolGAS
firms are in competition but contribute to the cluster development through specialization	LNG Bunkering Terminals, i.e., SAMSØ case in Denmark in which dedicated ship is built
firm's proximity generates social and trust relations	Copenhagen, Gothenburg, and Klaipeda areas are populated by companies that employ LNG Technologies or use them.
a common infrastructure used in innovation by rapid transfer of knowledge and because of the support offered by universities and research centers	GoLNG competence center, Universities and, Institutions in the BSR.

The objective in executing such an analysis is that it will demonstrate key areas or factors that can either enable or impair the regional development of LNG in the BSR. By coordinating with over 400+ members that are a part of the GoLNG network, the opportunity to produce results that are credible is high. In the following Figure 16, an example provided by (Porter, 1998) illustrates the composition of regional economies such as the BSR and classifies them as either local clusters or traded clusters.

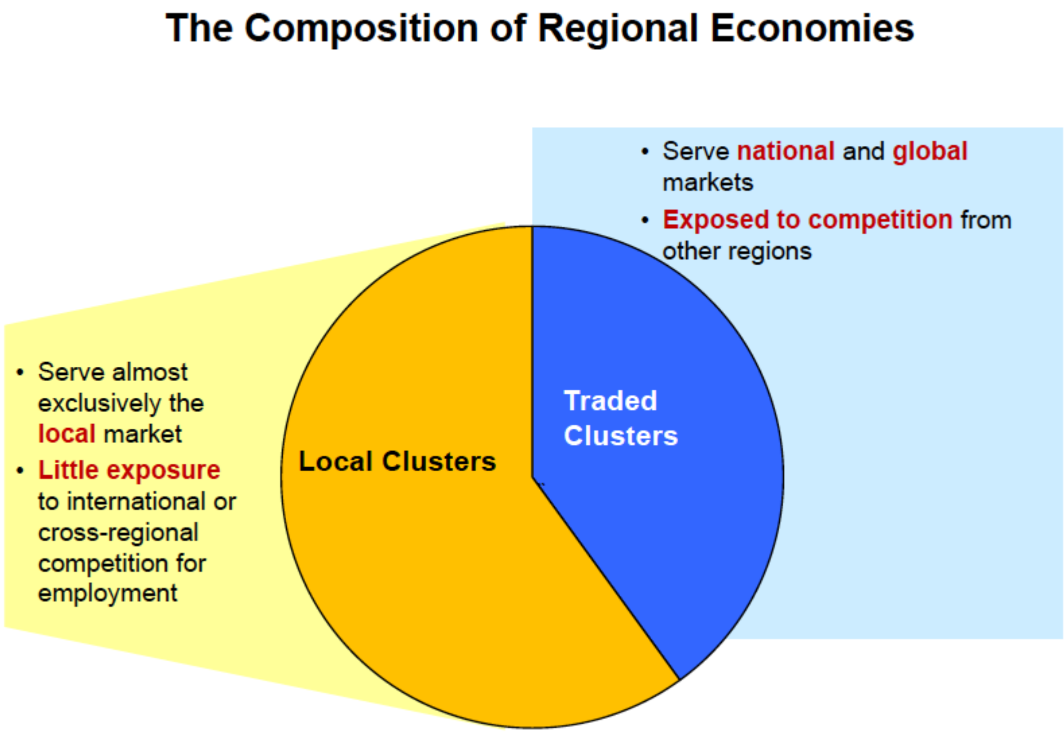

Figure 16. The composition of the regional economies.

Furthermore, the factors linked to the development of LNG are to form a model, which is known as Porter's Diamond. This model is characterized by interdependence relations between all factors:

- initial resources and existing economic environment
- firm strategies and the competitive environment
- market conditions
- related and supporting industries

Another important factor for cluster development is the innovation and the continuous exchange of information, such as

- direct technology transfers
- indirect transfers through workforce migration
- indirect transfers through spin-off by supporting new businesses

In summary, the introduction of cluster analysis has been recognized due to the benefits it offers and has been viewed as influential by many governments seeking to implement policies (Sölvell et al, 2003), which are intended to launch initiatives to support existing clusters or to form new ones with regard to:

- Small and Medium Enterprises (SMEs)
- regional industrial development
- attracting external funds and foreign investors
- research and innovation at national or local level

In this study, it is deemed that economic development based on cluster models can offer multiple benefits in terms of regional development and competitiveness in an industry. In addition, cluster modeling can generate a means to develop LNG into an economic environment, such as that found in the BSR.

3.2 SWOT ANALYSIS FOR THE DEVELOPMENT OF LNG IN THE BSR METHODOLOGY

The SWOT analysis is a useful tool for forecasting the effectiveness of the decisions to be taken in strategic planning.

The *strengths* are positive internal factors that can help achieve the goal. The *weaknesses*, on the other hand, represent internal but negative factors, since these are attributions that can compromise the achievement of the objective. As far as external factors are concerned, the positive ones are represented by the *opportunitie*s, that is the conditions of the market or of the socio-economic context that can favor an adequate development and achievement of the objective. *Threats*, represent negative external factors and include unfavorable external risks and conditions, i.e., all possible obstacles that could prevent the achievement of the objective.

In the specific case of the Blue Corridor Strategy, the SWOT analysis has been used to understand the current context and the positive / negative trends for the development of LNG in the BSR.

Figure 17 shows how the SWOT analysis relates weaknesses, strengths, threats, and opportunities which would, with adequate support, allow for the development of the sector and identifies the weaknesses on which improvements must be made.

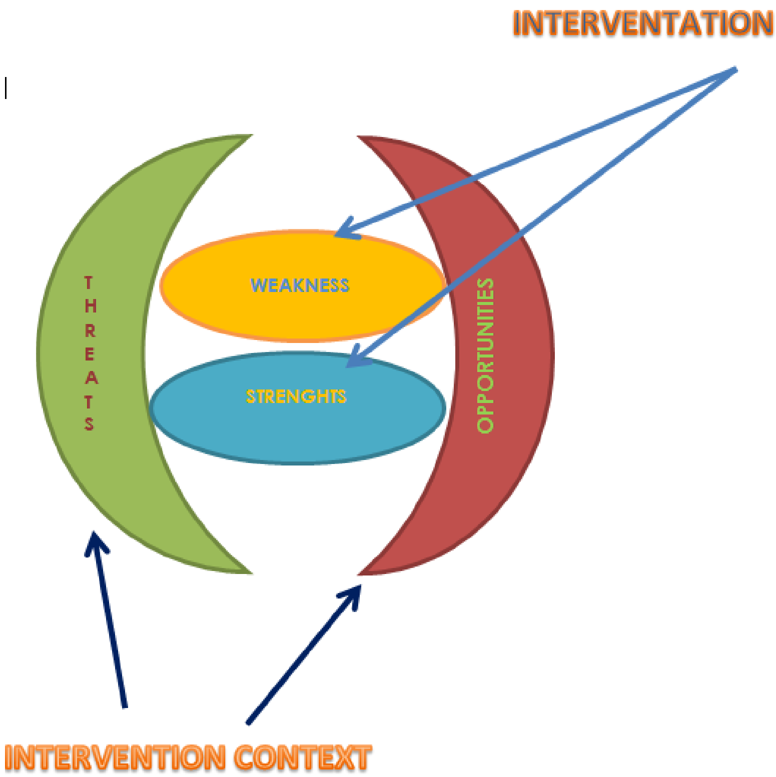

Figure 17. SWOT analysis

Overview of Klaipeda Port - Klaipėda small-scale LNG terminal

Klaipeda's state seaport is the largest Lithuanian transport hub, connecting sea, land, and rail from east to west. It is located on the eastern coast of the Baltic Sea, representing the northernmost ice-free port. The port of Klaipeda sees the presence of 14 large stevedoring companies, ship repairs, and shipyards operating within the port, as well as all types of cargo handling and freight services.

The goods handled annually are about 65 million tons. The port can accommodate ships of up to 366 m in length, up to 52 m in width, having a maximum draft of 13.8 m. The markets of natural outlet are represented by the most important industrial regions of the eastern hinterland (Russia, Belarus, Ukraine, Slovakia, and Czechia) connected to it by short sections. The port of Klaipeda is located at the LNG terminal, the so-called "Klaipėda LNG FSRU" (Lithuanian: Klaipėdos suskystintų gamtinių dujų terminalas), whose working state dates back to December 3rd 2014. Thanks to the investments implemented, Lithuania will be the fifth country in the world to use the FSRU technology for liquefied natural gas.

The FSRU receives LNG from gas carriers and acts as storage and regasification for LNG. KN (AB Klaipėdos Nafta), an operator of oil and LNG terminals of Klaipeda, is responsible for the development of the port's LNG charging station. KN has an agreement with Shell Western LNG B.V. (Shell) and established the delivery of a load of 1,000 tons of LNG to commission the plant in September 2017 using the Bunker vessel Cardissa. This represented the first LNG refill operation from a small-scale LNG vessel in the new onshore refueling station.

The purpose of the LNG charging station was to create a small-scale LNG infrastructure and to develop the LNG market in the Baltic Sea region by making Klaipeda an LNG distribution hub for the Baltic area. The station is active on the Klaipedos Nafta site located along the second quay. Figure 18 shows the Klaipeda FSRU Independence.

Figure 18. FSRU Independence at Klaipeda, Lithuania. Source: [https://www.kn.lt/ accessed 28-01-2019].

The LNG infrastructure in the BSR should be designed strategically, in order to guarantee ships adequate facilities for the safe and efficient operation of LNG.

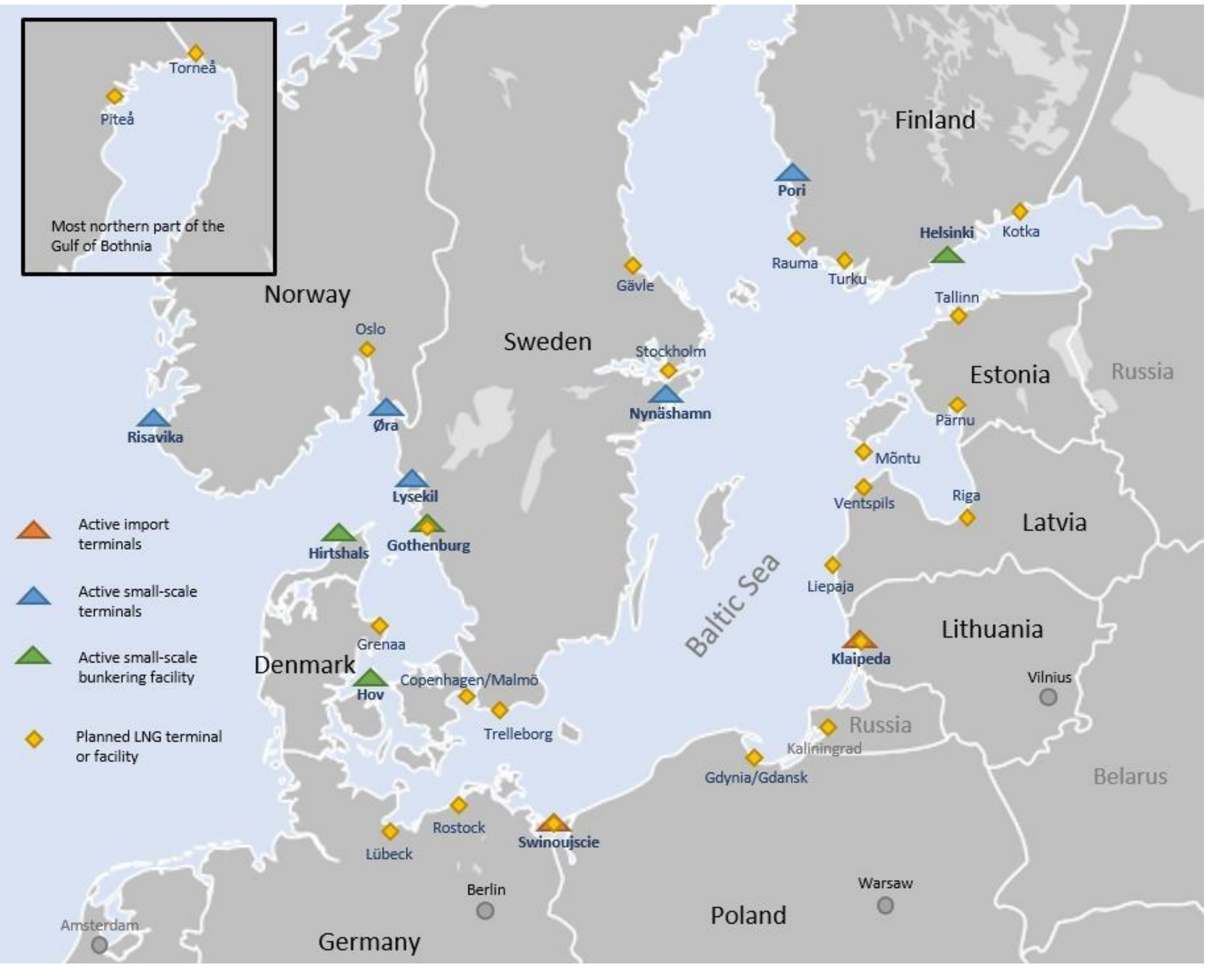

Figure 19. Active and planned LNG terminals and facilities. Source: GoLNG fuel distribution strategy. [http://www.golng.eu/] accessed 28-01-2019.

Aim and objectives of the business case scenario

The aim of the business case was to quantify, from an LNG user point of view, how closely the LNG infrastructure needs to be spaced in order to facilitate marked uptake of LNG.

The specific objectives were to answer how densely do LNG refueling facilities have to be spaced for LNG to become more attractive than MGO from an economic point of view and how attractive the investment would be by calculating a payback period for an LNG powertrain on a vessel in the BSR. The objectives may be summarized as follows:

- **First objective:** How densely do LNG refueling facilities have to be spaced for LNG to become economically more attractive than MGO 0.1?
- **Second objective:** the payback period when using LNG rather than MGO 0.1.

It was assumed that MGO with a sulphur content of 0.1% (MGO 0.1) would be an alternative conventional fuel used for comparison, given the sulphur cap in the BSR. An additional alternative available to shipping companies is the use of exhaust gas cleaning systems, commonly referred to as ‘scrubbers’, to remove sulphur oxides from the exhaust gases after

HFO, having a higher sulphur content than the SECA limit requirements, was used in the engines. This method can often be the most cost-effective measure to be taken, but with the exception of dry scrubbers, all wet scrubbers, even those currently referred to as ‘closed systems’ are not really closed systems and partly emit polluted water, which contains not only sulphur but also hydrocarbons, directly into the sea.

Assumptions

First, a ship type was selected. Its cruising speed and respective fuel consumption data were taken from the TEFLES (2012) database. The Lower Heating Value (LHV) of MGO was assumed to be 42.7 MJ/kg and that of LNG consisting of pure methane was assumed to be 50.1 MJ/kg. Bunker fuel prices were derived from DNV-GL for low sulphur MGO (17.29 $/MMBTU) and for LNG (10.79 $/MMBTU).

Further assumptions included:

- Distance traveled over time
- Ship energy consumption same for LNG and MGO
- Distance through BSR for the route analysed: kilometers traveled converted into nautical miles, estimated

It was assumed that the vessels had a tank capacity equivalent to being able to travel the following distances on LNG:

- Distance of 500 Nautical miles
- Distance of 1,000 Nautical miles
- Distance of 1,500 Nautical miles

The cost for the LNG tank was estimated at 2,500 $/m^3 capacity.

The cost for an LNG engine installation was assumed to be 130% of that for a conventional MGO engine. The cost of a conventional MGO engine was assumed to be 1,000$/kW of power. LNG typically requires 4 times more space for shipboard bunkering than MDO or HFO does, resulting in some lost cargo capacity for LNG driven ships. For simplicity, this cargo loss was ignored in the calculation, as were any economic losses resulting from lost time when refueling LNG.

Using the above assumption allowed calculating:

- The potential savings when using LNG rather than MGO 0.1
- The corresponding extra distance worth traveling on MGO 0.1 to reach an LNG fuel station

Method

First Objective: How densely do LNG refueling facilities have to be spaced for LNG to become economically more attractive than MGO 0.1?

The key descriptors considered in this analysis comprise the *ship power*, *ship speed*, *power specific fuel consumption*, the *Lower Calorific Value* of the fuels, and the *fuel cost for energy* for each fuel. These assumptions yield the *cost per nautical mile traveled* and the potential savings when using LNG rather than MGO 0.1. This information also yields the extra distance worth traveling on MGO 0.1 in order to reach an LNG facility and complete the remainder of the journey on LNG. This assumes that the LNG powertrain has already been paid for and that the vessel is a dual-fuel vessel with MGO 0.1 available at its starting position. The specific question addressed is: “what is the additional distance worth traveling on MGO 0.1 to reach an LNG bunker facility so that the remainder of the journey can be sailed on lower-cost LNG?”. Answering this question provides an approximate measure of how closely spaced LNG bunkering facilities should be. The extra distance can be expressed as a percentage of the distance to be traveled as:

$$\frac{D_{extra}}{D_{total}} = \frac{(P_{MGO} - P_{LNG})}{P_{MGO}} = \frac{(17.29[\$/MMBTU] - 10.79[\$/MMBTU])}{17.29[\$/MMBTU]} = 38\ \%$$

Where D_{extra} is the extra distance worth traveling to refuel on LNG, D_{total} is the total distance traveled, P_{MDO} is the price of MGO 0.1, and P_{LNG} is the price of LNG.

Second Objective: We calculate the payback distance traveled for a vessel and the payback period when using LNG rather than MGO 0.1, with savings discounted over time. Departing from the savings LNG vs MGO 0.1 [$/nautical mile] we consider the cost for an LNG drivetrain, the distance traveled for payback of the LNG investments to be achieved and the payback period. The cost for the LNG drivetrain includes the tank capacity for LNG, and the LNG-powered engine.
Regarding the discount rate, after a careful investigation it was decided to refer to the hyperbolic discounting model of M.L. Weitzman, which provides for an evolution of the discount factor, based on a hyperbolic function with respect to time and not exponential. According to Weitzman, the average discount rate should be 4% for the period from 1-5 years, equal to 3% for the period between 6 and 25 years, equal to 2% for the period between 26 and 75 years, equal to 1% for the period between 76 and 300 years and equal to 0 for more than 300 years.
The flow of costs and benefits is calculated at constant values, consequently with a real discount rate that was appropriately adjusted for the expected inflation rate in the medium-long term, equal to 1.9% . Applying the Fisher Equation we get the real discount rate equal to 0.45%:

$$r = \frac{(1+n)}{(1+i)} - 1$$

Where n is the nominal interest rate, i is the rate of inflation, and r is the real interest rate.

4 Analyses and Results

4.1 Cluster analysis of LNG value chain in the BSR

Various projects and reports have been conducted by the European Union in assessing the factors that support or impede LNG, and identifying LNG Clusters in the BSR. In the White Papers on the future development of the common transport policy, the European Commission outlined future priorities based on the need to reconcile the demand for mobility with the requirements of the environment, in line with the principle of “sustainable mobility”. The results of the White Papers indicate a solid strategic plan that considers not only ships in the operations of LNG bunkering but includes other modes, such as rail and trucking as partners in improving quality of service as a leading factor for LNG success. These implementation studies also indicate that government support initiatives for LNG terminals would attract ships leading to cargo revenue. Many shippers, ports, stakeholders, and intermodal-forwarding specialists do not yet fully understand the potentials and capabilities of LNG as an alternative fuel for the use in land-based transportation modes, such as rail and road haulage.

The results of this study's findings, international and domestic research, interviews of industry stakeholders, and consultants' expertise have led to the development of a list of critical decision factors that may support or impede the initiation of an LNG Strategy in the BSR based on the scope of the GoLNG project. The list was developed considering the industry as a whole, with relevance to specific attributes considered. The list is as follows with a brief explanation as to the significance of each factor:

Critical Decision Factors

- Congestion – major concern in certain area of the Baltic regarding the number and size of ships
- Cost – cost involved to initiate any new project must be considered
- Demand – a "must have" for any project
- Economic Development – local & regional – port authorities have a responsibility to provide economic development within their local and regional area
- Environmental Impact – must be considered by port authorities prior to initiating any new ventures
- Financing – necessary for any new venture
- Geographic Location – a major contributing factor to any LNG (e.g.,terminal or bunkering) venture
- Government Funding Programs – can be recommended by port authorities as a funding source for potential "partners", i.e., marine operators
- Infrastructure Capability – must have the appropriate infrastructure, services, and capabilities in order to provide seamless and successful LNG bunkering operations
- Integration of Transport Modes - a system must be in place that seamlessly processes, stores, and reports necessary information
- Intermodal Connectors – must have all of the "links" in place to receive and deliver cargo and passengers
- Labor – necessary to have adequate and available labor resources for a successful operation
- Public Support – port authorities have a responsibility to their community
- Service Cost – ability to provide competitive pricing
- (LNG) Transportation Culture – other transportation stakeholders have to support

the initiative

Critical Decision Factors with sub-categories:

- Congestion – level of area congestion, proximity to congested metropolitan areas, alternatives to congested ports
- Cost – infrastructure investment, marketing / lobbying
- Demand – shipper / consignee, marine operators, motor carriers;,port partners
- Economic Development – local & regional – impact on region, job creation
- Environmental Impact – mitigation of existing regional impact, local impact due to increased activity
- Financing – port ability to finance infrastructure needs
- Geographic Location – proximity to trade lanes, proximity to distribution networks, proximity to major markets, proximity to regional catchment areas
- Government Funding Programs – federal, state, EU
- Infrastructure Capability – existing LNG infrastructure, available capacity, depth of water, warehousing, cargo handling equipment, barge service, cargo ship service, container capability, Ro/Ro capability, Ro/Pax capability
- Integration of Transport Modes – IT systems integration
- Intermodal Connectors – highway, rail
- Labor – union, non-union
- Public Support – political, state, residents, businesses
- Service Cost – port cost structure
- Transportation Culture – industry level of acceptance

In developing and then evaluating the model, the probability factors are used to help understand the weights of decisions that have an impact on the success of the LNG cluster. Once each Critical Decision Factor was weighted, weightings were also determined for each sub-category within the decision factor. "TBDs" (To Be Decided) were used in cases where not enough information was available to make a determination. The factors were not eliminated from the Decision Tool so that the user does not lose sight of the importance of these items for future assessments.

An overall "Probability Factor" was then calculated for each sub-category for the entire analysis. The Probability Factor was calculated by multiplying the "Sub-Category Weight" for each sub-category within the Decision Factor by its Critical Decision Factor Weight.

To further develop the BSR LNG Cluster Probability Decision Tool and process, the study evaluated the 5 countries participating in the GoLNG project (DE, DK, LT, PL, & SE) based on their "Present Condition" and on their "Future Potential" for each sub-category. The evaluation was based on the findings from our research, interviews, analysis, and expertise. Present condition and future potential scores were assigned the following scores:

- 5 – Excellent
- 4 – Very Good
- 3 – Good
- 2 – Fair
- 1 – Poor

To conclude the BSR LNG Cluster Probability Decision Tool analysis, "Present Probability" and "Future Probability" factors were calculated by multiplying each decision item sub-category's probability factor by its present condition and future potential score. The Present Probability and Future Probability factors were then summarized to determine the overall Weighted Average Present Condition and Future Potential scores. The weighted average was then divided by 5 (total possible score) to calculate Current Condition and Future Potential Probabilities.

In review, the process of the BSR LNG Cluster Probability Decision Tool is as follows:

1. Identify LNG critical decision factors
2. Identify sub-categories for each critical decision factor
3. Weight the importance of each critical decision factor
4. Weight the importance of each sub-category within the critical decision factor
    - Steps three and four were performed as individual steps in order to better assess the weighting of each sub-category. It would have been too arbitrary to try to weight the importance of all forty sub-categories against one another.
5. Calculate probability factors for each sub-category
6. Score present condition and future potential
7. Calculate present probability and future probability for each sub-category
8. Calculate a weighted average score for the overall present probability and future probability
9. Calculate Probability of Success for current conditions and potential future

The BSR LNG Cluster Probability Decision Tool resulted in the following scores:

- GoLNG Present Condition 2.53 (Fair to Good)
- Future Potential 3.99 (Very Good)

These scores translate to a:

- Present Condition probability 50.6%
- Future Potential probability 79.9%.

In Table 11, a comparison between the current and future potential scores indicates that LNG Clusters in the BSR have the potential to improve their likelihood of initiating a successful

LNG shipping initiative if many actions are implemented within many of the sub-categories that have been identified as critical.

Table 11. Likelihood of LNG clusters starting a successful LNG shipping initiative.

Decision Factors	Importance	Sub-category Weight	Probability Factor	Present Condition	Present Probability	Future Potential	Future Probability
Congestion							
Level of area congestion	High	0,25	0,0225	5	0,1125	3	0,0675
Proximity to congested metropolitan areas	High	0,30	0,027	5	0,135	5	0,135
Alternative to congested ports	High	0,45	0,0405	2	0,081	5	0,2025
		1,00	**0,09**				
Cost							
Infrastructure investment	High	0,50	0,035	1	0,035	5	0,175
Marketing / Lobbying	High	0,50	0,035	2	0,07	4	0,14
		1,00	**0,07**				
Demand							
Shipper / Consignee	High	0,30	0,036	1	0,036	3	0,108
Marine Operators	High	0,30	0,036	1	0,036	4	0,144
Motor Carriers	High	0,30	0,036	1	0,036	3	0,108
Port Partners	Medium	0,10	0,012	1	0,012	3	0,036
		1,00	**0,12**				
Economic Development – Local & Regional							
Impact on region	High	0,50	0,035	1	0,035	5	0,175
Job creation	High	0,50	0,035	1	0,035	5	0,175
		1,00	**0,07**				
Environmental Impact							
Mitigation of existing regional impact	Low	0,10	0,009	5	0,045	5	0,045
Local impact due to increased activity	High	0,90	0,081	3	0,243	2	0,162
		1,00	**0,09**				
Financing							
Port ability to finance infrastructure needs	High	1,00	0,08	5	0,4	5	0,4
		1,00	**0,08**				
Geographic Location							
Proximity to trade lanes	High	0,30	0,036	5	0,18	5	0,18
Proximity to distribution networks	High	0,20	0,024	2	0,048	3	0,072
Proximity to major markets	High	0,30	0,036	4	0,144	4	0,144
Proximity to regional catchment areas	High	0,20	0,024	1	0,024	3	0,072
		1,00	**0,12**				
Government Funding Programs							
Federal	Low	0,20	0,016	1	0,016	2	0,032
State	Medium	0,80	0,064	1	0,064	4	0,256
		1,00	**0,08**				
Infrastructure Capability							
Existing infrastructure	High	0,15	0,0165	2	0,033	4	0,066
Available capacity	High	0,10	0,011	2	0,022	4	0,044
Depth of water	Medium	0,10	0,011	5	0,055	5	0,055
Warehousing	Low	0,05	0,0055	2	0,011	3	0,0165
Cargo handling equipment	High	0,15	0,0165	1	0,0165	4	0,066
Barge service	High	0,10	0,011	2	0,022	4	0,044
Cargo ship service	High	0,10	0,011	2	0,022	4	0,044
Container capability	High	0,10	0,011	1	0,011	4	0,044
Ro/Ro capability	High	0,10	0,011	2	0,022	4	0,044
Ro/Pax capability	Low	0,05	0,0055	2	0,011	4	0,022
		1,00	**0,11**				
Integration of Transport Modes							
IT systems integration	High	TBD		TBD		TBD	
Intermodal Connectors							
Highway	High	0,75	0,0825	3	0,2475	4	0,33
Rail	Medium	0,25	0,0275	1	0,0275	4	0,11
		1,00	**0,11**				
Labor							
Union	Low	0,50	0,02	5	0,1	5	0,1
Non-union	Low	0,50	0,02	5	0,1	5	0,1
		1,00	**0,04**				
Public Support							
Political, State	High	TBD		TBD		TBD	
Residents	High	TBD		TBD		TBD	
Businesses	High	TBD		TBD		TBD	
Service Cost							
Port cost structure	High	TBD		TBD		TBD	
Transportation Culture							
Industry level of acceptance	High	1,00	0,02	2	0,04	4	0,08
		1,00	**0,02**				
Weighted Average (on a Scale from 5 to 1)					**2,53**		**3,99**
Probability of Success			**1,00**		**50,6%**		**79,9%**

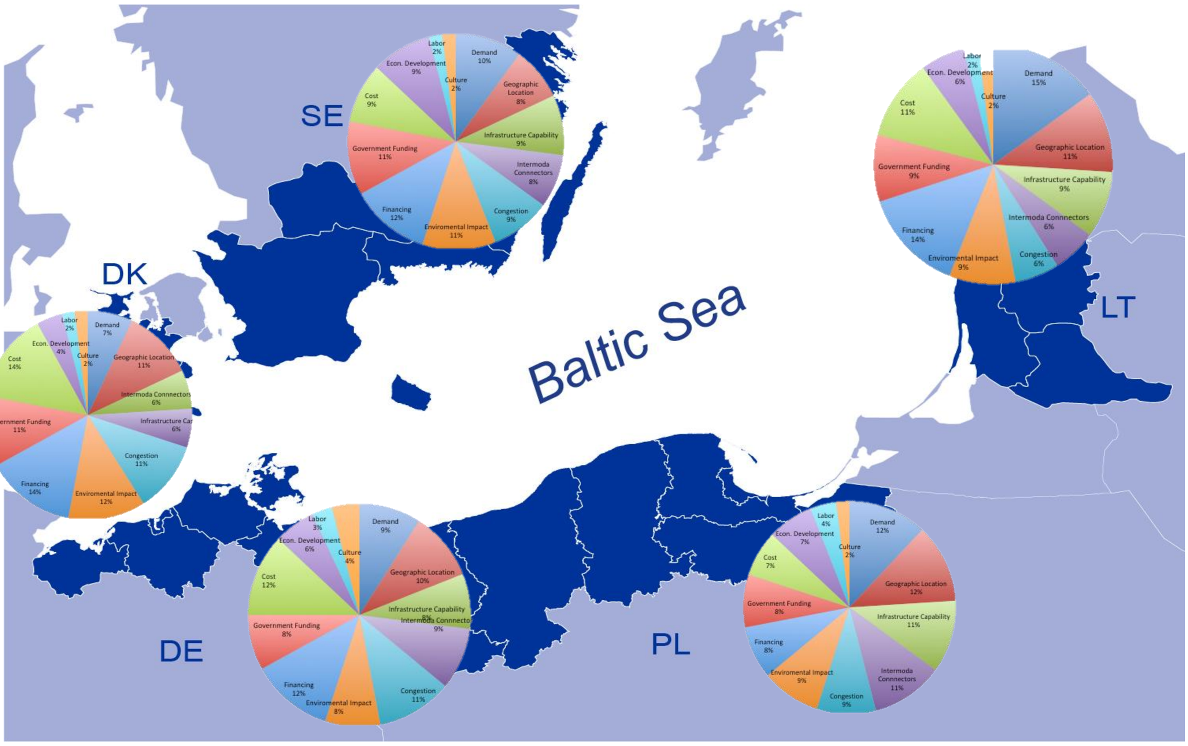

Figure 20. Importance of Critical Decision factors for countries in the BSR, reported by the Cluster analysis

The BSR LNG Cluster Probability Decision Tool was used to evaluate the identified national LNG clusters for each of the member states participating in the GoLNG project (DE, DK, LT, PL, & SE). The results from the BSR LNG Cluster Probability Decision Tool are reported as a percentage per Critical Decision Factor. The Critical Decision Factors were:

- Demand
- Geographic Location
- Infrastructure Capability
- Intermodal Connectors
- Congestion
- Environmental Impact
- Financing
- Government Funding
- Cost
- Econ. Development
- Labor
- Culture

In Figure 20 above, the results for each LNG Cluster is presented as a pie chart diagram. The Critical Decision Factors vary between the LNG clusters located on the BSR and help to shed light on what factors have the strongest influence in decision making in order to yield a robust Blue Corridor Strategy.

It was found that financing, cost, government funding, and environmental impact were the most important decision factors for successful initiation of the LNG clusters. The BSR LNG Cluster Probability Decision Tool scores of 2.53 (Fair to Good) for its present condition, and 3.99 (Very Good) for its future potential, showing that the conditions for successful cluster formation are promising. A successful formation of the LNG clusters should prioritize the critical decision factors listed above.

4.2 SWOT ANALYSIS FOR THE DEVELOPMENT OF LNG IN THE BSR

The SWOT analysis highlights strengths, weaknesses, opportunities, and threats to the development of LNG in the BSR.

Table 12. SWOT analysis table

STRENGTHS	WEAKNESSES
✓ Comply with EU regulations ✓ Gas characteristics: large quantities available, competitive costs, etc. ✓ Less polluting than petroleum, eco-friendly ✓ Greater energy independence for BSR countries ✓ Important Role in BSR Energy Mix ✓ Strong gas demand and supply growth in the BSR countries ✓ Best practices on LNG in the BSR (Norway, Sweden, etc.) ✓ Increase in the liquefaction and regasification capacity of the LNG markets in the Baltic Sea countries ✓ Good scientific knowledge in the BSR countries ✓ Accomplished safety record along supply chain ✓ Viable in different areas not reached by pipeline (Norwegian fjords, for example) ✓ Regas/storage sites planned to increase the supply to BSR market ✓ Forescast subidies and/or tax cut in the BSR	✓ Differences (geographical, socio economic, etc) between BSR countries ✓ High capital costs ✓ Needed implementation of joint actions ✓ Public consciousness in regards to safety and environmental risks ✓ Oversupply risk due to total size of global LNG small market
OPPORTUNITIES	**THREATS**
✓ Stricter regulations come in place ✓ More jobs for the people living in the area ✓ Improving LNG education in BSR countries to increase awareness and future innovations within the area: skilled personnel will be able to sustain rapid growth ✓ Economic development in the area ✓ Sharing risk and reducing the risk level ✓ Good conditions for new competitive LNG cluster development	✓ Uncertainty over gas price, market situation ✓ Security aspects: terrorism, cyber security attacks, etc. ✓ Accidents: increase in public perception of LNG safety ✓ The development of alternative technologies

✓ Attraction element of human, industrial, and financial resources to be allocated to technical innovations ✓ Supply in new markets ✓ Implementation of economies of scale ✓ Improving operating, procurement, and contracting procedures ✓ Increasing price competitiveness	

The main *strength* of LNG development in the BSR is that there exists an inherently large supply and a potentially high demand for LNG. This means that the market has a large potential to grow, which could be exploited for the further economic development of the whole region. The SWOT analysis shows that there exists substantial potential for attracting capital, a specialized workforce, and technology providers for LNG use.

The *weaknesses* section of the SWOT analysis highlights that the regional development of LNG requires the productive use of the available resources. Obstacles impeding the development of LNG in the BSR should be overcome, if possible. These are the geographical differences between the BSR countries, the high capital investment cost, and the need to coordinate infrastructure deployment efforts, safety standards, and public information on safety and environmental risks. These weaknesses will negatively affect the success of LNG in the BSR unless they are appropriately addressed. A conclusion from this SWOT analysis is that a common policy for the development of LNG would be beneficial. Obstacles such as the high initial capital costs for infrastructure may be addressed by offering a long-term perspective for LNG through key public investments or through an incentive system promoting LNG in the market.

The *opportunities* and *threats* emerging from the SWOT analysis have been identified by considering external factors and potential risk scenarios that may be envisaged for the region. These scenarios comprise in particular the development of general and sector policies (the economic policy scenario), the emergence of new technologies (the technological scenario), new international trends in regards to demand in the market as well as scenarios concerning supply and competitiveness (the scenario of external economic dynamics).

The SWOT analysis evidences many ways in which the success of LNG infrastructure development can be affected positively and negatively. Making good use of the strengths and opportunities and addressing weaknesses with suitable countermeasures and threats with mitigation measures will improve the chances of success of LNG in the BSR.

Results

Calculating the extra distance worth traveling for a ship in order to access an LNG bunker facility, allows us to estimate how closely the LNG bunkering infrastructures must be spaced from each other to make operation of LNG-powered ships worthwhile.

This measure for bunkering facility spacing uses a simplified business case scenario for a naval operator: a bulk carrier, whose average consumption is around 14,400 kW at a design speed of 14 knots (TEFLES 2012), has a main engine efficiency of 50.8% requires about 57 tons of MGO 0.1. It travels over a distance of 1,000 nautical miles before refueling. Assuming a price of 17.29 $ / MMBTU (DNV-GL, 2018) for LSMGO, this trip will result in a total fuel cost of 119.61 $/nautical mile. The same journey with LNG, and a 51.1% main engine efficiency requires about 49 tons of LNG. Assuming a price of 10.79 $ / MMBTU (DNV-GL, 2018) for LNG, this trip has a fuel cost of 74.11 $/nautical mile. Switching to LNG thus saves 45.37$ per nautical mile covered, which represents about 38% of the total cost of fuel. For the ship, it is therefore worthwhile to travel an additional distance of up to 380 nautical miles, if this allows reaching an LNG refueling facility, to operate on LNG for the remainder of the journey. The time needed to recover the investments in an LNG powertrain (it is assumed that the capex occurs in the first year and cumulative cash flow is discounted) is equal to about 2.35 years. An overview of three such examples for different types of ships is provided in Table 13.

Table 13. Overview of additional distance worth traveling for various ship types to bunker LNG and payback time (route distance 1,000 M)

Ship type	Cruise speed [knots]	Cruise power [kW]	Route Distance [M]	Additional Distance [M]	Price MDO [$/MMBTU]	Price LNG [$/MMBTU]	Payback time discounted [years]
Bulk carrier	14	14400	1000	380	17.29	10.79	2.35
Car carrier	16.5	7618	1000	380	17.29	10.79	2.03
Container ship	16	9992	1000	380	17.29	10.79	2.08

Table 14. Overview of additional distance worth traveling for bulk carrier to bunker LNG and payback time for different route distances

[M]	Cruise speed [knots]	Cruise power [kW]	Route Distance [M]	Additional Distance [M]	Price MDO [$/MMBTU]	Price LNG [$/MMBTU]	Payback time discounted [years]
Bulk carrier	**14**	**14400**			**17.29**	**10.79**	
FIRST DISTANCE			500	190			1.71
SECOND DISTANCE			1000	380			2.35
THIRD DISTANCE			1500	570			3.41

Table 14 shows the additional distances for a bulk carrier that travels 500, 1,000 and, 1,500 nautical miles on its journey and provides a general indication of the maximum distance between LNG bunker facilities required to make the investment in LNG-powered ships profitable for ship operators. The difference in prices between SFMGO and LNG notably influences the additional distance a ship can travel to reach an LNG terminal.

In order to evaluate how the change in bunker prices influences the critical additional distance a ship can travel, a sensitivity analysis on SFMGO and LNG prices was conducted using Monte Carlo Simulation software (MCS). The prices of SFMGO and LNG were varied individually on 10,000 tests. A normal distribution was assumed with a standard deviation of 25% of the price values indicated above.

The results showed that even with these variations in fuel prices, the additional distance that was worth traveling for the bulk carrier ship was greater than 340 nautical miles in about 68% of cases. This means that in 68% of the cases, LNG would have a competitive advantage over MGO 0.1 if there existed a bunkering facility every 340 nautical miles (Figure 21).

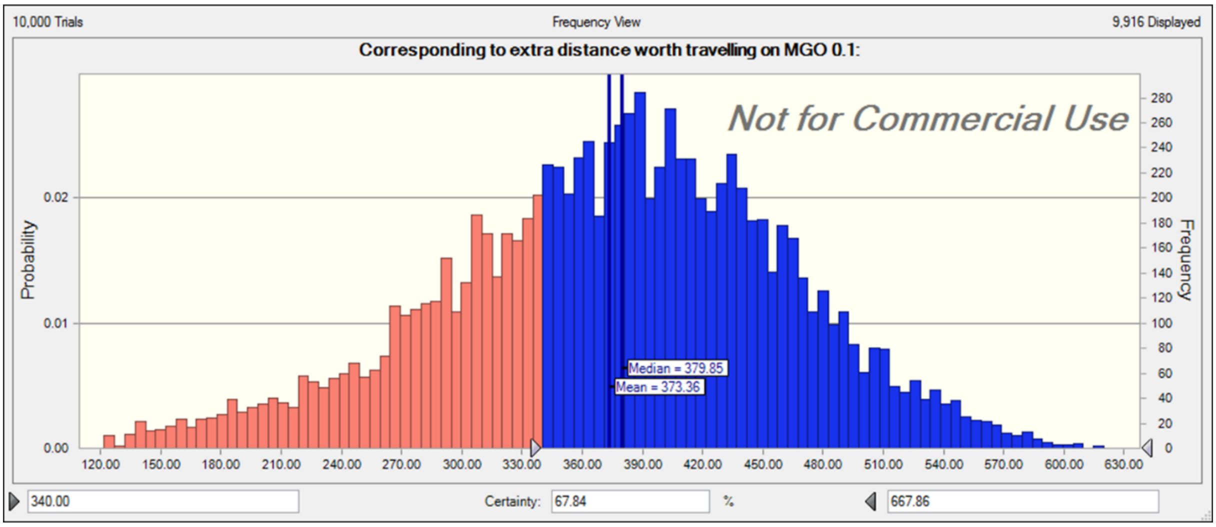

Figure 21. Distribution of "additional distance worth traveling for LNG" for a bulk carrier on a 1,000 M route. [Figure generated by the authors]

The distance between the only two large LNG terminals in the BSR is that between Świnoujście and Klaipeda which is currently 262 nautical miles. Small-scale LNG terminals are currently present in the ports of Helsinki, Pori, Nynäshamn, Gothenburg, Hirtshals, Hov, Lysekil, and Fredrikstad. As demonstrated by the above examples, smaller vessels will require more closely spaced fueling facilities than larger vessels traveling longer distances on their routes. Smaller vessels generally cover smaller distances and are less likely to pass one of the main LNG bunkers on their way. Larger vessels that sail longer distances are more likely to pass close to an LNG bunker facility on their way, and given their higher consumption of fuel, the savings when operating on LNG rather than MGO 0.1 are higher. Ships sailing beyond the BSR will pass the entry routes of the Skagerrak, Kattegatt, Big Belt, and Øresund and will pass strategically positioned LNG bunkering locations to refuel. These areas already have a series of LNG bunkering facilities and in order to ensure adequate market competition, there should be a number of them, given their privileged position at the entrance to the BSR.

From the point of view of the assessment of the economic benefits from the perspective of the shipowners, the amortization period has been calculated using the bulk carrier mentioned above as an example. Assuming that a large LNG tank was installed on the ship, which would allow it to travel 10,799 nautical miles (i.e. 20,000 km or half-way around the globe) on LNG, and assuming a specific LNG tank cost of 2,500 $/m³, a total cost for the tank was assumed to be $8.2 million. The engine was assumed to cost $14.4 for only MDO operation and $18.7 million for a dual fuel engine that can operate on MDO or LNG. The total additional cost for LNG operation including tank and engine upgrade was thus assumed to be $12.5 million.

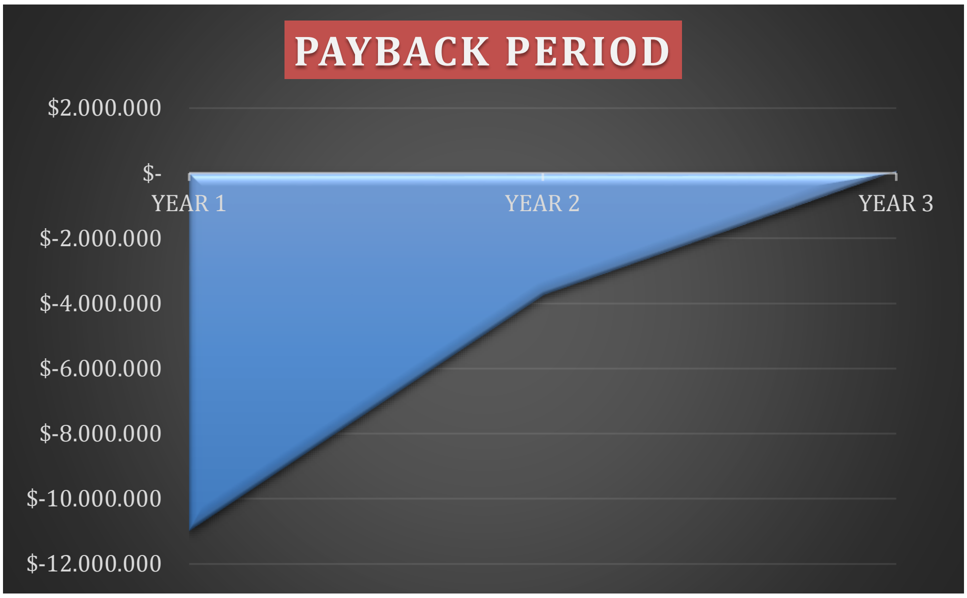

Figure 22. Payback period 2.35 years for LNG installation on new ship. [Figure generated by the authors]

Figure 22 shows that the recovery period for an LNG vessel of this type would be around 2.35 years, assuming a net discount rate of 0.45. The payback time is proportional to the payback distance. If the capacity of the LNG tank was reduced, the payback period could be significantly reduced. If the capacity of the tank is reduced to accommodate only the LNG capacity for a round trip of 500 nautical miles, the depreciation period is reduced to less than two years. This means the economic benefits for ship owners are strongly dependent on how often ships need to refuel and ultimately on the LNG bunkering infrastructure density.

Summary and conclusions

The results of the business case show that if a ship travels 1,000 nautical miles, the additional distance worth traveling for a container ship to bunker LNG is approximately 380 nautical miles (equivalent to approximately 704 km). Considering that, the developed model is very simplified (a wide range of ship operating costs have not been taken into account), a shorter distance (as recommended by TEN-T) equal to 400 kilometers can be considered reasonable. Yet, for large ships it is not unreasonable to assume that the LNG infrastructure in the BSR may be more widely spaced apart (e.g. 380 M or 704 km shown in Figure 21).

Regarding the payback time, the shipowners can expect to recover their investment on LNG installation in a time interval of approximately 2.35 years, if the ship has a tank capacity to cover 10,799 nautical miles (i.e. 20 000 km or half-way around the globe) on LNG, which is of course much more that the existing distance between LNG refueling points.

4.4 EXAMPLES OF BLUE CORRIDORS

The Blue Corridor Strategy aims to develop LNG as fuel for medium- and also long-distance transport, first as a complementary fuel and later as an adequate substitute for diesel oil. In recent decades, the usual use of natural gas in road transport has been mostly limited to compressed natural gas (CNG). Typical users of CNG were garbage collection trucks and urban buses, although several major car manufacturers have offered CNG-powered passenger cars produced in series. The experience from these cases has proven that engine performance for gas-powered vehicles is as good as for conventional fuels. However, five times more volume of CNG is needed to travel the same distance when compared with diesel fuel. This has prevented the use of CNG in heavy road transport, because its volume and weight would be too great to be viable for a long-distance truck (European Commission, 2014).
LNG can contribute to Europe’s policy of reducing greenhouse gas emissions and improving air quality. The use of LNG also decreases Europe’s dependency on crude oil and improves the energy supply security via diversification. For road transport, natural gas heavy-duty vehicles already comply with the emission standard of Euro VI (European Commission, 2014).

Figure 23. LNG Blue Corridors. Source: [LNG Blue Corridors, 2015].

To meet the objectives, a series of LNG refueling points have been defined along the four corridors (Figure 23) covering the Atlantic area (green line), the Mediterranean region (red line), and connecting Europe’s South with the North (blue line), and its West and East (yellow line). In order to implement a sustainable transport network for Europe, the LNG Blue Corridors project has set as a goal to build approximately 14 new LNG stations, both permanent and mobile on critical locations along the Blue Corridors while building up a fleet of approximately 100 Heavy-Duty Vehicles powered by LNG.

The LNG Blue Corridors project was financed by the Seventh Framework Programme (FP7). The LNG Blue Corridors project proved that LNG is an available, environmentally friendly (if implemented properly), and cost-efficient alternative to diesel fuel oil for goods transportation in long distances in the EU. There are also outstanding experiences of application of LNG as a fuel for trucks outside of Europe in USA, China, and Australia. China is a leading country in use of LNG for land transportation as more than 50,000 LNG vehicles are already in use there. In Australia, LNG road trains run through the desert and show that the technology is mature and safe. In Europe, Spain has been a leading country, due to the experience with LNG satellite plants and the transportation of LNG by trailer. Spain now has more than 14 stations to refuel trucks. Also UK, Sweden, and the Netherlands have a reasonable network to allow operations on a regional scale (European Commission, 2014).

The real challenge is to connect the different actors. Therefore, there is a need not only for the right heavy duty vehicle technology but also for the network of fuel stations. To realize the project goals, a structure of seven technical work packages was defined as part of the LNG Blue Corridors project. LNG vehicle technology and LNG fuels logistics technology were addressed in WP2 and WP3. WP4 dealt with regulations, homologations, and safety aspects, providing recommendations for reaching common and harmonized European standards. The definition of the roadmap for the role of the LNG blue corridors was dealt with in WP7 whereas the first stage of the rollout took place in WP5, titled: Fleet Demonstrations. WP5 was at the heart of the LNG Blue Corridors project comprising the construction and operation of 14 LNG or L-CNG stations at critical locations in the Blue Corridors (Figure 24) and the building–up of a fleet of approx. 100 LNG heavy-duty vehicles operating along the corridors. In WP6, LNG fuel station performance, LNG vehicle performance, and GPS data were collected and processed over a 2-3 year's demonstration period to assess the evolution of the rollout of the roadmap for European LNG Blue Corridors. Dissemination of the results took place in WP8 (European Commission, 2014).

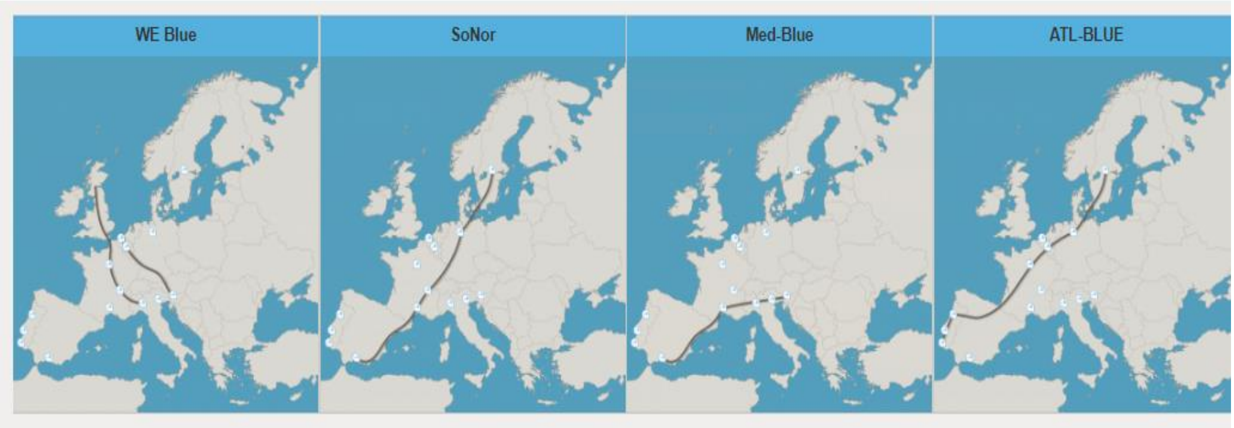

Figure 24. LNG Blue Corridors fuel stations. Source [LNG Blue Corridors, 2015].

LNG BC Stations:

- Rungis (ENGIE)
- Piacenza, Italy (ENI)
- Nîmes (ENGIE)
- Dourogás Natural – Elvas-Caia
- Berlin, Germany (UNIPER)
- Antwerp, Belgium (LNG Drive)
- Pontedera, Italy (ENI)
- Örebro, Sweden (SGA)
- Matosinhos, Portugal (GALP)
- Dourogás Natural – Carregado
- Barcelona, Spain (GNF)

Figure 25. The basic components of an LNG fueling station. Source: [LNG Blue Corridors, 2015] http://lngbc.eu/system/files/deliverable_attachments/LNG%20BC%20D%203.12%20Security%20and%20safety%20issues%20implementation.pdf.

LNG Vehicles considered for these Blue Corridors were Iveco Stralis, Hardstaff Mercedes, Benz Actros, and Volvo FM (European Commission, 2014) (see Figure 26).

Figure 26. LNG vehicles for the Blue Corridors. Source [LNG Blue Corridors, 2015]

As part of the EU Blue Corridors project, several technological innovations and the market were examined, including different LNG-powered engine concepts for heavy road vehicles, bio-methane as a transport fuel, gas production and storage, and studies on customer behavior and market development.

The LNG Blue Corridors Project was the first LNG project supported by the European Commission (within the 7th framework). The results so far were encouraging. Infrastructure installations related to the LNG Blue Corridors Project make up about 18% of the present European LNG infrastructure (Natural & bio Gas Vehicle Association, 2018).

Figure 27. Fuel station -logistic company Mattheeuws Eric Transport in Veurne. Source: https://www.ngva.eu/encouraging-progress-in-lng-blue-corridors-project.

At the end of March 2016, 12 LNG stations out of the planned 14 were in operation. Thirty truck fleets had joined the project, and as a result, 120 LNG trucks were active and monitored as part of the project; this is well in excess of the 100 trucks aimed for. Up to 150 trucks are expected to be operational by the end of the project. As of the year 2016, the engines used consisted of 75% engines compliant with Euro VI emissions regulations and 25% compliant with type Euro V emissions regulations. By the year 2016, the trucks in the project had covered a cumulative distance of 10 million kilometers. About 3,000 tons of LNG had been consumed. The fuel was dispensed in about 20,000 fillings, each filling amounting to an average of 100 kg of LNG. Some truck operators reported very good results in terms of specific fuel consumption and CO_2 emissions (Natural & bio Gas Vehicle Association, 2018).

4.5 Incentives for the promotion of LNG in the Baltic Sea region

Incentives for the promotion of LNG can be important tools in facilitating the market uptake of LNG. These may stem from industry, NGOs, or from governments. Some incentives in the BSR have had more effect on LNG deployment than others. In the following sections, we will describe the incentives.

4.5.1 Clean Shipping Index – focus LNG

Clean Shipping Index (CSI) is an independent labeling system of the environmental performance of ships and shipping companies and delivers market incentives for clean shipping. It is a tool to achieve environmental progress in the shipping industry that provides key players in the maritime supply chain with the information they need to make environmentally responsible decisions. The idea is to create competitive economic advantages for environmental leaders in the shipping industry.

The information in the CSI database comes from shipowners who submit details of their fleet to the index. They have completed a comprehensive questionnaire covering the relevant environmental parameters. CSI has introduced an updated scoring system to measure the environmental performance of ships and shipping companies. Taking into account a wide range of environmental parameters, the revised methodology includes data regarding carbon dioxide, sulphur oxides, nitrogen oxides, particulate matter, onboard use of chemicals, as well as treatment of water and waste. Vessels of all types are rated in a scale from one to five stars, depending on the total score obtained (Clean Shipping Index, 2018). LNG-fueled vessels can obtain higher ratings than vessels fueled by HFO or MDO by being able to achieve reduced carbon dioxide, sulphur oxides, nitrogen oxides, and particulate matter emissions.

The Swedish Maritime Administrations new fee structure, which is expected to be implemented on January 1st 2018, will be environmentally differentiated based on a vessel's CSI score. The fee structure is subject to notification by the European Commission, hence any new code of statues or price list will be sent out after acquiring more information about the notification.

4.5.2 Norwegian NO_X-tax and the NO_X-fund

In Norway, a tax on emissions of nitrogen oxides (NO_X) arising from energy generation using certain specified sources has existed since mid-2000s. The tax is calculated per kilogram of actual emissions of NO_X. The tax covers NO_X emissions from the following sources:

-propulsion machinery with a combined installed engine power output of over 750 kW
-engines, boilers, and turbines with a combined installed power output of over 10 MW
-flaring on offshore installations and onshore plants

The NO_x-fund covers emissions from shipping with taxable operation in Norway (i.e., between Norwegian ports), as well as petroleum installations (also taxable). In 2008, the NO_X fund was established by 15 business organizations. Businesses that sign the NO_x-agreement are exempted from the state NO_X tax. Instead, they pay a lower fee to the fund and in turn may apply for financial support for NO_X reducing measures. What you receive is directly linked to amount of NO_X-reduction (max. 80% of the extra investment cost) (Næringslivets Hoved Organisasjon, 2018). An illustration of how the NO_X fund works is shown in Figure 28.

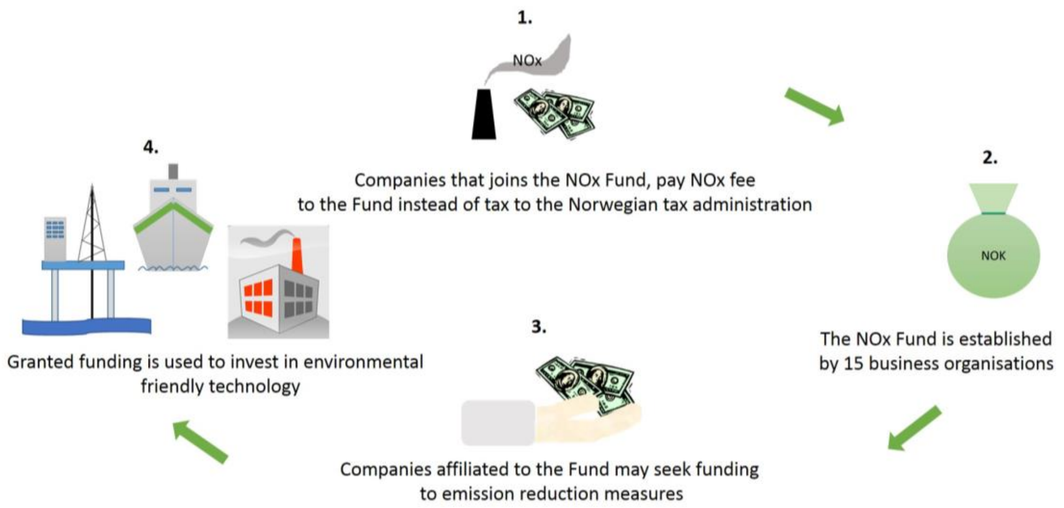

Figure 28. How NO_x Fund reduces NO_x-Emission. Source: NHO (2018).

More than 1,000 projects with installation of NO_x-reducing technologies have been implemented from 2008-2018, with investments of more than 2 billion Euros and support of about 0.7 billion Euros. It was estimated that this would result in at least 34,000 tons of yearly NO_x-reductions by 2018 and to an increased use of LNG. The fund has been very successful, is applauded both by the industry and the authorities, and is agreed to be continued until 2025. A possible arrangement for a CO_2-fund in Norway is currently being investigated.

4.5.3 Zero Vision Tool

Zero Vision Tool (ZVT) is a collaboration method and project platform for a safer, more environmentally friendly and energy efficient transport by sea (ZVT, 2016). Within the platform, representatives of industry, academy, agencies, and administrations meet to share experiences and to find common, workable, and sustainable transport solutions. As of today, approximately 130 different organizations from different countries use the ZVT method. The ZVT method is co-funded by the Swedish Maritime Administration (Sjöfartsverket) and is jointly owned by the Swedish Shipowners' Association and SSPA Sweden AB. ZTV has been, and is still involved in several EU projects, e.g., Pilot LNG, which consists of Joint Industry Projects (JIP): Scanbunk, Flexi, SSD&B, EVOlution, LNG Sea River, and LNG CONV. In total, ZVT has been involved in eight different projects on LNG.

4.5.4 Environmentally differentiated port and fairway dues

Environmentally differentiated port fees are a financial incentive used to support or encourage shipping companies to reduce their environment "truck-to-ship" air emissions footprint. It is an excellent tool which enables a port to deal with external pollution from ships. This would be done by distributing the costs of the services provided by the port between its customers where ships that are more environmentally friendly will pay a smaller fee. It is believed that differentiated fees would have a larger impact if accepted and embraced by ports of a whole region (e.g., North Sea or Baltic Sea) as well as by shipowners and operators. There are many factors to be considered when developing a fee system, for example: “is the scope global, regional, or local?”, “which environmental issues should be included?”, “should all ship types be included?”. There are already several initiatives and indices for an improved environmental standard of ships describing different systems of how to construct environmentally differentiated port and fairway dues in the CLEANSHIP project. The CLEANSHIP project provides a system which includes NO_x, PM, noise, and chemicals.

4.6 Infrastructure examples

4.6.1 Klaipeda FSRU

The terminal in Klaipeda is a very interesting case where a new energy terminal, devised predominantly for the purpose of diversifying the supply of natural gas in the Baltic states, had repercussions affecting several levels and industries. Not only energy, shipping, and other transportation were affected, but also education and business cooperation possibilities. For example, in 2016, the Lithuanian LNG cluster was established to consolidate knowledge, technology, and business partnerships in order to enable LNG business models. LNG cluster members are successfully developing LNG related projects like liquid intelligent tank and others (Lithuanian LNG Cluster, 2018). Also, an LNG competence center was created between cluster members to provide support for students studying “LNG terminal engineering” and for research, development, as well as for business companies for training purposes. Within the Go LNG project, a BSR LNG cluster was established in April 2017 and a competence center was established to strengthen the cooperation between Baltic Sea Region countries in the field of LNG innovations, technologies, and infrastructure.

The Helsingborg and Klaipeda infrastructure facility project HEKLA was started in 2015. The purpose of the project was to develop an LNG network within the Baltic Sea region. The implementing bodies were Helsingborg Hamn AB and Klaipedos Nafta. The project ended in December 2017 (HEKLA, 2018, & Motus Foundation, 2018).

4.6.2 Swinousjcie

On August 19th 2008, the Polish Council of Ministers adopted a resolution in which the construction of the LNG terminal was acknowledged as a strategic investment for the interests of Poland, compliant with the plans for diversification of energy sources, specifically of natural gas and thereby guaranteeing the energy security of the country. Construction of the

LNG terminal in Świnoujście started in March 2011 and the terminal was inaugurated on October 12th 2015. The first LNG carrier transferred LNG on December 11th 2015. The total cost of the terminal was €950 million. The project investor was Polskie LNG – a company established in 2007 by Polish Gas and Oil Company PGNiG (PGNiG SA) for the purpose of constructing and operating the LNG re-gasification terminal. On December 8th 2008, 100% of the shares of Polskie LNG were acquired by GAZ-SYSTEM S.A. On January 1st 2010, Polskie LNG Ltd. was transformed into a public limited company (PLC.)

GAZ-SYSTEM S.A. supervised the construction of the Świnoujście LNG terminal, whereas the Polish Oil and Gas Company PGNiG became responsible for the supply and transport of the LNG to the terminal.

Current possibilities

Nowadays, the terminal enables the regasification of 5 billion m^3 of natural gas annually, satisfying approximately 30% of Poland's annual gas demand. LNG can be unloaded from the LNG carriers with a capacity of 120,000 up to 216,000 m^3 (Q-Flex) with the draft up to 12.5 m and length up to 315 m. After regasification, the gas supplies the national gas network. Storage of LNG is possible thanks to the two LNG tanks with a capacity of 160,000 m^3 each.

Small-scale LNG

Nowadays, the LNG terminal is equipped with three reloading stations dedicated to LNG trucks. The maximum reloading rate is 90 m^3/h each. From the beginning of the second quarter of 2016 to the end of November 2017, more than 1,800 LNG trucks have been loaded.

Plans for the future

Plans for the development of the LNG terminal include increasing its regasification capacity up to 10 billion m^3 annually by building a third LNG storage tank and expanding the regasification facilities using submerged combustion vaporizers (SCVs).

Medium and small-scale LNG

The most interesting plans for the future are those relating to the establishment of medium- and small-scale LNG projects. The development plan prepared for such facilities includes:

- The construction of a second jetty at the Świnoujście LNG terminal, which will enable reloading LNG into smaller LNG carriers, LNG bunkering vessels, and bunkering of LNG powered vessels. The planned loading capacity is about 6000 m^3LNG/h and the transshipment capacity is about 12,000 m^3 LNG/h.
- The construction of a new LNG bunkering vessel.

- Further development of existing reloading stations for LNG trucks to enable reloading of LNG into ISO Tank containers.
- The construction of a railway siding with a reloading installation including 12 loading arms with rate 75 m^3 LNG/h each, possibility of loading of 20 ft and 40 ft ISO tank containers and rail cryogenic tank. The total capacity of loading of LNG into trains is about 1,700 t LNG/day.

4.6.3 SAMSØ

The Renewable Energy Island of Samsø, Denmark, with its 3,750 inhabitants, has a vision to become free of fossil fuels by 2030. The vision has been formulated in a long participatory process involving business and civil society. Samsø Energy Academy and the Samsø Municipality have been two major driving forces together with the civil society and the local small enterprises. The vision of becoming fossil free has been adopted by the municipal planning. For this to be realized, the transport sector needs to focus on alternative fuels. Therefore, the municipality started its own shipping company in 2013 and ordered a new LNG-fueled ferry which was inaugurated in 2015. An important part of the motivation for this investment was to pave the way for biogas production on the island. Biogas production has hitherto been difficult due lack of profitable gas use opportunities. Much of the island is heated by straw and woodchip fired district heating and the island already exports renewable power from wind turbines and photovoltaic (PV) installations to the mainland. It is the ambition to become a model society for the national 2050 goal of a 100% fossil fuel free Denmark. The most crucial element in the infrastructure of Samsø is the ferry. It is the lifeline of the island, and at the same time by far the single largest consumer of fossil fuel.

The biogas sector accounts for 66,000 jobs in Europe, most of which are in rural areas, generating inclusive growth. In 2015, more than 17,000 biogas plants and over 350 biomethane upgrading installations existed in Europe and these numbers are increasing (European Biogas Association, 2015). Germany by far outnumbers other countries, but the development here is stagnant. However, many plants are developing and increasingly biogas is understood as a potential engine for a circular economy and also as a necessity to be able to supply the transport sector with increasing demands for renewable fuels. Upgrading and injecting into the gas grid is an option in many areas where biomethane certificates can make biogas available for transport in many regions. However, it is expected that the tendency towards LNG for heavy vehicles and for shipping is going to drive the next step towards the phasing out of fossil fuels by conversion of biogas into biomethane (upgrading by removal of CO_2) and further on to Liquefied Biogas (LBG), a very concentrated fuel comparable to fossil fuels.

Two of the main advantages of LBG are that it can be transported relatively easily, and it can be dispensed to either LNG vehicles or CNG vehicles. LBG is transported in the same manner as LNG, that is, via insulated tanker trucks designed for transportation of cryogenic liquids.

Still, very few installations producing LBM are currently operational, notably one plant in Sweden, one in Norway, and a few demo plants around the world. A major challenge is that the liquefaction technology has been developed for large scale installations for liquefaction of natural gas, and the technology for micro- or nano- scale liquefaction (in case of most biogas plants) in the range of 250-200 Nm^3 hourly of biogas production is still young technology.

The global LNG shipping industry has grown rapidly in recent years, supporting the increasing use and availability of natural gas and the drive to cut costs in LNG processing and transport. It took 34 years from the commencement of commercial LNG shipments for the in-service fleet of LNG carriers to reach 100 vessels in 1998, but the 200-vessel barrier was broken in 2006 and from June 2017, 500 vessels were on the global market.

The growth in LNG shipping is concentrated in Norway, the Baltic Sea, and in China, but other regions are developing their LNG markets too. The next huge step will be to replace LNG with LBG, and for this to happen, the planning in very different sectors, such as agriculture, marine industry, and local/regional transport planning will need to be aligned. The obvious place to start is where a local /regional ferry has a strong connection to a coastal community and serves as main transport means from an island to the mainland and to the market for agricultural produces. In such a case, there exists mutual interests in building the innovative cooperation around local energy consumption and sustainable development, job creation, and world connectivity.

The development of technological concepts and business models that enable coastal communities to reach a sustainable energy consumption is important. In order to demonstrate the feasibility of LBG production and distribution, a business plan demonstrating these advantages should be developed for one of the biogas plants in the BSR.

4.7 Future Blue Corridors in the Baltic Sea Region

Europe aims at dramatically reducing its dependency on oil, cutting carbon emissions, improving air quality, and reducing noise from transport. Transport accounts for one third of total energy use in the EU. The decarbonization of road transport will be a major challenge considering that it represents more than 70% of the energy used by all transport modes.

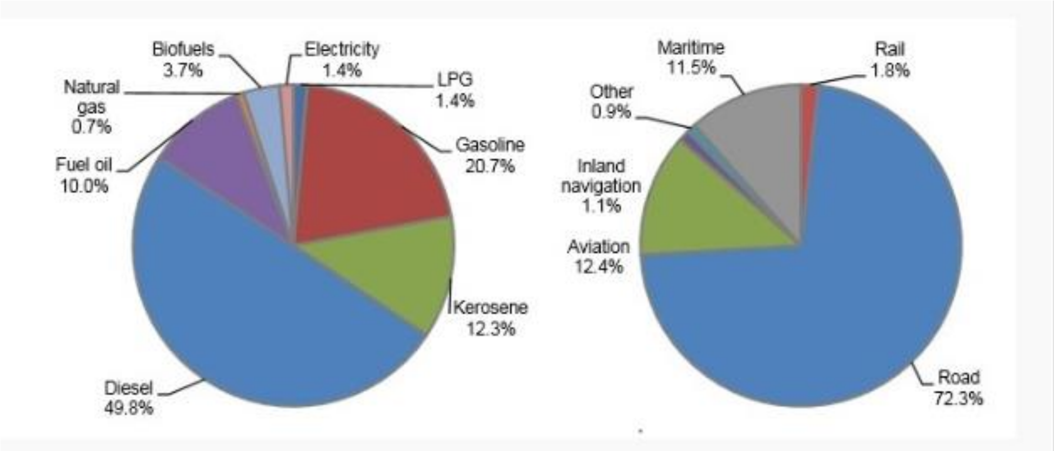

Figure 29. Total energy demand by source and mode. Source: Expert Group on Future Transport Fuels.

Natural gas and biomethane, including synthetic methane, have been identified as strategic alternatives to replace oil-derived fuels. European policy, supported by the Clean Power for Transport (CPT) package, recognizes that natural gas and biomethane will play a major part in both road and maritime transport.

Fossil LNG has the potential of reducing CO_2 emissions from transport by about 10-20% compared to fossil diesel fuel. It also practically eliminates the emission of sulphur oxides and reduces the emission of particulate matter and NO_x compared to diesel fuel.

LNG is expected to improve security of energy supply by diversifying the sources of energy in the BSR. It also has the economic advantage that more flexibility in supply reduces costs to energy consumers. Natural gas consumers thus become less dependent on specific suppliers and transit countries than they are for a pipeline supply and vice versa. Another advantage is the growing spot market for LNG and the fact that through increased availability, LNG systems have become cheaper. There are, however, great uncertainties in regards to future energy politics which can something make present actors hesitant to make large investments in LNG import terminals. Moreover, an expansion of the pipeline network, e.g., from Germany or Russia could also be more cost-effective than LNG import if the maximum capacity could be met this way.

The Blue Corridor Strategy is aimed at providing an efficient LNG infrastructure development plan and LNG distribution strategy for the BSR. A strategy is a plan of action that is designed to achieve a long-term or overall goal. In developing this strategy, an illustration in Figure 30 pinpoints the advantages for choosing an economic strategy rather than a policy one.

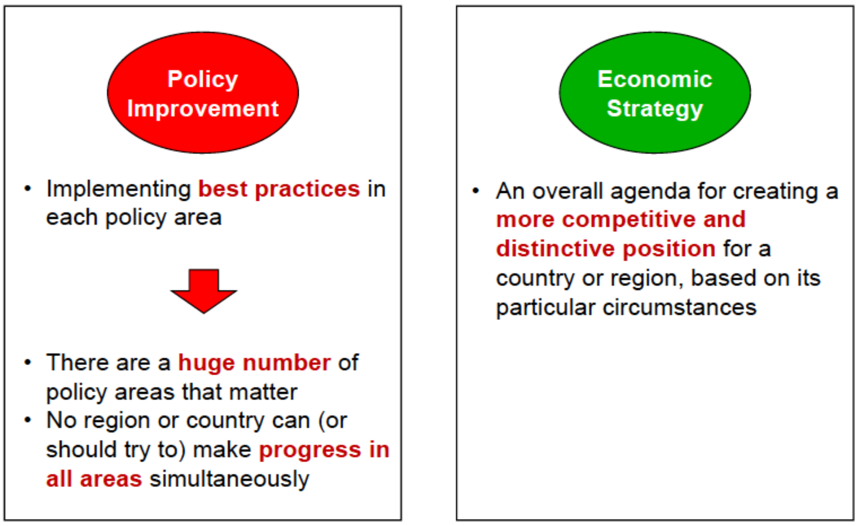

Figure 30. What is Economic Strategy?

The Blue Corridor Strategy was defined by analyzing the existing infrastructure and estimating future need, using an integral vision of the BSR. Key points for a competitive development of the LNG were identified and recommendations for the definition of policy improvement and economic strategy were given.

Fuel distribution in the BSR is currently achieved via natural gas pipelines using the existing natural gas network to production and liquefaction facilities for LNG or directly via LNG tankers from Norway and other LNG producing countries to import terminals in the BSR, either large or small scale. From these terminals, the final destination can be reached either by transporting LNG on trucks, rail, or via bunkering vessels. The land-based and maritime LNG markets are expected to become closely integrated in the future. With harsher emission regulations, more ships will be built with LNG propulsion or will be retrofitted. Liner traffic and vessels with regular routes in the BSR are expected to be the first to be equipped with LNG propulsion systems.

As of December 2016, there were two active import terminals in the Baltic Sea. One in Świnoujście (Poland) and one in Klaipeda (Lithuania). Additionally, there are two small scale LNG terminals in Pori (Finland) and in Nynäshamn (Sweden). More are in development. Few small-scale bunkering facilities are active (some in Denmark, Sweden, and Norway), but overall, most bunkering facilities in the Baltic Sea Region are still under construction or only planned.

With regards to land-based distribution of LNG, the main focus should be on the route from North Germany, through Poland to the Baltic States. Originating in the Ruhr Area in western Germany, the route could run towards the Baltic Coast and continue from there through ports in Lübeck or Rostock towards connecting points in South Sweden. The rail capacity to the German ports is sufficient. From the connecting points in Sweden, the LNG distribution routes can lead towards the Baltic States.

According to Directive 94/2014/EU on the creation of an alternative fuels infrastructure, which is the cornerstone of the EU's Clean Power for Transport (CPT) package, EU member states will have to develop a plan (National Policy Framework) to establish a network of refueling stations for natural gas vehicles in cities, ports, and along the Trans-European-Network for Transport (TEN-T). Member States have to provide refueling points for: CNG in cities/densely populated areas by 2020, CNG & LNG along the TEN-T core network by 2025, LNG in sufficient TEN-T seaports by 2025, and LNG in sufficient TEN-T inland ports by 2030. The final Directive, as adopted by the European Parliament and the Council on September 29th 2014 following the inter-institutional negotiations:

- requires Member States to develop national policy frameworks for the market development of alternative fuels and their infrastructure,
- foresees the use of common technical specifications for recharging and refueling stations,
- paves the way for setting up appropriate consumer information on alternative fuels, including a clear and sound price comparison methodology.

As part of the Go-LNG strategy, and in consideration of the EU's Trans-European-Network for Transport (TEN-T) plans, a map of currently existing LNG infrastructure and planned infrastructure was created. Figure 31 shows a map of existing LNG fuel facilities in the BSR, with circles indicating a 400 km radius around each facility.

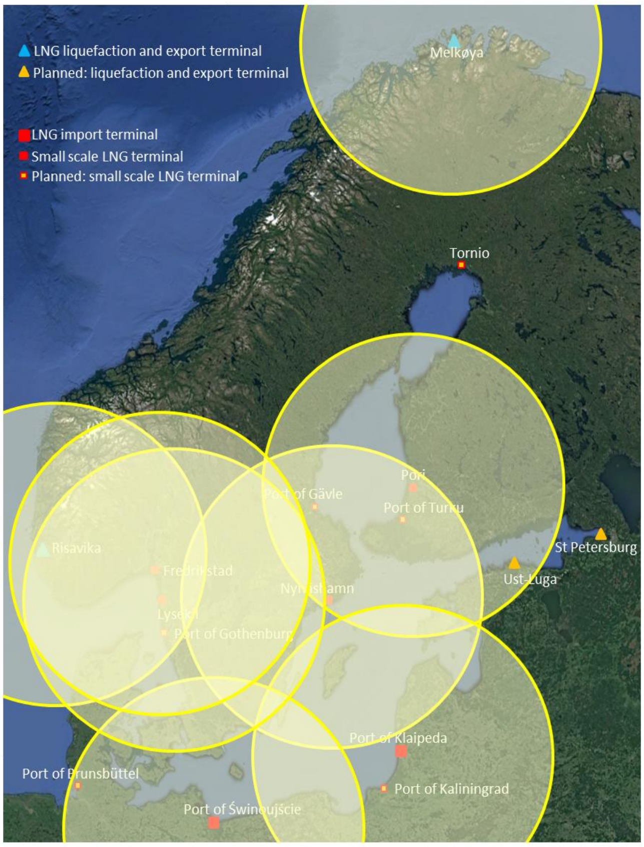

Figure 31. LNG coverage in the BSR as of August 30th 2017. Source: [GoLNG presentation 2017].

Figure 32 shows that current LNG fueling facilities cover most of the Baltic sea with a radius of 400 km as of the August 30th 2017. The distance of 400 km has been suggested as part of EU's Trans-European-Network for Transport (TEN-T) plans for the maximum distance between LNG fuel facilities, in order to ensure that LNG is sufficiently available (see IP/13/948). The map shows that currently available LNG facilities are almost sufficient to cover the entire BSR (European Commission, 2017b). Only the northernmost parts of the Gulf of Bothnia, and the easternmost part of the Gulf of Finland are not within 400 km of an LNG facility. These two locations would thus be considered to be strategic places for the deployment of LNG infrastructure, provided that there is a need for LNG in these areas.
An updated map showing future LNG infrastructure has been drawn in Figure 32 to assess how the availability of LNG is expected to evolve in the future.

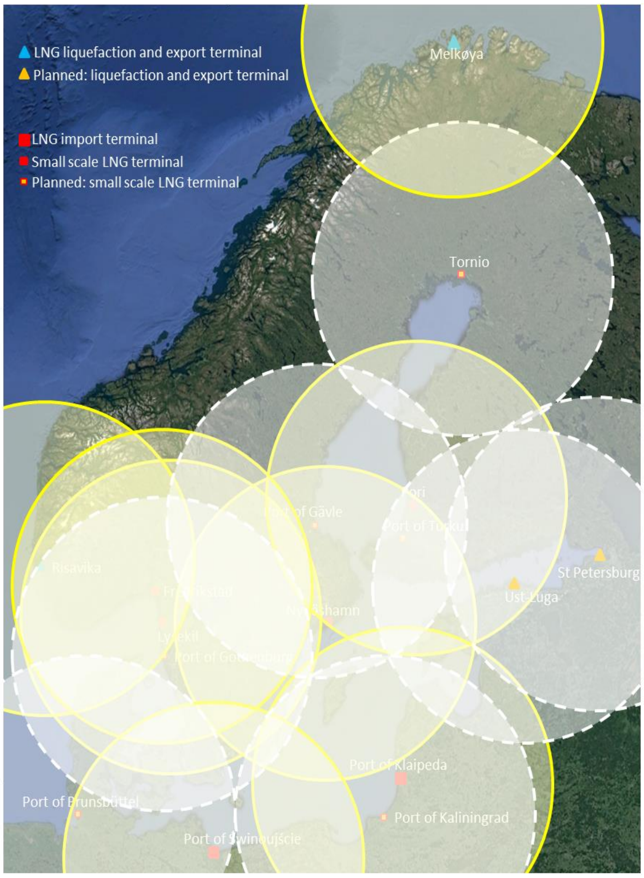

Figure 32. LNG coverage in the BSR with future infrastructure. Source: [GoLNG presentation 2017].

Figure 32 shows that future LNG facilities planned for Tornio, Ust-Luga, and St-Petersburg will make LNG available within a 400 km radius in the BSR. As shown by the business case analyses in the present report, the competitiveness of LNG depends on the distance between LNG fueling facilities. If a vessel has to travel a long distance in order to bunker LNG, the cost of traveling this additional distance will make LNG less competitive with regard to locally available fuels. This distance depends both on the size and typical routes of the vessels, and for large vessels on international routes, the minimum distance between LNG bunkering facilities may well be as much as 704 km.

In addition to fuel distribution, the Blue Corridor Strategy also addresses the following issues:

- Safety
- Environmental aspects
- Economic aspects
- Usefulness for users
- High standards
- Understanding the needs of the population

Safety issues are very important, because LNG is classified as a dangerous good and users, as well populations always place a lot of attention on safety. Ensuring safe operation of LNG across the BSR requires proven technical and operational standards.

Environmental aspects of LNG are important across the entire LNG life cycle. It is important that emission regulations are put in place for methane slip for the entire LNG life cycle, comprising natural gas extraction, upgrading, liquefaction, transport, regasification, and conversion to heat or power. Intentional or unintentional releases of methane from safety procedures, accidents, planned overhaul, or boil-off-gas should be avoided as much as possible and should be reported. They should be properly accounted for in the overall environmental performance of LNG in terms of greenhouse gas emissions so that the GHG footprint of LNG can be correctly measured against other fuels or propulsion methods.

Any transport corridor should be useful from an economical point of view. This means that all possible costs (direct and undirected), of corridor users and society should be considered. As part of the Blue Corridor Strategy, business cases were used to assess the infrastructure requirements in terms of the maximum distance between refueling stations for ships. It was concluded that LNG bunkering should be present every 400-704 kilometers in order to ensure LNG competitiveness over standard heavy fuel oil in shipping.

A corridor must be useful for their users, meaning that it is necessary to identify carefully what infrastructure is necessary for the end users and to avoid the construction of unnecessary infrastructure and services.

Transport corridors cross areas of different countries, all of which must be informed of the planned and ongoing activities of the planned Blue Corridors. Clear and timely information must be provided to the population, and feedback mechanisms for the population should be established, in order to formalize the concerns of the population. This is important in order to respect the views of the citizens and to avoid conflicts or resentment.

The following sections look deeper into each country's specific strategy regarding current LNG development and deployment. By coupling this information with the planned TEN–T corridors of the EU, including rail and road transport, and the findings of the Go LNG extended and integrated LNG value chains (stakeholder's perspective), proposals for infrastructure necessary to create a Blue Corridor in the BSR will be made. It is important to keep in mind that a corridor must be useful for its users, that is, it is necessary to create a transport corridor that includes all requests for well-functioning infrastructure and superstructure.

4.7.1 DENMARK

Denmark is in alignment with European strategies on LNG and has delivered its national strategy on alternative fuels infrastructure to the EU. In that strategy, it is mentioned that the long-term vision of Denmark is to be free of fossil fuels by 2050 at the latest which includes the domestic transport sector.

An adequate number of LNG gas stations will be established in the ports to allow LNG vessels for inland waterway or sea-going LNG vessels to sail on the entire TEN-T main network by no later than 2025. Seaports providing access to LNG gas stations must be identified in the policy framework, taking into account current market needs (European Commission Directive 2014/94/EU, 2014).

For maritime transport, it is particularly relevant to include developments in neighboring countries with infrastructure for alternative fuels. The development will be assessed in connection with ongoing reports to the EU Commission on the implementation of Denmark's national policy framework.

It is clear that the use of LNG in Denmark is primarily driven by the maritime industry which uses LNG as fuel for shipping and by an increase in heavy-road transport. However, given that CNG stations already cover large parts of Denmark, LNG may not be as relevant for modalities other than for shipping. Yet, for the planned bunkering stations in Hirtshals and Fredrikshavn, providing LNG for road transport is part of their business model. In addition to this, LNG might be of interest to industry located in remote areas where there is no gas grid. One example is Grenå, where a small-scale bunkering facility is planned for the port.

Figure 33 shows operating public service station (green color) and those planned (red color).

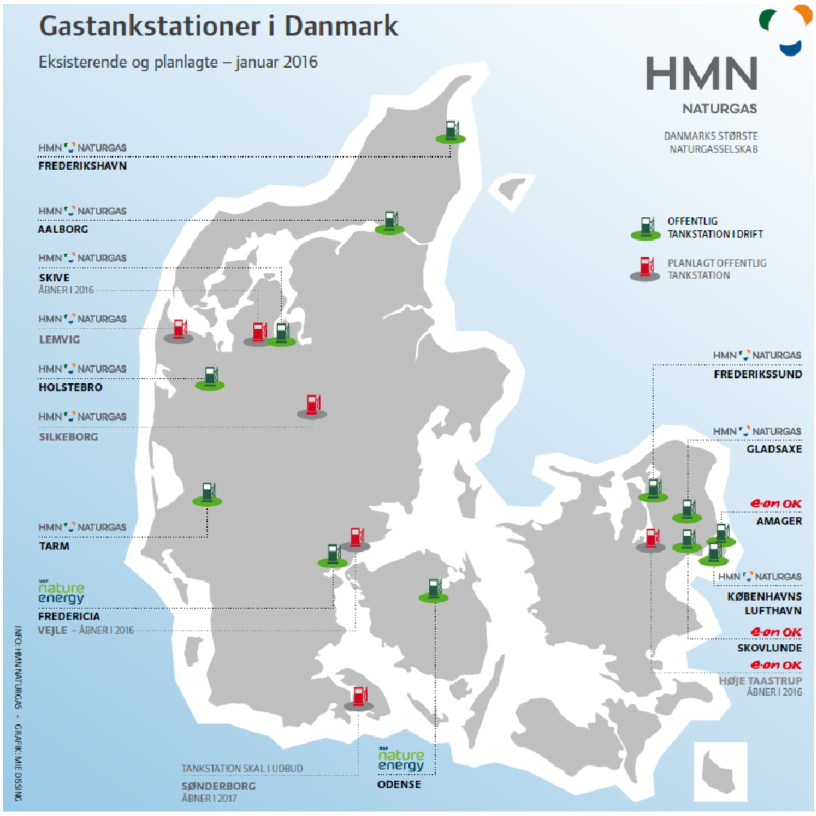

Figure 33. Operating public service station and those planned in Denmark. Source: https://naturgas.dk/.

Road:

In Denmark, there are currently no vehicles or trucks running on LNG. However, 18 CNG refueling stations exist and – as of 2014 - 61 gas vehicles, 26 gas busses, and 17 gas trucks were registered[2].

In Denmark, it is believed that law and regulations are still the main drivers of LNG infrastructure development, especially once the BSR becomes a NECA-region. For further development, Denmark is asking for regulations concerning port dues and for a standardized regulation on bunkering procedures and related equipment. The main challenge when it comes to *"more LNG"* is the lack of LNG suppliers and distributors which interferes negatively with the pricing of LNG. Therefore, alongside an increase in clear regulation, the low number of LNG suppliers and distributors is the main obstacle.

When it comes to safety and security, sufficient players are available in the area of risk assessment, however, a change in culture to a more open-minded/open sharing culture could be beneficial in the sense that simultaneous and identical studies/risk assessments are made. Education is a general problem for the Danish maritime sector with a need for more qualified

[2] http://www.dgc.dk/sites/default/files/filer/publikationer/N1501_naturgaskoeretoejer_EU.pdf, page 4, 6 & 8

maritime personnel (especially craftsmen). This problem also affects the LNG supply chain, highlighted by a possible future lack of qualified personnel operating large LNG carriers.

More LNG infrastructure is required in order to permit more flexible use of LNG in the sense that a potential LNG customer does not have to go "off course/drive the extra mile" in order to get the fuel needed.
This means that more LNG infrastructure/filling stations are required both for land-based traffic and for waterborne traffic, as follows:

- More ship-to-ship bunkering possibilities
- More fixed LNG refueling possibilities in ports, for a time in the future when more shipowners become users of LNG
- More refueling stations for heavy vehicles in road transport (above 350 hp)
- LNG-fueled power supply for large production industries (sugar, cement) and refineries
- LNG-based gas distribution to remote areas (no grid), such as the Grenå municipality.

4.7.2 Finland

The Finnish energy strategic framework (closely linked to the European one) provides for the creation of a network of medium-sized LNG terminals. These are aimed at improving the regional supply security of natural gas by diversifying the source of natural gas, to guarantee gas supplies to the industry, and to permit LNG for bunkering of ships.

Within this strategic framework, the construction of a new LNG terminal at the port of Hamina will be completed by 2020 and will be able to supply the national grid (unlike existing departments of Tornio and Pori). Grid connection and will therefore make it the first LNG terminal in the country to be able to further the aim of ensuring security of natural gas supply. Once the LNG terminal at the port of Hamina is commissioned, LNG transport by trucks to the main ports in Finland is planned.

The second Finnish project is represented by Baltic Connector: a gas pipeline linking Finland and Estonia, allowing the integration of the Finnish and Baltic markets with the EU common energy market. The total cost of the project is 250 million euros of which 187.5 million are financed by the European Commission. With these measures, it is hoped that future market growth of LNG will be achieved, and that LNG and LBG will gain better access to the natural gas market in Finland.

4.7.3 Germany

The National Strategic Framework (German: NSR), published in November 2016, formulates Germany's goals and measures for developing infrastructure for the alternative fuels of electricity, hydrogen, and natural gas (Bundesministerium für Verkehr und digitale

Infrastruktur 2016: Nationaler Strategierahmen über den Aufbau der Infrastruktur für alternative Kraftstoffe). Germany is thereby fulfilling an important specification of the EU Directive 2014/94/EU. It thus supports the aims of the national mobility and fuel strategy to reduce energy consumption and to diversify energy mix.

Worth around one billion euros, the investments are together composed of the following: 300 million from the electric mobility recharging infrastructure program, 140 million from the funding program "On-site electric mobility", 247 million from the National Innovation Program for Hydrogen and Fuel Cell Technology (NIP), and 268 million from the Mobility and Fuel Strategy.

At the moment, there are 900 refueling stations for compressed natural gas (CNG) in operation. By 2025, there will be a basic network of LNG refueling stations (liquid natural gas) for heavy goods vehicles along the TEN-V core network. LNG supply of ships in harbor via "truck-to-ship" bunkering is already secured. The development of infrastructure for LNG supply in harbors will take place according to demand.

The aims of the German Federal Ministry of Transport and Digital Infrastructure (BMVI) are:

- Fund the first demonstration projects, e.g., procurement of LNG truck fleets, LNG PowerPacks for shore-side power supply of container ships during downtime
- Develop a BMVI funding program in order to support the equipping and conversion of ships with LNG drive systems (NOW-GMBH, 2016)
- Develop an LNG fueling station network along the TEN-T-corridors by 2025 for heavy duty trucks
- Support the demand-orientated development of LNG infrastructure in sea- and inland ports[3] until 2025

Along the core network of German TEN-T corridors, less than 10 fueling stations shall be installed and cover the essential range for long distance transportation. The BMVI provides incentives for building LNG infrastructure and to support the purchase of LNG driven trucks and ships. The German Federal Ministry of Economy and Energy initiated a round table with relevant stakeholder to further develop the national mobility and fuel strategy (Mobilitäts- und Kraftstoffstrategie) in September 2016. The relevant stakeholders are national branch associations, scientific institutions, and companies from different sectors.

Different incentives are planned to support stakeholders in realizing the strategic aims. Incentives mainly focus on the demand-driven market to strengthen the use of alternative fuels. Measures have been set up to subsidize the construction of LNG filling stations for trucks. Companies are typically granted federal subsidies to construct alternative fuels-related infrastructure. Networks such as the "LNG task force" or "Zukunft ERDGAS" communicate the needs regarding LNG related topics. These networks consist of companies, associations, and R&D institutions.

[3] Corresponding to https://www.bmvi.de/SharedDocs/DE/Anlage/VerkehrUndMobilitaet/Wasser/nationales-hafenkonzept-2015.pdf?__blob=publicationFile

A total amount of approximately 1 billion euros of public funds will be provided to alternative fuel related activities. The following funding structure is envisaged:

- 440m € for charging infrastructure electro-mobility
- 247m € for hydrogen and fuel cell technology
- 268m € for projects regarding the national mobility and fuel strategy.

Information about FDI in German LNG industry is not available.

The Federal Ministry of Finance gives a fiscal discount on fuel taxes on LNG. LNG is provided to the maritime sector tax-free.

The Port of Hamburg gave a discount that was limited in time and ended on December 31st 2018. The discount was granted for ships that were solely powered by LNG, only use LNG for their own electricity needs, and have an ESI SO_x score of > 99 on the GT portion of the port with fees of a maximum of 2,000 € (Hamburg Port Authority, 2015).

The German Federal Ministry of Transport and Digital Infrastructure released their strategy of mobility and fuels (Mobilitäts- und Kraftstoffstrategie, MKS) with the strategic aim to fulfil the energy and climate targets of reducing the GHG emissions by 60% by 2050. The MKS aims to strengthen the diversification of fuels used for heavy transportation and the maritime sector, the assessment of LNG infrastructure, and the development of a LNG go-to-market-strategy for the shipping industry (including inland waterway shipping). A central incentive mechanism is the energy tax reduction for climate friendly fuels.

In autumn 2015, the Federal Ministry for Economic Affairs and Energy published its key points of a Maritime Agenda 2025 (Eckpunkte Maritime Agenda 2025). These were:

- to support research and development
- to initiate maritime innovations
- to develop additional markets for the future, to strengthen international competitiveness
- to promote green shipping
- to develop and maintain maritime infrastructure and
- to ensure vocational training and employment in the maritime sector.

The strategies focus on supporting the development of LNG-based propulsion, furthering LNG-based technologies, the creation of a state aid confirmative incentive system for the deployment of LNG, and the coordination of standards and regulations relating to port infrastructure valid amongst the federal states and port authorities (Bundesministerium für Wirtschaft und Energie, 2015).

On a federal level (Schleswig-Holstein, Mecklenburg-Vorpommern, and Hamburg), no LNG distribution strategy has been established so far. Different ports (Brunsbüttel, Rostock et al.) and the Federal Ministry of Transport, Building and Urban Affairs (Bundesministerium für Verkehr, Bau und Stadtentwicklung) has initiated feasibility studies for the distribution of LNG. Ports have implemented LNG in their Port development plan as a future fuel (Hamburg Port Authority 2012). Currently, the demand of LNG is supplied by trucks and small-scaled units. In a next step, barges with a capacity of 6,000-7,000 m3 could be developed in case of a rising demand for LNG. The national political strategy now is to promote the advantages of LNG and to subsidize promising projects in the LNG sector (Ehrmann, 2016).

On national level, the main focus relies on the national strategy for abandoning atomic energy through the stable growth of power generated from renewable sources (especially wind power). The national policy is concentrating their efforts on building the necessary power grids. Nevertheless, it is mentioned that the energy supply with gas shall continue to play a major role and especially the pipeline-independent import of LNG has to be supported (Bundesministerium für Wirtschaft und Technologie 2012).

4.7.3.1 CHALLENGES AND FUTURE PROSPECTS

The tasks of national and regional interest in Germany can be summarized as follows:

Maritime sector:

- Construction of LNG infrastructure and bunkering facilities
- Construction of new ships and vessels with LNG propulsion as well as conversion of existing ships

Road sector:

- Installation of fueling station network along the TEN-T-corridors
- Developing a market for the use of LNG-powered heavy trucks

Industry:

- Developing anindustrial demand for LNG

4.7.4 LITHUANIA

Lithuania is one of the LNG hubs of the BSR with its new large-scale LNG import terminal. The Lithuanian strategy is to implement Klaipeda LNG terminal as a Hub for LNG transshipment in the BSR. The Marine bunkering facilities for lading bunker ships and small tankers have been agreed with Bomin and Skangas. KN and Bomin have chartered a 7,500 m3 small LNG carrier for distribution and bunkering procedures. The auction system for booking LNG terminal capacities in Klaipeda has been implemented; any interested party can make a capacity allocation for regasification and transshipment in the BSR.
KN is investing in an onshore terminal with an LNG capacity of 5,000m^3, which will be able to fill ships, trucks, and containers with LNG. One such onshore terminal is planned for the Baltic States and northeast Poland. A Lithuanian LNG cluster was established in order to develop a Lithuanian LNG distribution and technology hub for the BSR. The cluster members have joined forces in providing technologies for LNG distribution, cold energy applications, energy production, and transport.

The economic competitiveness of the Lithuanian LNG terminal and its ability to guarantee energy security is based on the implementation of the EU third energy package. This will enable the gas distribution in the 3 Baltic States from the terminal. Public capacity allocation possibilities will establish the market for private traders of gas to better utilize existing infrastructure. The connection of the Baltic gas grid to the LNG terminal is crucial to expanding its market possibilities. After KN and Bomin have chartered the bunker vessel and the Klaipeda FSRU started providing transshipment services, the distribution of LNG to small-scale terminals in Finland, Sweden, and Estonia became possible.

Onshore infrastructure will enable LNG distribution by car, ship, and container. This will enable the distribution of LNG across the Baltic States and strengthen the implementation of the EU Clean Fuel Strategy and the EU Directive on Deployment of Alternative Fuel Infrastructure.

Lithuania regularly imports LNG from Norway under a supply deal with Statoil. The imported volumes are split between Litgas, Lietuvos Duju Tiekimas, and the Lithuanian fertilizer producer Achema. The FSRU LNG terminal currently provides Lithuania with roughly half of its gas needs with the rest being sourced from the Russian company Gazprom.

4.7.4.1 Challenges and future prospects

The law and regulations for the FSRU terminal's operation are well established. Market benefits such as discounts on port duties and incentives for road transport have not been agreed yet. Regulations for LNG bunkering, infrastructure location, and operations need to be established.

Klaipeda University has established a bachelor program for LNG terminal engineers with a major focus on LNG infrastructure. A dedicated LNG research laboratory facility has been established as part of this work.

New business models need to be applied in order to facilitate the demand for ship-to-ship LNG bunkering. Also, there is a need to decrease the investment and operation costs by better integrating business models and markets with the available infrastructure.

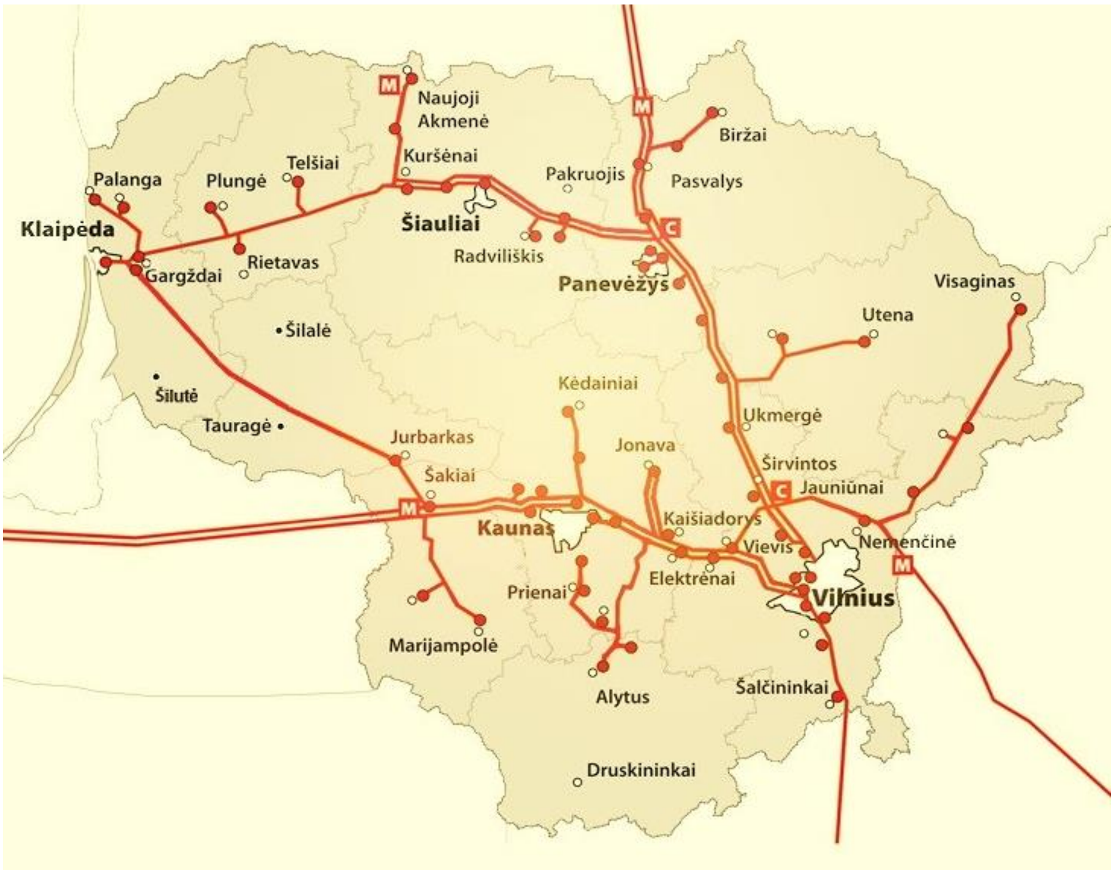

Figure 34. Future: LNG use in different sectors, build LNG refueling stations for road and rail in the Lithuanian gas grid system.

As is shown in Figure 34, about 14 municipalities in Lithuania have no link to the natural gas grid and these areas are potential LNG users. A better integration of these potential markets with the LNG infrastructure could provide new business opportunities for LNG in the region.

4.7.5 Norway

Norway was among the first to adopt LNG as fuel for ships, including on passenger ships. A separate procedure for LNG on passenger ships was created, which also included competence requirements. The qualification requirements are later incorporated into regulations, qualifications, and certificates of seafarers.

Norwegian LNG competence has become an export article (Norwegian Shipowners' Association Annual Conference, 2015).

A training requirement developed for the gas ship MF Glutra has now become an international standard as part of The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STCW) and the IGF-code.

The regulations for small-scale LNG have largely been developed in Norway. Before MF "Glutra" was adopted, both class requirements were developed by Veritas (now DNV GL). The

Norwegian Maritime Directorate devised a new regulation for LNG-fueled passenger vessels and defined bunkering rules and procedures. The work that was done at that time formed the basis of all later developments in rulemaking for the use of LNG as fuel for ships.

The ability of withdrawing LNG in small volumes from various import terminals in Europe ensures the supply of LNG. With this, it is possible to supply future growth in natural gas supplies, even though production capacity in Norway is not extended.

During the last few years, the production capacity in Norway has been increasing, and this is believed to continue. Norway could also be a role model for the distribution system of LNG, with small-scale receiving terminals scattered along the coast. The reason why this system is so successful in Norway is because of the high cost of building pipelines across the Norwegian landscape, with its mountains and fjords.

The small-scale LNG should be distinguished from the base-load LNG, where much larger quantities are handled. The ship currently operating in Norway carries 1,100 m^3 of LNG (Gasnor operated *Pioneer Knudsen*), whereas base-load ships handle volumes of 80,000 – 300,000 m^3 of LNG. The consignees in Norway are small users such as local industries or towns. Base-load LNG users are typically complete Nnatural gas networks with thousands or even millions of users. An intermediate market position is presently developing where new ships are under construction with loading capacities of 7,500 – 10,000 m^3 of LNG. These are neither bound by the concepts of large-scale base-load imports nor by small-scale distribution, creating a new type of market.

Both Gasnor and Skangas (Norwegian companies) should now have in place arrangements so that LNG can be extracted with small-scale vessels from Zeebrugge.

The industry in Norway is fully aware of the development in Europe as of the GATE terminal in Rotterdam with a capacity of 510,000 m3, is now being expanded to deliver LNG in small-scale volume since 2016, along with Grain LNG at Isle and Grain in England with a capacity of one million m^3. This terminal will facilitate the refilling of small-scale LNG carriers, where Grain LNG has previously facilitated the filling of LNG trailers for deployment on land.

Governmental incentives for cleaner energy have intensified the shift towards more clean solutions. Examples of such incentives are the NO_x fund, Enova, and stricter ferry tenders.

Some harbors, Oslo and Bergen, have lower fees for the most environmental friendly vessels (dependent on ESI-index).

The infrastructure for LNG is not finally developed, and further development is required for LNG as fuel for ships to become a mature market, but the creation of new terminals should be in line with increased demand.

4.7.5.1 CHALLENGES AND FUTURE PROSPECTS

The Norwegian players in the use of LNG as fuel for ships have initiated a project to develop a new bunkering procedure that does not include intentional emissions of methane, takes less time, and increases safety.

The continued extension of LNG infrastructure, including vessels, has slowed down. Interest persists in exporting LNG and for use in already developed facilities. Norway's own industry now focuses on greener energy, for example on batteries. For the NO_X-fund, LNG-based projects are not interesting anymore.
Biokraft AS and TrønderEnergi have built a new production plant for Liquid Biogas (LBG). The investment cost amounts to about 370 million NOK. Initially, a 125 GWh Liquid Biogas (LBG) was be produced, with a planned increase to 250 GWh (Scandinavian Biogas, 2016; Wärtsilä, 2016).

4.7.6 Poland

Poland has a national strategy for the development of LNG, which is in line with the Trans-European Energy Networks – TEN-T and TEN-E and Plans for EU Gas Connectivity and Interconnection in Europe. As of 2017, the LNG bunkering network and rolling stock in Poland consisted of 3 LNG refueling stations and 46 LNG powered buses and one truck. Apart from the planned LNG bunkering facilities of the Polish core ports (two in Gdańsk, Gdynia and two in Szczecin and Świnoujście), according to the TEN-T corridors and establishment of LNG in Poland, 14 refueling stations on roads have to be made available by 2025, eight along the Baltic-Adriatic Corridor, three along the North Sea-Baltic Corridor and three along other roads.

At the same time, there are 26 CNG refueling stations, 431 CNG buses and in total 3,600 vehicles powered by CNG. The Polish gas grid, is operated by Polska Spółka Gazownictwa Sp. z o.o., the largest operator of gas distribution systems in Europe. It consists of 179,000 km of distribution grid and handles 9.82 bln m^3 of natural gas every year. The distribution grid covers 57.8% of the municipalities, meaning that over 40% of the municipalities are without gas coverage. This in turn provides opportunities for local regasification plants:

- dozens of home and small scale LNG plants (4-20 m^3)
- several large-scale LNG plants > 20 m^3.

Figure 35 shows potential distribution: orange color represents areas covered by the national gas grid.

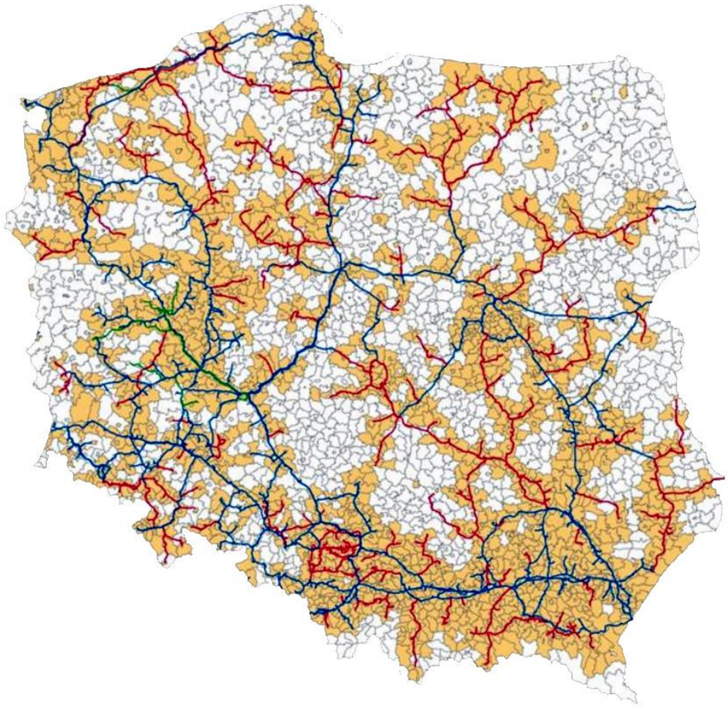

Figure 35. Potential distribution: Orange color represents area covered with national grid. Source: Polska Spółka Gazownictwa (2016).

Figure 36. Map of existing and planned LNG infrastructure on the polish coast.

- CNG in agglomerations
  - 72 in 32 Polish agglomerations (Warszawa 6)

Figure 21 shows the forecasted number of vehicles CNG (blue line) and LNG (red line).

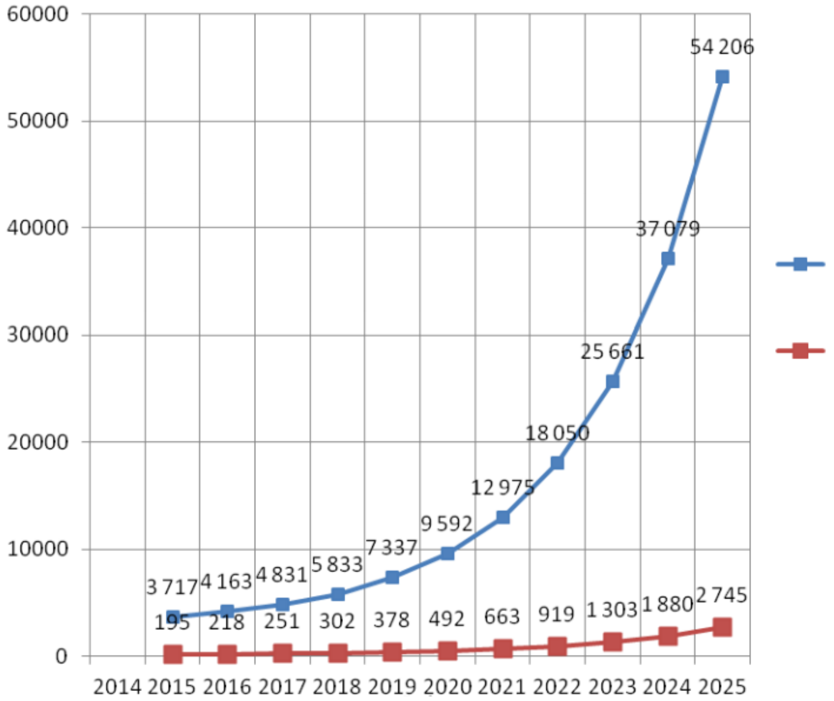

Figure 1. Forecast of number of vehicles. Blue CNG, red LNG (from Polish ministry of energy).

4.7.6.1 CHALLENGES AND FUTURE PROSPECTS

The LNG import terminal's main purpose was to diversify gas supplies in Poland and reduce the dependence on pipeline imports from Russia. So far, LNG is not as popular as a fuel. In the maritime field, there are no benefits for ships which have less impact on the environment already or for ships which give off harmful emissions and must pay high fees for water pollution in ports. But there are plans to implement the following rules:

- no obligation to pay income tax on usage cars for private purposes if the company uses low-emission vehicles
- favorable tax depreciation on the purchase of low-emission vehicles for businesses
- the introduction of a more favourable tonnage tax rate for "green ships"the introduction of more favorable rate registration fees for ships powered by alternative fuels.

There is a national strategy for LNG road filling stations and LNG bunkering facilities regarding infrastructure and alternative fuels. The goal is to install 14 LNG road filling stations and bunkering services in 4 main seaports by 2025.

Poland's planned innovations can be summarized as follows:

- LNG bunkering of vessels
- LNG-powered vessels
- LNG container
- LNG buses
- Small LNG power plants
- The recovery of "cold energy".

4.7.7 SWEDEN

The Swedish government has set the ambitious goal of becoming the first fossil fuel free country in the world by 2050. This means that the domestic transport sector is to be free of fossil fuels by 2030 and heavy industry is to be free from fossil fuels by 2050. In a state investigation made in 2013 (Fossilfrihet på väg, 2013), it was stated that for the transport sector to reach its goal, about 20TWh of biofuel will be needed, which is a doubling from 2013. It was further stated that 12 out of 20 TWh could be made up of biogas.

The establishment of large LNG terminals will only be made in very restricted numbers in Swedish ports. The types of vessels visiting such a terminal are too big; only a couple of the Swedish ports are able to handle these vessels. Also, large land areas need to be covered by the supply of LNG. Therefore, the Swedish strategy to fulfil EU transport and environmental strategies is to make sure that the different regions of Sweden will be able to provide LNG for those that ask for it. This will be done through a couple of main LNG terminals from which LNG will be distributed to smaller ports in smaller volumes using bunkering vessels or by trucks to LNG refueling stations and industry. There is a difference between Sweden and the rest of Europe in its potential LNG use. In other European countries, LNG is imported to a well-advanced gas network and either replaces pipeline natural gas or adds capacity to the network. In Sweden, LNG would replace other energy sources, by making natural gas available to more locations. Natural gas currently covers 2% of the energy demand in Sweden. In Europe, this figure is 20%. The area covered is concentrated towards the west coast. The amount of biogas in the gas grid for vehicle gas was 70% as an average across Sweden in 2015. About 25% of the public transport buses can use methane/vehicle gas.

The emerging infrastructure for LNG in Sweden gives many industries the opportunity to use natural gas as a fuel instead of oil. The Swedish heavy industry (basindustri) has to replace oil and coal. It has been estimated that there is a potential to replace 10 TWh of oil with LNG. According to the Port of Gothenburg, once their LNG terminal is up and running, they will be able to provide half of the amount of LNG needed in the industrial sector. According to Stenkvist et al. (2011), many industries within the iron and steel making industry, as well as in the chemical industry, are interested in converting to LNG as a fuel source. Practically, the LNG terminals can distribute LNG to industries that are at a distance of approximately 300-350 km from the facilities, beyond which it becomes too expensive. A minimal critical volume of 15 GWh has to be delivered to a factory that wishes to use LNG; for lower volumes, it becomes too expensive (compared to oil). It should be mentioned that the LNG terminals in Sweden would not have been built if they had not had customers in the heavy industry sector and refineries. LNG is requested by several large industries that wish to use natural gas but who are situated too far away from the Swedegas national gas grid. Indeed, according to Swedegas, getting hold of natural gas could be a matter of survival for companies. Swedegas envisions that natural gas transported as LNG by boat might solve the coming problem, but there is indeed a need for terminals in strategic locations. It is also perceived that sustainable and competitive open gas distributions systems are paramount for the Swedish industry, maritime transport, and other transport to be able to get rid of their oil dependency.

To date, almost all natural gas in the Swedish system comes from the Danish gas fields in the North Sea while LNG is imported from Norway.

It is believed that, just like natural gas opened the market for biogas in Sweden, LNG will support the market development for LBG, which will also be safer and more secure. Today, there are major problems related to the logistics and distribution of biogas that could be helped by liquefaction. Once the market for LBG is open, more research and development on technical issues related to LBG are likely to take place. The economical potential of biogas is estimated at 22 TWh through anaerobic digestion and a further 60 TWh in conjunction with thermal gasification. Biogas can be transported together with natural gas in the Swedish gas grid.

According to the Swedish Gas Association (a member-funded, industry association dedicated to promoting a greater use of gas energy) the following areas should be prioritized:

- Increase knowledge and acceptance of gases used in the energy sector.
- Increase awareness of the growth conditions of the gases and the need for political guidelines, goals, and strategies.
- Develop guidelines, industry standards, and authorization in the whole gas field.
- Offer professional courses toward a safe, environmentally friendly, and efficient use of gases.

4.8 World Energy Outlook 2017

The International Energy Agency (IEA) in cooperation with OECD monitored the status of the energy in the world and provided in-depth insights on the outlook of the world energy by 2040. In the associated report (World Energy Outlook, 2017), three scenarios were considered, as follows:

- First scenario is the Current Policies Scenario in the world.
- Second is the New Policies Scenario where existing policies might lead the energy system, in the anticipation that this will inform decision-makers as they seek to improve on this outcome. In the New Policies Scenario, global energy needs rise more slowly than in the past but still expand by 30% between today and 2040 (OECD/IEA, 2017).
- Third scenario is the Sustainable Development Scenario, which outlines an integrated approach to achieve the energy-related aspects of the UN Sustainable Development Goals.

Only the Sustainable Development Scenario offers an integrated way to achieving a range of energy-related goals which are crucial for sustainable economic development: climate stabilization, cleaner air, and universal access to modern energy, while also reducing energy security risks. Figure 37 illustrates gas use projection by 2040 in three scenarios. It shows an average increase by 1.6% per year, on average, in the New Policies Scenario (OECD/IEA, 2017).

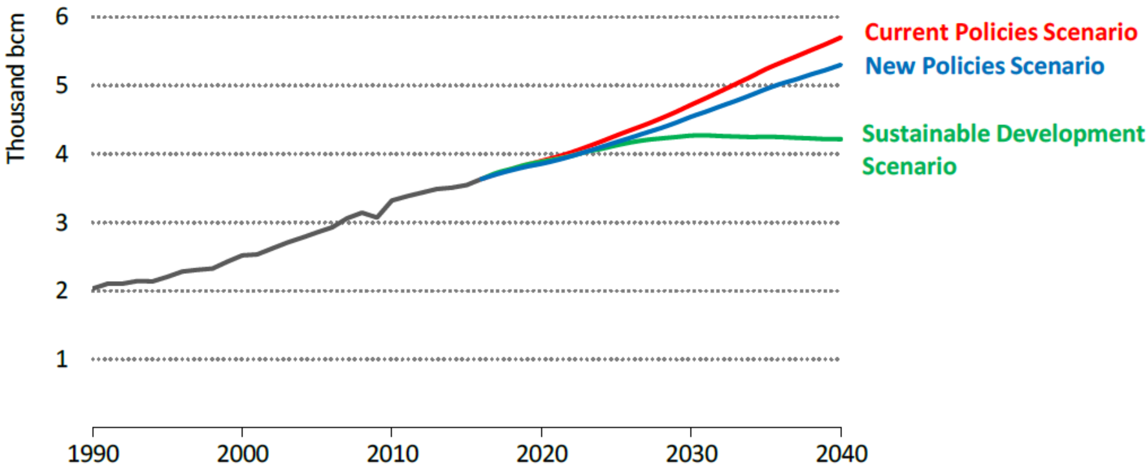

Figure 37. Worldwide natural gas demand in three scenarios. Note: bcm = billion cubic meters. Source: World Energy Outlook, (2017).

In the New Policies Scenario, the worldwide consumption of natural gas increases by 45% in the coming 25 years, while industry will account for a third of the growth, slightly ahead of the gas consumption in the power generation sector. In the New Policies Scenario, the underlying policy of gas consumption growth of 1.6% per year between 2016 and 2040 is a stark deceleration compared to the 2.3% observed over the past 25 years. However, in this scenario, gas expands its share in primary energy supply from 22% in 2016 to 25% in 2040 (OECD/IEA, 2017).

The United States will be the biggest global gas supplier (with 300 bcm = billion cubic meters) over the next 25 years, more than any other country, followed by China (200 bcm), Russia, and Iran (both around 145 bcm). Except for the pipelines to China from Russia and Turkmenistan, supplies of LNG in the world will make it hard to construct many new cross-border pipelines. The European Union is predicted to be the biggest importer of gas by 2040 (OECD/IEA, 2017). In the New Policies Scenario, the United States, i.e., the world's largest gas producer, will become the largest LNG exporting country by the mid-2020s. Gas consumer countries are looking for gas with low prices and to secure additional volumes of LNG. As illustrated in Figure 38, approximately 140 bcm of liquefaction capacity is under construction in the world, which is expected to be in service in the next few years (OECD/IEA, 2017).

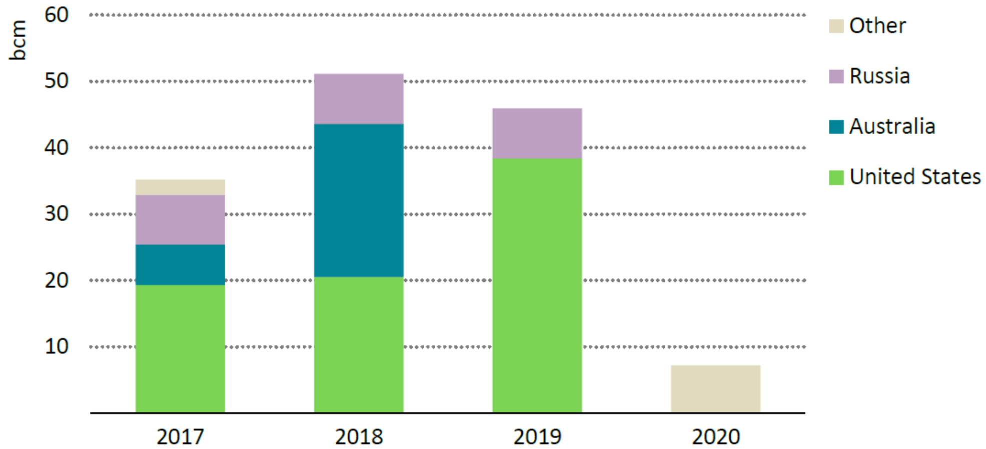

Figure 38. Liquefaction capacity currently under construction and year of first commercial operation. Source: World Energy Outlook, (2017).

Within the Sustainable Development Scenario, gas demand growth will be an average of 0.6% annually. It will experience a continuous growth up to the year 2030, due to its contribution to achieving the environmental goals, notably in phasing out coal. However, in 2030, gas consumption is expected to plateau because of the energy efficiency improvements and the rise in the share of lower-carbon fuels in the primary energy supply (OECD/IEA, 2017).

The Current Policies Scenario, which assumes no new measures beyond those adopted up to now, predicts a rise of 1.9% in annual gas demand by 2040 and the share of gas in primary energy supply basket is expected to reache 24% in 2040 (OECD/IEA, 2017).

4.9 Sectoral trends in gas demand

As indicated in Figure 39, industry is expected to drive the demand for gas upwards in the period leading up to 2025, but thereafter, momentum shifts to the power sector. Apart from the rising needs of natural gas in Asian industries, much of the growth in gas demand in new policy scenarios will materialize in the United States and in the Middle East, due to the cheap gas availability for industries (OECD/IEA, 2017).

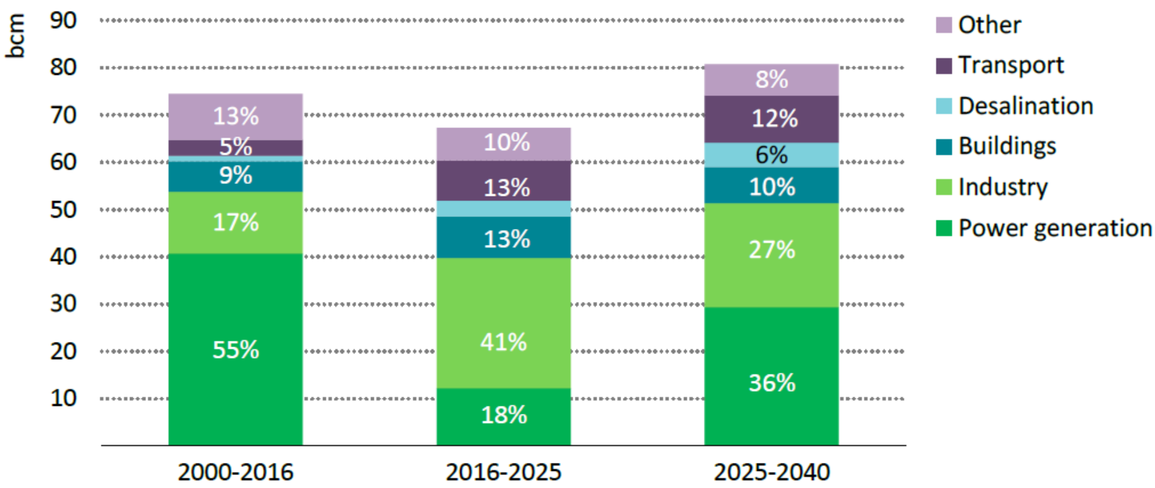

Figure 39. Annual growth of global natural gas demand by sector in the New Policies Scenario. Source: World Energy Outlook, (2017).

The remaining natural resources of gas are sufficient to meet the global demand growth until 2040 in all three scenarios of current policies, new policies, and sustainable policies. Proven reserves were at some 215 trillion cubic meters (tcm) at the end of 2016, equal to around 60 years of production at current output rates. The global production of natural gas will increase from 3,621 in 2016 to 5,304 in 2040. (Table 10). The United States, Russia, and Iran are the three largest gas producers today, a ranking that remains unchanged over the Outlook period although China will come close to that of Iran by 2040 (OECD/IEA, 2017).

Table 15. Natural gas production by region in the New Policies Scenario (bcm). Source: World Energy Outlook, (2017).

	2000	2016	2025	2030	2035	2040	2016-40	
							Change	CAAGR*
North America	**763**	**960**	**1 166**	**1 212**	**1 282**	**1 338**	**379**	**1.4%**
Canada	182	174	159	165	190	222	49	1.0%
Mexico	37	37	35	38	48	58	21	1.9%
United States	544	749	971	1 009	1 043	1 058	309	1.4%
Central & South America	**102**	**175**	**178**	**207**	**242**	**279**	**104**	**2.0%**
Argentina	41	42	53	70	90	104	62	3.9%
Brazil	7	24	28	43	60	77	53	5.0%
Europe	**337**	**285**	**244**	**238**	**236**	**236**	**- 49**	**-0.8%**
European Union	264	134	91	85	80	76	- 58	-2.3%
Norway	53	121	105	101	99	100	- 22	-0.8%
Africa	**124**	**205**	**273**	**330**	**392**	**460**	**254**	**3.4%**
Algeria	82	92	97	102	107	113	21	0.8%
Mozambique	0	5	13	32	49	64	59	11.6%
Nigeria	12	41	46	45	56	70	29	2.2%
Middle East	**198**	**585**	**703**	**832**	**931**	**1 003**	**418**	**2.3%**
Iran	59	190	243	301	332	338	149	2.4%
Qatar	25	165	182	214	240	256	91	1.8%
Saudi Arabia	38	90	107	120	131	142	52	1.9%
Eurasia	**691**	**842**	**935**	**978**	**1 035**	**1 095**	**252**	**1.1%**
Azerbaijan	6	19	37	44	51	55	36	4.6%
Russia	573	644	718	730	752	788	144	0.8%
Turkmenistan	47	80	86	102	124	141	61	2.4%
Asia Pacific	**290**	**568**	**675**	**749**	**832**	**894**	**326**	**1.9%**
Australia	33	88	149	162	188	195	107	3.4%
China	27	137	222	261	298	336	199	3.8%
India	28	31	42	59	72	84	53	4.3%
Indonesia	70	77	70	73	80	90	13	0.6%
Rest of Southeast Asia	89	146	128	131	131	127	- 19	-0.6%
World	**2 506**	**3 621**	**4 174**	**4 545**	**4 950**	**5 304**	**1 683**	**1.6%**
Unconventional	196	780	1 180	1 320	1 486	1 654	874	3.2%

* Compound average annual growth rate.

4.10 Demand and Supply insights in the European Union

Gas use in the European Union (EU) countries increased by 7% in 2016. Higher gas demand for power generation was the main driver of this trend, and the power sector will remain central to the long-term prospects of gas in the European Union. Since the EU is pursuing the target of cutting greenhouse-gas emissions by 40% (compared with 1990 levels) by 2030, many coal power plants will be out of operation which gives space for gas in the power sector, even with growth of the renewables share over the same period until 2040 (OECD/IEA, 2017). Another momentum to enlarge gas usage in the EU power system arises from an increasing downbeat future for nuclear power. As a result, gas use in the power sector expands slightly in the period up to 2040. Natural gas consumption in the European Union stays around current levels for most of the projection period (Figure 30). Even with a flat demand outlook, the European Union's gas imports increase by 2040 as domestic output production experiences a considerable decline. The European Union nevertheless is well prepared for substitution of the dropping domestic output with an increase in imports. This flexibility comes from a well-functioning internal gas market, many regasification terminals, and a wide portfolio of pipeline import routes (OECD/IEA, 2017).

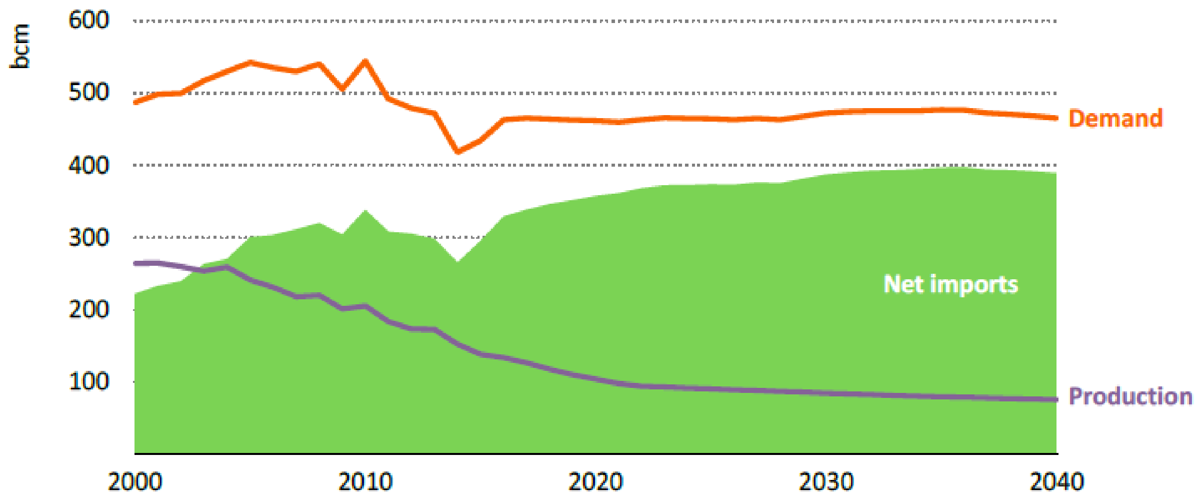

Figure 40. Natural gas balance of the European Union in the New Policies Scenario. Source: World Energy Outlook, (2017).

Since it is projected that 80% of the EU coal-fired capacity will retire by 2040, gas security gains more attention and will remain an important topic on policy-makers' agendas. The projection for the EU gas import shows an increase by some 60 bcm, reaching around 390 bcm in 2040. Russia remains the largest supplier of gas to the European Union, with its market share being approximately 40%. Production in Norway, the second-largest source of imports, is expected to remain at high levels over the next few years (OECD/IEA, 2017). However, Norway faces the prospect of declining export availability over the longer term; after 2020 production is expected to gradually decline towards the end of the Outlook period in 2040. As Norwegian gas exports drop, other suppliers will have a greater chance of accessing the European gas market. Chief among them are US LNG suppliers, who will reach a market share of just over 10% in 2025. Together with LNG from other sources, the European Union's dependence upon pipeline gas imports will drop from over 85% in 2016 to two-thirds in 2040 (OECD/IEA, 2017).

4.10.1 Trade and investment in LNG - Drivers

Global Inter-regional gas trade faces an increase of 525 bcm in the period up until 2040, meaning a yearly growth rate of 2.4% on average, close to the same rate over the past 25 years. The importance of inter-regional LNG trade grows substantially with nearly 90% of the incremental volumes traded over long distances taking the form of LNG compared to just under two-thirds in the past 25 years. The growth of LNG trade is underpinned by several factors,the flexibility offered by LNG being one of the most important ones. LNG provides countries with the possibility of avoiding commitment to a long-term supply contract. Flexibility in supply is also essential in order to meet seasonal demand fluctuations. LNG enhances security of supply to countries through diversification of their gas procurement portfolios with the examples of regasification terminals in Lithuania, Poland, and Jordan (OECD/IEA, 2017).

Some gas buyers might choose LNG rather than oil products because of the cheaper gas price. With advancement in gas industry and technologies, development of the small-scale LNG facilities, and the rise in distribution terminals, LNG slowly takes the role as a fuel for smaller countries and islands. Generally, growth of energy demand along with the political will to meet this demand with cleaner and more flexible sources are the key drivers for gas import rise in many countries worldwide (OECD/IEA, 2017).

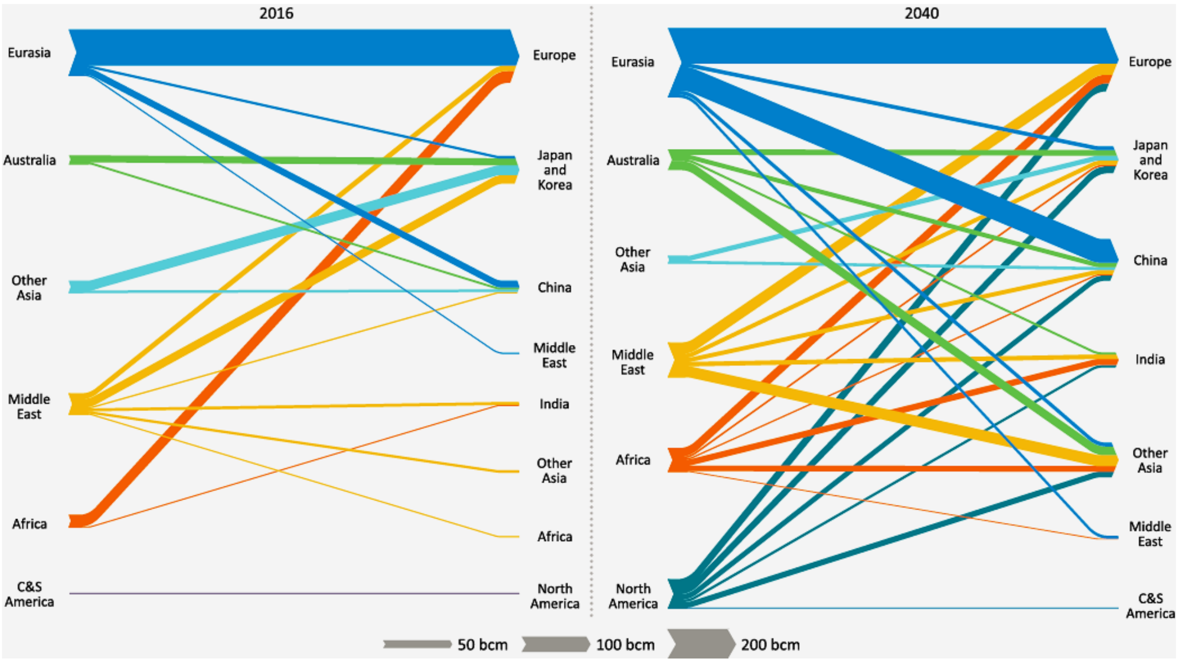

Figure 41. Global gas trade flows in the New Policies Scenario (bcm). Source: World Energy Outlook, (2017).

4.10.2 How is the market for LNG shipping evolving?

The number of LNG vessels increased from 340 to 460 between the years 2011-2016. This reflects an LNG demand for shipping of 70 million cubic meters in 2016, with a rise of 35% from 2011 levels. Currently, the LNG shipping market is in an over-capacity phase, which resulted in low charter rates. New LNG vessels will be needed in the first-half of the 2020s along with the expected growth of the US LNG export (OECD/IEA, 2017. (See Figure 42).

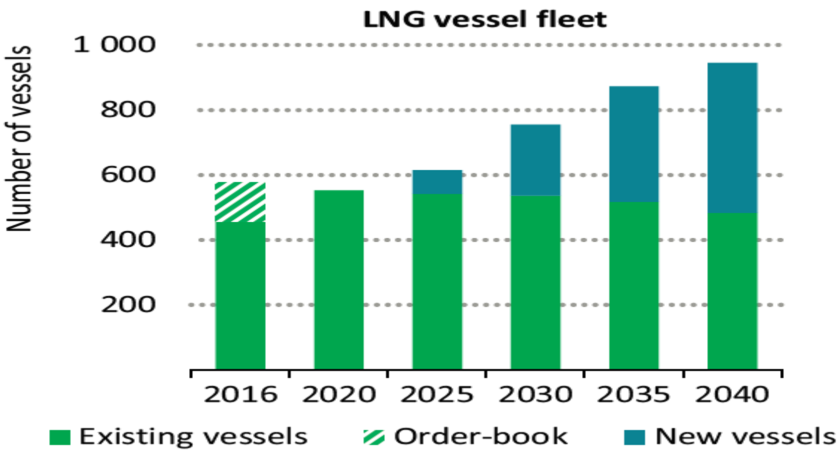

Figure 42. LNG-powered vessel fleet in the New Policies Scenario. Source: World Energy Outlook, (2017).

How might LNG change the game?

As per the New Policies Scenario, a rise of 40% in gas production is projected in the United States by 2040, mainly due to the growth in shale gas production. The move towards a more diverse, flexible, and liquid global gas market has important implications for investment with significant benefits such as energy security. In the short-term, uncertainties over the market outlook and the shift in contractual and pricing arrangements will likely be in favor of smaller supply projects or of the expansions of existing facilities. However, the challenges for long-term investments are likely to generate enough confidence between sellers and buyers in the emerging gas markets which will serve as the basis for their future plans (OECD/IEA, 2017).

As the North American local market is not large enough to consume the rise in US gas production, the additional gas produced will be exported to other countries in the form of LNG. In the mid-2020s, the United States will temporarily be the world's largest exporter of LNG (OECD/IEA, 2017).

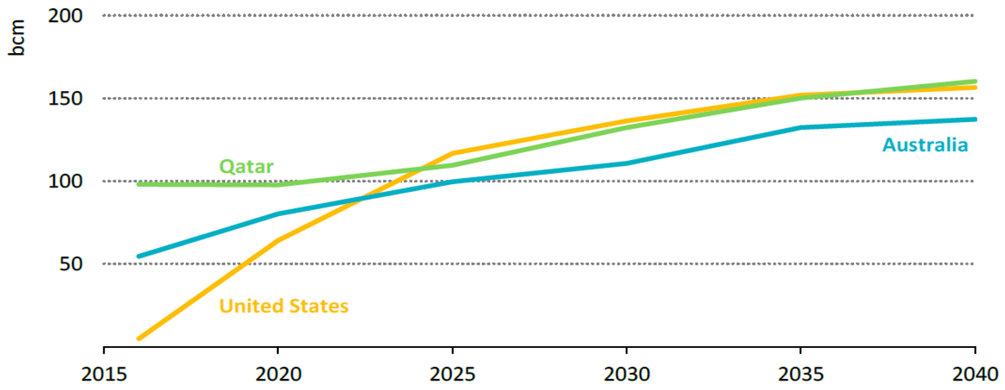

Figure 43. Selected LNG exports in the New Policies Scenario. Source: World Energy Outlook, (2017).

The trade of gas is changing internationally. Flexibility in delivery place, pricing based on gas-to-gas competition, and shorter contract durations have gradually affected the global gas markets. Recent exporters such as Australia, Angola, and Papua New Guinea have led to increasing LNG supplier diversity. However, the main momentum towards a more competitive gas market arises from the stark increase in LNG production in the United States in recent years (OECD/IEA, 2017).

The best practices in the transport sector developed inside and outside the BSR are described in Table 16.

Table 16. Best practices in the transport sector developed inside and outside the BSR

Best practice	Location	Description	Related picture	Link
The gas-powered VOLVO FH LNG engine	**Sweden**	Comes with a 420 or 460 hp engine that delivers performance and productivity on par with a regular Volvo FH with the same power rating. As a result, it emits 20% less CO_2 than a regular Volvo FH. Allowing transport operators to take big steps towards sustainable transports. When fueled with bio-LNG, CO_2 emissions can be reduced by 100%.		http://www.volvotrucks.com/en-en/trucks/volvo-fh-series/volvo-fh-lng.html
Green Coastal Shipping Programme	**Norway**	Norway has established a joint program between government and industry to create the world's most effective and environmentally-friendly fleet of coastal vessels. The program is aiming to revolutionize the way coastal shipping operates, converting fleets to run partly or entirely on batteries, liquified natural gass (LNG), or other green fuels. The program has now presented the first five pilot projects focusing on environmentally-friendly fuels and energy efficient design.		https://www.dnvgl.com/maritime/research-and-development/futuristic-projects-transform-coastlines/index.html
LNG Lokomotive	**Russia USA Spain**	RUSSIAN Railways (RZD), Gazprom, Transmashholding (TMH) and Sinara signed an agreement on June 17th at the St Petersburg International Economic Forum aimed at increasing the use of natural gas as a fuel for rail transport. FLORIDA East Coast Railway (FECR) has become the first North American railway to adopt liquefied natural gas (LNG) for its entire line-haul locomotive fleet. US- FECR officially unveiled its modified fleet of 24 GE ES44AC locomotives, which operate in pairs with a purpose-built fuel tender supplied by Chart Industries, United States. Spain- The project, which is a joint venture between train operator Renfe, Gas Natural Fenosa, and Enagás, is being implemented within the framework of Spain's 2014-2020 strategy for developing vehicles with alternative energy (VEA) and is also part of Renfe's drive to explore the use of alternative fuels.		http://m.railjournal.com/index.php/tag/LNG.html

Best practice	Location	Description	Related picture	Link
Hybrid LNG Barge for cold ironing to cruise ships	**Germany**	The Hummel LNG Hybrid barge is the world's first environmentally friendly hybrid liquified natural gas (LNG) barge built by Becker Marine Systems. The vessel is a floating power plant providing clean and efficient cold ironing power to cruise ships. It also acts as a backup power bank to the local electric and power grid. Compared to the current method of producing energy using onboard diesel engines, power supplied by the LNG Hybrid Barge will lead to a dramatic reduction of harmful CO_2, NO_X, SO_X and particle emissions during layovers at port.		https://www.becker-m
Gas trucks boom in China as governmen t curbs diesel in war on smog	**China**	LNG trucks account for about 4% of the more than six million heavy vehicles able to haul 40 to 49 tons of goods that are currently on China's roads. The vast majority of the 43 billion tons of freight transported across China last year was by highway. But demand for LNG trucks is soaring as companies and manufacturers shift to vehicles that run on the gas that Beijing sees as a key part of its war against smog.		https://www.reuters.com/article/us-china-pollution-gas-trucks/gas-trucks-boom-in-china-as-government-curbs-diesel-in-war-on-smog-idUSKBN1CC0T0
Applied LNG wins supply deal for LA fleet	**USA**	Energy solutions provider, Applied LNG has been awarded a contract by the City of Los Angeles to supply renewable liquefied natural gas (RLNG) to fuel their fleet of natural gas vehicles. The fuel will be delivered to multiple Los Angeles LNG/LCNG stations where it will be dispensed as RLNG or converted into compressed renewable natural gas.The renewable LNG is derived from biomethane or biogas naturally generated by the decomposition of organic waste, then processed, purified, liquefied, and transported to the City of Los Angeles fueling stations. The expected volume will be over 5.6 million LNG gallons per year reducing greenhouse gases by 90% compared to that of traditional diesel and gasoline, according to the company.		http://www.lngbunkering.org/lng/bunkering/developments-in-ports/lng-shipping-fuel-port-los-angeles
VTG unveils LNG tank wagon for Europe	**Czech**	VTG has unveiled what it says is Europe's first tank wagon for transporting liquefied natural gas (LNG) at the Transport and Logistics trade fair in Munich. VTG has developed two prototype wagons to demonstrate its "LNG by Rail" concept, which was developed over the past three years in partnership with Chart Ferox, Czechia, which built the wagons.		http://m.railjournal.com/index.php/rolling-stock/vtg-unveils-lng-tank-wagon-for-europe.html?channel=000

Best practice	Location	Description	Related picture	Link
The Rotterdam port sees LNG-fueled future	**Netherlands**	The port of Rotterdam is one of the biggest hubs for the distribution of LNG in Europe. The port is also home of the Dutch first terminal, Gate, where small-scale is a daily business and, as of 2017, Shell's bunker vessel Cardissa regularly loads LNG and delivers the fuel to northwest Europe. The Port Authority "wants to encourage the transition from fuel oil to LNG as a transport fuel for the shipping sector,". Attractive incentives are offered •Environmental Ship Index (ESI)--Only in Rotterdam, a 20% discount on port dues applies for LNG-propelled vessels •PoR LNG bunkering incentive program--PoR offers an additional 10% discount on port dues when bunkering LNG in Rotterdam •Green Award--Incentive program for LNG-fueled barges with a 30% discount on port dues •Partner in European funding projects 2011: Truck-to-ship bunkering Seinehaven (inland navigation) 2015: Dolphin for ship-to-ship transfers including bunkering (sea going vessels) 2015: Truck to ship bunkering sea going vessel 2016: LNG Gate 3, Yukon haven operational loading LNG bunker vessels (+ bunkering) 2017: 1st LNG bunker vessel for ship-to-ship bunkering (sea going vessels) 2018: 2nd LNG bunker vessel for STS (Inland and sea going vessels) Further ambition: shore based bunker facility (inland)		http://www.vm.nrw.de/verkehr/schifffahrt/Hafen--und-Logistikkonferenzen/LNG-in-der-Binnenschifffahrt/4_-Vortrag-Boon_22_02_2017.pdf https://www.lngworldnews.com/dutch-rotterdam-port-sees-lng-fueled-future/
The world's first dual-fuel/LNG asphalt tanker	**North America**	The World's first dual-fuel / LNG asphalt – bitumen tanker is specially designed for St. Lawrence Seaways and for operation in the harsh environment of the great lakes of North America. The vessel has been designed for maximum fuel and propulsion flexibility allowing for efficient and environmentally friendly operation at all times. The Vessel has power take home features which are the same as a number of safety features for safe operation within the polar areas.		https://www.newswire.ca/news-releases/desgagnes-takes-delivery-of-the-worlds-first-dual-fuel--lng-asphalt-tanker---the-mt-damia-desgagnes-617725703.html
Port of Antwerp: first alternative energy hub for LNG	**Belgium**	Antwerp Port Authority has signed a 30-year concession agreement with the ENGIE energy group to develop an Alternative Energy Hub. The construction of the bunkering facility has made LNG "permanently available in the port of Antwerp," the port authority said. The port of Antwerp has long encouraged the use of this environmentally friendly fuel. Since 2012, there have been facilities in the port for truck-to-truck, ship-to-ship, and terminal-to-ship bunkering with LNG. Now, thanks to this agreement, it will be possible for all port users to fill up with LNG at any time.		http://www.portofantwerp.com/en/news/first-alternative-energy-hub-lng

Best practice	Location	Description	Related picture	Link
Workshop on LNG bunkering to Port Authorities & Administrations 12.1.2016-12.2.2016	**EMSA**	■ LNG for shipping - EU policy with regard to the use of LNG in maritime transport ■Development of the EMSA Guidance on LNG Bunkering to Port Authorities ■Standards & Guidance on LNG Bunkering ■LNG bunkering infrastructure in the EU ■Administrations : Procedures PART PART 1 - Port Management for LNG Bunkering ART PART 2 - LNG Bunkering Operation and Port Authority PART3 - LNG Bunkering Safety PART 4 – Permitting		http://www.emsa.europa.eu/main/air-pollution/items.html?cid=188&id=2905
The Bunker Holding Group has established a collaborative effort with Danish partners in the green-energy market to launch a new LNG project.	**Denmark**	In order to have LNG delivered in Denmark, it is necessary to transport the gas from one of the large LNG terminals outside Denmark. The establishment of the production facility in Frederikshavn will make it possible to exploit the well-developed natural gas grid available in Denmark to produce local LNG, ensuring fast, efficient, and safe delivery of gas to customers. Peter Zachariassen, Head of Physical at Bunker Holding, described the project: “We expect a rising demand for LNG in the years ahead, and we have been good at finding the perfect business partners. Our extremely well-organized set-up means that we are ready to cover all of Denmark and Sweden. LNG is part of the future, and it is important for us to be at the cutting edge of developments and to be able to offer our customers diversification in our product portfolio. Thus, several shipping companies have already taken great interest in our project which helps to emphasize Denmark’s focus on green energy”.		http://www.greenport.com/news101/lng/new-lng-project-in-denmark https://www.gasworld.com/new-lng-project-launched-in-denmark-/2009954.article
LNG-powered heavy trucks tests	**Poland**	4.11.1.1 LNG supplying company Crygas M&T Poland in cooperation with truck provider Iveco Poland, transport service provider Link Transport, and big shippers Unilever and IKEA, carried out the long term road tests aiming at measurement of LNG truck efficiency and performance in comparison to Diesel standard trucks. The tests confirmed the reduction of carbon dioxide emissions and the reduction of fuel consumption and, consequently, the reduction of costs which confirmed the economic viability of using LNG-powered trucks. 4.11.1.2 https://www.cryogas.pl/pliki_do_pobrania/artykuly/Cryogas_IVECO_Report._Polish_road_tests_.pdf		

Best practice	Location	Description	Related picture	Link
		4.11.1.3 https://www.cryogas.pl/pliki_do_pobrania/artykuly/20171110_Raport_LNG_Unilever_Link_Iveco_.pdf		

4.12 New business opportunities and cooperation

New business opportunities could be identified through an analysis of the prospects offered by the natural gas market. The current general context is that natural gas provides 22% of the energy used worldwide and accounts for almost a quarter of electricity production and also plays a key role for industry as a raw material. (Source OECD / IEA, 2017).

A better understanding of the variables that influence the development of the market is given by the definition of the drivers, specifically "market drivers" and "regulatory drivers".

The drivers of the market include the "environmental drivers" represented by the growing decarbonization needs of the economy and the reduction of polluting emissions. Macroeconomic drivers include the growth rate of the general economy, the inflation rate, the cost of energy, the trend in exchange rates, and the level of interest rates. The "technical drivers" can include new applications or the modularity and flexibility of small-scale LNG technologies. Finally, the "economic and development drivers" are given by the possibility of expansion and industrial development starting from the naval sector (through the fleet retrofitting, the construction of new ships, and the relative growth of the port areas), up to the development of the modalities of transport (Source OECD / IEA, 2017).

The regulatory drivers represented by environmental legislation (for example Nitrogen Oxides Control Areas - NECA and Sulphur Emissions Control Area - SECA) illustrated in the previous paragraphs play a role of primary importance in permitting an adequate development of the entire LNG value chain.

Moreover, considering the context above, a harmonious development of the LNG market involves the LNG value chain (liquefaction, storage, transport, regasification) appropriately integrated to optimize efficiency, through the minimization of costs and improving effectiveness, with the result of maximizing the services offered. A key role in improving the LNG value chain is likely to be played by technological innovation.

An additional key element for creating new business opportunities is represented by the new types of LNG users, such as transport from the maritime, railway, road, and heavy industries, as well as by the integration of biogas into gas networks. A portion of the generation of the market demand depends on them.

An appropriate market can create the conditions for the growth of an ecosystem of companies that operate or wish to operate in the supply chain or in the value chain related to the production of LNG. Their presence is important in creating adequate economies of scale.

Focusing on the BSR from a strategic point of view, it would be essential to strengthen the achievement of the following objectives:

Upstream level:
Exploitation and marketing of natural gas reserves

Increased security in supplies:
To achieve a diversification of LNG supplies, the risk of dependence on pipelines of traditional producers belonging to politically unstable countries must be minimized.

In order for LNG to have adequate development and diffusion in the transport sector from road logistics, it is necessary to support the development of onshore terminals in the areas of the BSR.

Infrastructure investments in Poland and Lithuania in connection with import terminals allows the two countries to access global LNG markets.

From this derives the advantage of diversification of supplies, ensuring greater security in regards to energy supply.

The development of small-scale LNG infrastructures can allow for the expansion of the contracts portfolio. These are characterized by:

- small dimensions of the terminals
- LNG ships and tankers with specific maximum capacities.

This translates into the possibility of LNG delivery to end consumers without a pipeline and to the development of a capillary network that allows access to LNG for various end users: Road, maritime, industrial, and power and heat generation.

In order to increase their competitiveness, the BSR countries importing LNG could evaluate the optimization of their portfolio, renegotiating long-term LNG import contracts and spot contracts. The development of small-scale LNG also creates opportunities for new markets.

In a context as the one hypothesized above, there would be an increase in competition in the region that would bring with it the typical advantages of a competitive market (stimulation of innovation and pursuit of efficiency by companies).

The energy and utilities sector is going through a historic moment of great dynamism, of structural change both at a global level and at a European level. These conditions lead to new perspectives on traditional business models.

In this present and future context, the sector operators will have to try to achieve strategic and competitive positioning in order to maximize the creation of value generated by effective monitoring of the different parts of the value chain, both regarding upstream production and import of raw materials, gas and electricity, and downstream distribution and sale to end users.

In a past context characterized by the traditional transport of natural gas through pipelines (with the limits represented by geopolitical and known risks), the growth of LNG production has encouraged greater competition from the supply side through access to the market by new competitors.

The profound changes illustrated herein, represent an opportunity for growth and development for the entire BSR area in terms of the continuous search for new and better ways of producing and supplying services. The challenges of the industry are represented by the pursuit of continuous innovation, which will result in developments in the LNG sector that will impact the countries of the entire BSR area.
If gas companies will invest in downstream activities, and markets and if they look for added value upstream, these trends will result in a growing integration into the LNG value chains.

4.12.1 For how long will LNG be the best available option?

LNG is competing against other energy sources, such as oil, but also against renewable energy such as wind energy, solar energy, and biogas. After all, LNG is a fossil fuel with a more negative environmental impact than other energy sources. These aspects could be considered by policy makers and hence from an environmental perspective, they could argue against the promotion of LNG. It is therefore challenging to define which energy sources should be promoted in order to achieve environmental improvement for the shipping industry but also for industry as a whole. LBG, batteries, and alternative energy sources such as wind and solar energy could provide better alternatives a decade from now.

Innovation achieved through research is the basis for progress. A strong synergy between education and research is essential. The BSR countries traditionally have a high level of innovation. R & D intensity, high-tech density: researcher concentration and intensive patent activity.

The BSR LNG Competence Centre will develop a model of interinstitutional cooperation that will enable the development of the joint projects and services required for the LNG sector. A network of educational institutions has been established to mobilize the infrastructure of science and research studies in the Baltic Sea countries, to promote LNG study programs, to develop training and research, and to increase the availability of knowledge about LNG technology, to promote awareness LNG sector among business representatives, developers, and the implementers of energy and environmental policies.

5 CONCLUSIONS

The prospects for the liquefaction and regasification capacity of the LNG markets in the Baltic Sea countries (expansion projects or new projects in the area relative to the LNG infrastructure) combined with optimistic hypotheses to increase the supply and demand in the region, represent the ideal basis for an organic development of the LNG value chain and for the creation of value for the entire region.

Analysis of the policy measures and regulations showed that it is essential to act on the driving forces for an adequate development of the market in the various sectors starting from a shared implementation of organic legislative measures and technical regulations. All this is integrated with a good system of incentives and / or tax relief that stimulate the demand for LNG.

The results of this study provide an indication that the BSR is well placed to provide the needed LNG to the maritime industries and peripheral or ancillary industries that makeup the LNG value-chain in the BSR. The SWOT analysis of section 4.2 showed that there exists an inherently large supply and a potentially high demand for LNG. This implies that the LNG market has a large potential to grow, leading to the success of LNG as a fuel and economic growth in this sector. A substantial potential exists for attracting capital, a specialized workforce, and technology providers for LNG use. The SWOT analysis highlighted the need to formulate a coordinated policy for the development of LNG, so that obstacles such as the high initial capital costs for LNG infrastructure can be overcome by offering a long-term perspective for LNG and incentives to make LNG more attractive for the market.

The Cluster Analysis in section 4.1, identified the critical factors for the successful implementation of LNG. It was found that financing, cost, government funding, and environmental impact were the most important decision factors for successful initiation of the LNG clusters, reiterating the weaknesses identified by the SWOT analysis. The cluster analysis estimated the likelihood of LNG success in the BSR at 50.6% at its present condition and at 79.9% at its future potential probability.

The business case scenario illustrated simple cases of how LNG bunkering infrastructure spacing affects the profitability for LNG-powered ships. The exact distance which a ship can travel to bunker LNG depends on the length of its intended route, meaning that smaller vessels typically covering smaller distances require a tighter network of LNG bunkering facilities than large international shipping vessels covering large distances. The 400 km distance between LNG fueling facilities recommended by the TEN-T network is reasonable. Large ships were shown to remain profitable on LNG for bunkering spacing of 380 nautical miles (704 km). LNG refueling facilities should be spaced at a maximum distance of 400 nautical miles from each other, when comparing LNG with MGO 0.1.

The analyses of the transport flows and integrated LNG value chains showed that it is important to push LNG outside of the sea sphere: this can be achieved by decreasing the price in order to make the markets more accessible to consumers. In this context, the individual national strategies, while bearing the needs of the individual countries, must flow into a comprehensive development plan for the entire BSR area, making use of various types of transport sectors, industry, and power generation.

Education and training were also identified as an important factor in guaranteeing the competitiveness of the BSR in LNG and energy technologies. Universities offer education on energy, sustainability, logistics, business, and transport in the BSR for LNG. The LNG Competence Center was devised to guarantee an integrated training system.

An LNG Blue corridor will be the guarantor of the preservation of the fragile Baltic environment in compliance with the international and national policies and regulations that call for faster transition to sustainable energy production and use.

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