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Developing a LNG Value-Chain in the Baltic Region

Abstract

Dozens of regulations pertaining to the environment and shipping or transport by ships have unquestionably generated additional costs to end-users of maritime transport and investments for ship owners and other related industries in the regions, such as the Baltic Sea Region, with potential socioeconomic benefits. However, these regulations will soon apply to other regions of the world, requiring from them on-going and functioning examples and solutions. An important contribution from an ongoing European Union funded project that is presented in this paper is to share the results of the research and transfer knowledge and "best practices" on the challenges that have been faced by the maritime industry in the Baltic Sea Region.

Several opportunities have been recognized that identify how additional revenue 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. While this study has shown that the investment dilemma is still a prevailing obstacle for LNG development, some aspects have been revealed that might help to overcome this stalemate situation. The results show that an LNG project is not profitable if only targeted at the demand from LNG vessel's side. Participation of the local industry and/or the energy sector is indispensable in order to initiate an LNG project.

The debate about the investment dilemma should hence be shifted away from the opposed perspectives of “project developer vs. ship owner”. An LNG terminal is not a facility that is restricted to the shipping industry. This misunderstanding leads to the limited perception that an LNG terminal only serves the customers from the shipping industry, neglecting the potential for local economy demand. A better inclusion of and focus on the local industries can help overcome the supply and demand side of the investment dilemma.

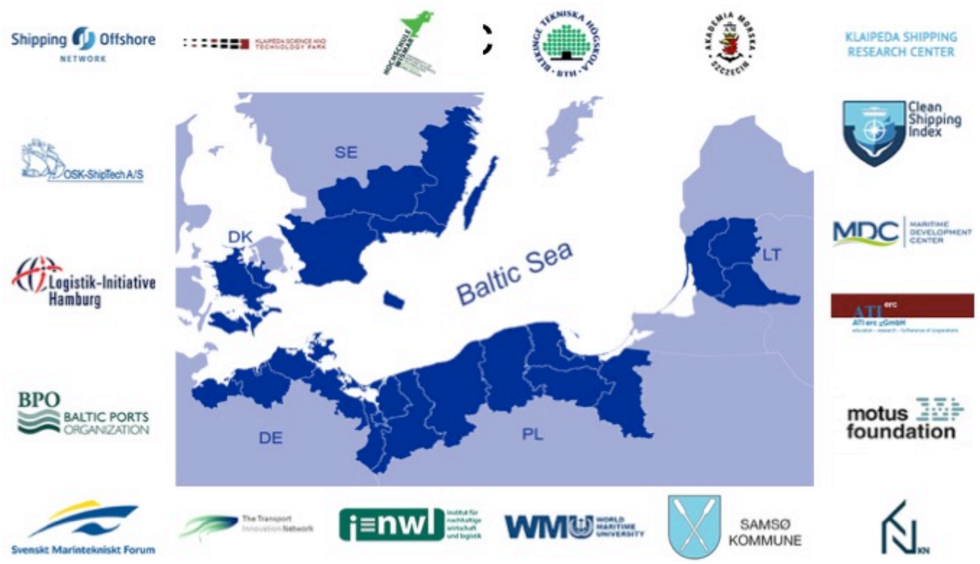
Keywords: *LNG, Value-Chain, Baltic Sea Region, ECA -emission control area, bunkering terminals*

1. Introduction

Two major obstacles stand in the way of resolving emissions from international shipping: shipping is not bound by the COP21 climate deal, and there is a lack of promising technology, in a close by future perspective, to replace fossil-based fuels and propulsion systems. Following the climate summit deal, any measures of the maritime industry combatting climate change is to be managed with by the International Maritime Organization (IMO). It is indeed known that by implementing available energy efficiency measures great reductions of GHG from shipping and other transport sections can be reached. It is very clear that major efforts, including market-based measures, need to be taken by the maritime and other transport means itself in order to be able to reach a fossil free industry by the end of the century.

This study considers the EU aims to reduce its greenhouse gas emissions by 2020 at least 20%, increase the share of renewable energy to at least 20% of consumption, and achieves energy savings of 20% or more (EUROPEAN COMMISSION, 2018). As part of the Energy Union Strategy, the EU is committed to building missing links and energy infrastructures, and ensuring that each Member State has access to several sources of gas. Integrating the Baltic Sea Region (BSR) with the rest of the EU’s gas system is one of the Commission's top priorities.

The purpose of this paper is to provide the strategic approach towards LNG infrastructure



development in BSR. The results presented in this paper are based upon the GoLNG project, representing 19 Institutions (c.f. Figure1) from 6 BSR countries working together (Denmark, Sweden, Norway, Lithuania, Poland and Germany), which is a response to the ever-changing situation on the LNG market. The findings presented are focused on the development of demand and accessibility of LNG in the Baltic Sea Region (BSR). The project activities are aimed at the implementation of the EU Clean Fuel Strategy and the EU Directive on deployment of alternative fuel infrastructure in order to establish a strategic approach for the development of LNG infrastructure and promote its usage in the transport industry.

Figure 1 – GoLNG Project Partners and Scope

Source: www.GoLNG.eu

1.1 What is LNG?

Liquefied natural gas (LNG) is natural gas (predominantly methane, CH_4, with some mixture of ethane C_2H_6) that has been converted to liquid state for ease and safety of non-pressurized storage or transport, liquefaction infrastructure (LNG carrier, hub terminal). It's necessary true for trucks e.g., truck cisterns where a pressure can increase up to 10 bars or more.

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

- Michael Faraday liquefied methane in 1820
- Karl von Linde developed 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. British Petroleum's Energy Outlook 2030 shows that natural gas contribution to more than 20% of global primary energy basket and it may rise over the next decades at the expense oil price.

Natural gas is transferred and traded mainly by means of pipeline. However, LNG takes the share of more than 30% of transported natural gas movements. Figure 2 shows the major trades 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 portion of natural gas transported as LNG to increase. Transportation of the natural gas in the form of the LNG gives flexibility in connecting the suppliers and consumers all around the world.

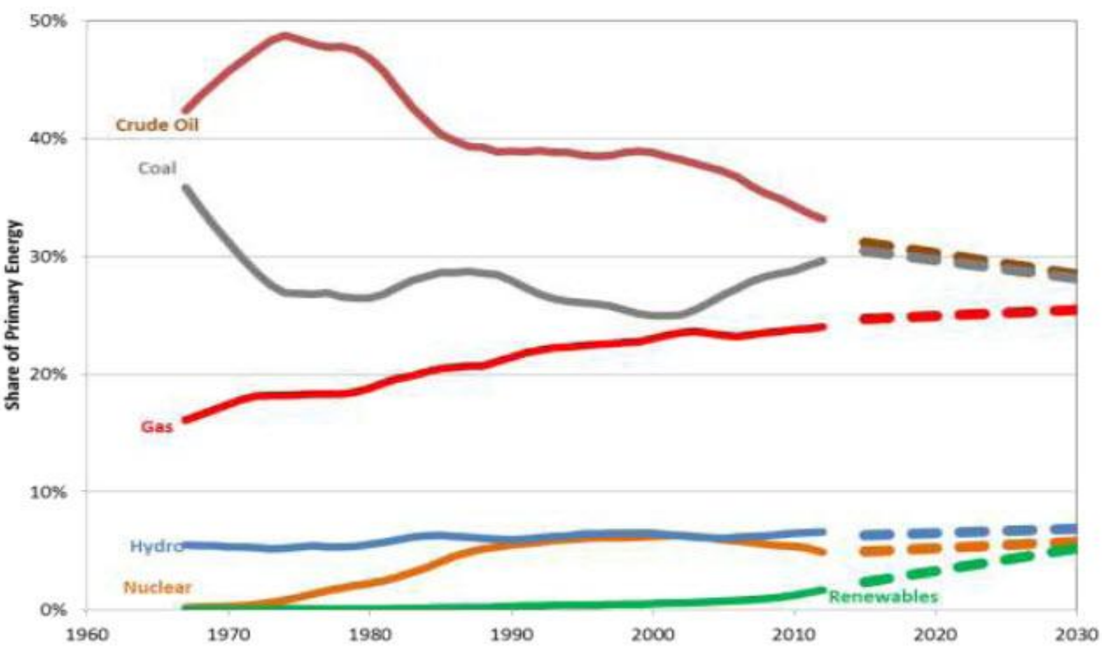


Figure 2 – World Primary Energy Mix
Source: Developed from BP Energy Outlook 2030, January 2013

2. Methodology

Methodology provides tools and techniques that researchers can use for gaining knowledge, firmer understanding and solving problems. A researcher either has a fixed aim and has to accommodate the means for getting there, or has fixed means (staff, lab, competence) and tries to find the optimal goals, given the means. At times, during the research, one must try to modify both the ends and the means. In the current research, the aim has been on how to develop (or extend) LNG Value Chains. According to (Yin, 1994), researchers may opt to use more than one methodology approach in answering a question. One type of strategy that was adopted in this research and employed in this study was the use of a triangulation strategy employing the following three methods, which combines quantitative and qualitative approaches:

- *Literature review*: A review of journals, periodicals, E.U. projects, and other research publications related to the subject area was executed during the initial phase of the research and updated throughout the research. The purpose was to obtain a firm understanding of what has been done.
- *Case Studies*: Several case studies were analysed and the critical success factors were identified. The case studies were namely in Norway, Denmark, Poland, Lithuania, Sweden and Germany.
- *Interviews*: Two types of interviews were conducted: qualitative and quantitative. The qualitative interviews were open-ended discussions that took place during visits, which assisted. A more focused survey was later conducted with selected users to identify areas considered to be bottlenecks. The results from the questionnaire assisted in the evaluating the findings.

2.1 Theoretical foundation on Value Chains and the development in the context of LNG in the BSR. 2.1

2.2.1 Value Chain

The concept of Value Chain was first postulated by Michael Porter (Porter, 1995) to be a set of activities that a firm is operating within a specific industry performs to achieve in delivering a product or service for the market. Within the field of development studies, value chain is often used for analyzing: "*the full range of activities that are required to bring a product from its conception, through its design, its sourced raw materials and intermediate inputs, its marketing, its distribution and its support to the final consumer*". In coordinating activities across regions, such as in the BSR, a regional value chain is viewed to include all the stakeholders and activities involved in the LNG production, service, supply, distribution and post sales activities.

2.2.1 Research Question

For the successful integration into the global or pan-regional economy of the EU, will require nations, such as those in the BSR, to first look inwards: by creating successful regional value chains, such as those in LNG. Through regional value chains, BSR economic actors may become more competitive to then enter global value chains. Value chain analysis can provide valuable insights into policy formulation and implementation.

3. The extended LNG value chain in the Baltic Sea Region

The SECA regulations have unquestionably generated 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), although with potential socioeconomic benefits (e.g. Ballini and Bozzo, 2015). However, these regulations will soon apply to other regions of the world, requiring from them ongoing and functioning examples and solutions. An important part of the Go LNG project will therefore be to transfer the challenges that have been faced by the maritime industry in the BSR into opportunities - that is, to show how additional revenue 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 "chicken-egg dilemma", while this study has shown that the

investment dilemma is still a prevailing obstacle for LNG development, some aspects have been revealed that might help to overcome this stalemate situation. For instance, the actual demand from ship owners for LNG is very low compared to the volumes of LNG that will serve the local energy or business demand. The results show that an LNG project is not profitable if only targeted at the demand from LNG vessels. Participation of the local industry and/or the energy sector is indispensable in order to initiate an LNG project. The debate about the investment dilemma should hence be shifted away from the opposed perspectives of "project developer vs. ship owner". An LNG terminal is not a facility that is restricted to the shipping industry. This misunderstanding leads to the limited perception that an LNG terminal only serves the customers from the shipping industry, neglecting the potential for local economy demand (Semolinos *et al.,* 2013, Adamchak, 2013). A better inclusion of and focus on the local industries can help overcome the supply side of the investment dilemma as illustrated in Figure 3 that shows various actors in a chain using LNG.

Figure 2 – Example of extended LNG Value Chain
Source: www.GoLNG.eu

In the BSR, often natural gas is transported either by pipelines from Norwegian gas fields to production and liquefaction factories, or by LNG carriers from Norway and other LNG producing countries, such as Qatar or US to import terminals that are either characterized as large or small scale. From these terminals, the final destination can be reached either by transporting LNG on trucks or rail or with bunkering vessels. The new possibility to use LNG as ship fuel requires the creation of a feeder (bunker) distribution system that manages the refueling of ships with LNG.

There are three different methods on how ships can be refueled. The tank-to-ship refueling takes place at the jetty with the vessel approaching the LNG tank and getting the LNG straight from there. The ships can be refilled either directly from the LNG storage tank. This implies that an LNG storage tank is installed at the port with the specific task to refuel ships. The second method is by Truck-to-ship. Trucks can also be used to feed the ships, this option is attractive if LNG has to be transported from further away and direct shore-to-ship bunkering is not feasible. LNG can be loaded on a truck and then this truck refuels the vessel. This method is more flexible as the vessel does not have to be next to the LNG tank but can be refueled further away, for example at ports where there is no LNG bunker terminal. The third method is by a bunker vessel. A specifically designed LNG bunker vessel takes the LNG from the storage tank and then refuels the ships. This method is also very flexible. The refueling can take place by different methods. This option is the most viable due to its flexibility to access sites where jetties are not installed or at ports where LNG bunkering sites are not installed yet.

3.1. Developing regional LNG Value Chains

As the BSR countries are taking the first steps in LNG business there are many opportunities for companies to find their niche. Indeed, a harmonized LNG infrastructure in the BSR could influence the introduction or adoption of different new business branches. For example, as LNG could be transported only in special cryogenic tanks the raise of demand for innovative transportation technologies could be also possible. It covers both the production of cryogenic tanks and its components. The technical supervision of infrastructure or production is another niche where more technical consultancies will be necessary. Moreover, the possibility to use LNG as ship fuel requires the creation of a feeder distribution system that manages the refueling of ships with LNG. The refueling can take place by different methods. The ships can be refilled either directly from the LNG storage tank. This implies that an LNG storage tank is installed at the port with the specific task to refuel ships. Trucks can also be used to feed the ships; this option is attractive if LNG has to be transported from further away and direct shore-to-ship bunkering is not feasible. The third option is to use feeder vessels that take the LNG from the storage tank and then refill the ships. This option is the most viable due to its flexibility to access sites where jetties are not installed or at ports where LNG bunkering sites are not installed yet. There are three different methods on how ships can be refueled. The tank-to-ship refueling takes place at the jetty with the vessel approaching the LNG tank and getting the LNG straight from there. The second method is by Truck-to-ship. LNG can be loaded on a truck and then this truck refuels the vessel. This method is more flexible as the vessel does not have to be next to the LNG tank but can be refueled further away, for example at ports where there is no LNG bunker terminal. The third method is by a bunker vessel. A specifically designed LNG bunker vessel takes the LNG from the storage tank and then refuels the ships. This method is also very flexible.

3.1. LNG bunkering, infrastructure and storage

Initially, a number of LNG trading hubs in the BSR should be decided for further successful development of infrastructure and services. It may influence an increase for short to long-term LNG supply contracts between trading hubs and transport/ intermediate supply companies. Also, this will impact the use of logistic/ intermediate services.

Indeed, the realization of bunkering stations, refueling stations, development of trucks, engines, retrofitting of vessels to LNG results in job opportunities and economic growth in the BSR and other parts of Europe. The strong interest of private parties in LNG deployment in Road, Maritime Transport and Inland Waterway Transport (IWT), demonstrates the potential to create economic growth and jobs, meeting the policy objectives in this field as well. As LNG could be transported only in special cryogenic tanks the raise of demand for innovative transportation technologies could be also possible. It covers a production of cryogenic tanks and components. The technical supervision is also an option.

At the infrastructure and production developing stage the technical consultancy would also be necessary. It could be provided from non-BSR countries or it could be also an opportunity to start a new services. From the project perspective to decrease price cap we need to consolidate wider value chain adding new users, that will contribute to LNG infrastructure development and maintenance price and will decrease investments risks. The topic of LNG as shipping fuel, while being a major challenge to the industry, also affects the interests of many different actors. The role of stakeholders is hence very important in the LNG development process, which has been acknowledged by various previous studies (Danish Maritime Authority 2012; Wang & Notteboom 2015; Adamchak 2013). Previous studies are also very aware of the investment dilemma concerning the introduction of LNG as ship fuel.

3.2. LNG Business Opportunities

Shifting from conventional fuel to LNG not only helps fulfilling new stricter environmental policies and to ensure energy security and diversification, but also opens up to new business opportunities and 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 adhering to international regulations, but rather how much of the energy and fuel market could be replaced by LNG and how to best market it as the preferred fuel/source of energy. For the specific market to be fully exploited, and as a consequence 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 risks and opportunities.

Regarding the current general context, natural gas provides 22% of the energy used worldwide and represents almost a quarter of electricity production, as well as playing a key role for industry as a raw material. (Source OECD / IEA, 2017)

The number of operating LNG fueled vessels presented in Figure 4 indicates it is steadily increasing worldwide, with 102 vessels in operation and 108 confirmed new builds until 2022 (DNV GL, 2016). 56% of the ships in operation are operating in Norway, 19% in rest of Europe, 11% in America and 8% in Asia and the Pacific. Regarding to 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).)

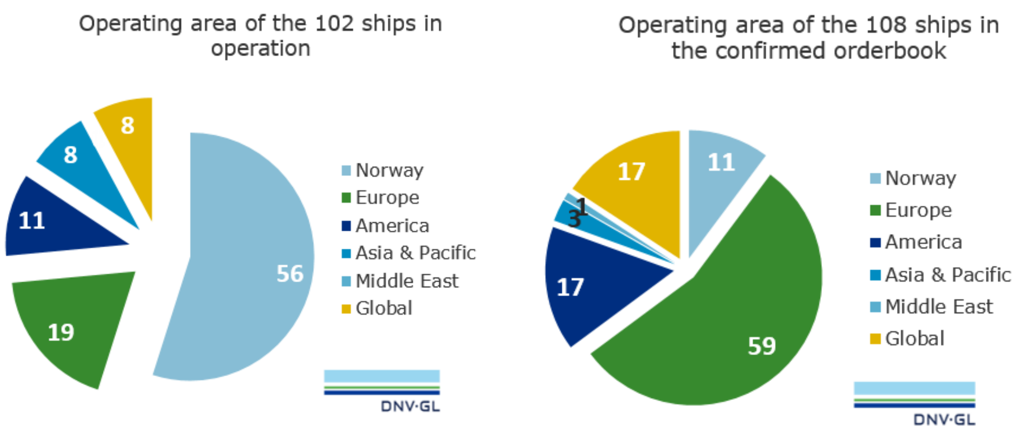


Figure 4 – LNG Fleet and those on order

Source: DNV GL LNG (March, 2018)

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. Global known gas reserves are considerably higher than 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, 2015a), while a Shell outlook specifies that LNG is set to rise 4 to 5% till 2030 (ref

Shell link). Moreover, Europe's part in global LNG imports is believed to rise from 16% to 19% between 2013 and 2035 (BP, 2015b). 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 takes up in SECAs, can also prevail and promote the use of the bunker in other areas across the EU.

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 guarantee an adequate development of the LNG market at a global level, "market drivers" and "regulatory drivers" can be identified. The drivers of the market identify the environmental drivers represented by the growing de-carbonization 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. Finally, the economic drivers given by the possibility of expansion and industrial development starting from the naval sector which sees a modernization of the fleet, the construction of new ships and the relative development of the port areas.

The normative drivers (for example Nitrogen-oxides Emission Control Areas "-NECA and Sulfur Emission Control Area - SECA) discussed in the following paragraphs play a role of primary importance in order to allow an adequate development of the whole System and LNG value chain.

3.3. LNG Challenges

Since the BSR would become an IMO SECA area, projects and research regarding LNG use in the region have been ongoing. These projects and studies have been of different nature, e.g., some have been pure infrastructure projects (HEKLA) while others have had a softer approach including feasibility studies such as: BSR Innoship, Cleanship, LNG in Baltic Sea Ports I & II, North European LNG Infrastructure Project, Martech (HEKLA, 2018, Madjidian *et al,* 2013, EU, 2015). The study performed and presented in this paper is a continuation of the Martech project now called GoLNG, which started mapping the LNG value chain development in the BSR.

The type of challenges for the continued development of LNG in the BSR has changed to not only include lack of planning for LNG infrastructure development or safety and public acceptance, but rather how to maintain the pace and continue the deployment of LNG in more areas. Another major challenge is the climate perspective of LNG - it needs to be noted that while the use of LNG in shipping will help to reach environmental targets with regards to emissions of sulfur and particulate matters, with regards to the 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, methanol, hybrid propulsion and hydrogen) need to be further analyzed and tested with a view to achieving a fuel mix that will further reduce greenhouse gas emissions. One interesting option is the mixing of natural gas with biogas before liquefaction. By doing that, the fossil derived CO_2 of LNG can be reduced (Sperling, 2017).

The list below includes the main challenges faced for the BSR LNG industry:

- Safe LNG storage in main LNG import and small scale LNG terminals on basis of "Safety first";
- Safe transportation from main import and small scale LNG terminals to LNG end users;
- Promote and start more wide use of LNG as fuel in different transport modes (sea, road, railway, inland waterway transport);
- Promote and start more wide use of LNG as energy resource in small and medium energy and heating plants;
- Promote and start more wide use of LNG as energy resource in industry;
- Promote and create LNG bunkering constant, movement and mobile stations in BSR region 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 (biofuels):
- Continue working for a greening of LNG, that is, including biogas 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:
- Promoting LNG and environmental performance of shipping so as to prevent a major shift of transport from shipping to land routes.

The Go LNG project focuses on widening the use of LNG to encompass not only the maritime sector by assisting stakeholders in finding relevant tools and regulations, education and networks, as well as discussing potentials for future sustainability.

4. Go LNG value chain

As one of the results from the Go LNG project is on studying the emerging integrated LNG value chain of the region, including different modalities and industry. Initially, the logical number of LNG trading hubs in BSR should be decided for further successful development of infrastructure and services (see section on Future Blue Corridors). This may have an influence on the increase for short to long-term LNG supply contracts between trading hubs and transport/intermediate supply companies, and an increase of logistic/intermediate services. To enable LNG powered transport corridors in BSR, the study will analyze and discuss on how to implement integration of LNG business models for the following: to increase LNG distribution efficiency, demand and economy, by adding users and integrating technologies. Moreover, it will showcase an integrated value chain by providing business plans. In order to perform the analyses, information on main LNG players of the region, value of business models, internationalization of best practices, subsidy systems etc., some presented below, will be used. The LNG value chain study will further present the prognosis for LNG technologies and market growth in Baltic Sea Region.

4.1. Cluster analysis of BSR LNG VALUE CHAIN

Much has been written on the subject of local and regional economic development policy (e.g. LNG development) but it is Michael Porter's cluster theory, above all others, which has been the dominating theory. The OECD, EU, national and local governments, has since adopted the cluster concept theory. In addition, dozens of countries have been consulted pertaining to national economic growth strategies. In the scope of LNG in the BSR, the aim of this study is to apply this methodology for understanding factors for implementing LNG development for this region.

In the framework of the Go LNG project, there exist 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 the particular field, which is LNG (Porter, 1998). Furthermore, the concept of cluster can be characterized by:

- regional economic activity located at all levels: community, geographic area, global;
- it is limited to a specific industry;
- includes both vertical links as supplier-manufacture-dealer-customer chain or horizontal production links as in sectors of the same industry;
- companies have identical or interrelated business areas;
- firms are in competition but through specialization contribute to the cluster development;
- firms proximity generates social and trust relations;
- a common infrastructure used in innovation by rapid transfer of knowledge and because of the support offered by universities and research centers

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. In the following

Figure 5 illustrate the example provided by Michael Porter on the composition of regional economies, such as BSR and classifies them as either local clusters or traded clusters.

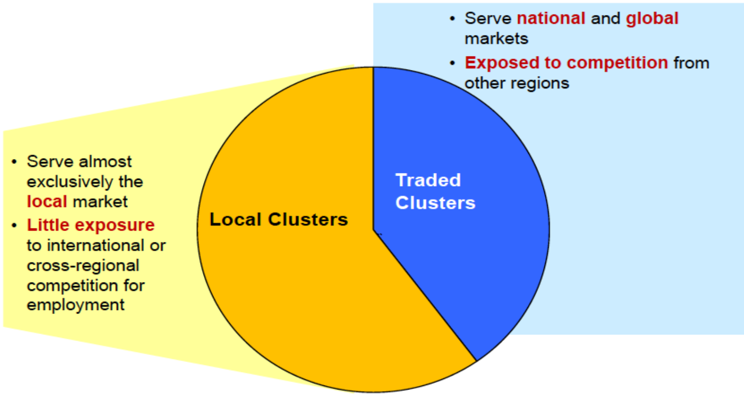


Figure 5 – Composition of Regional Economies
Source: Michael Porter, 1995

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), intended to launch initiatives to support existing clusters or to form new ones in regard with:

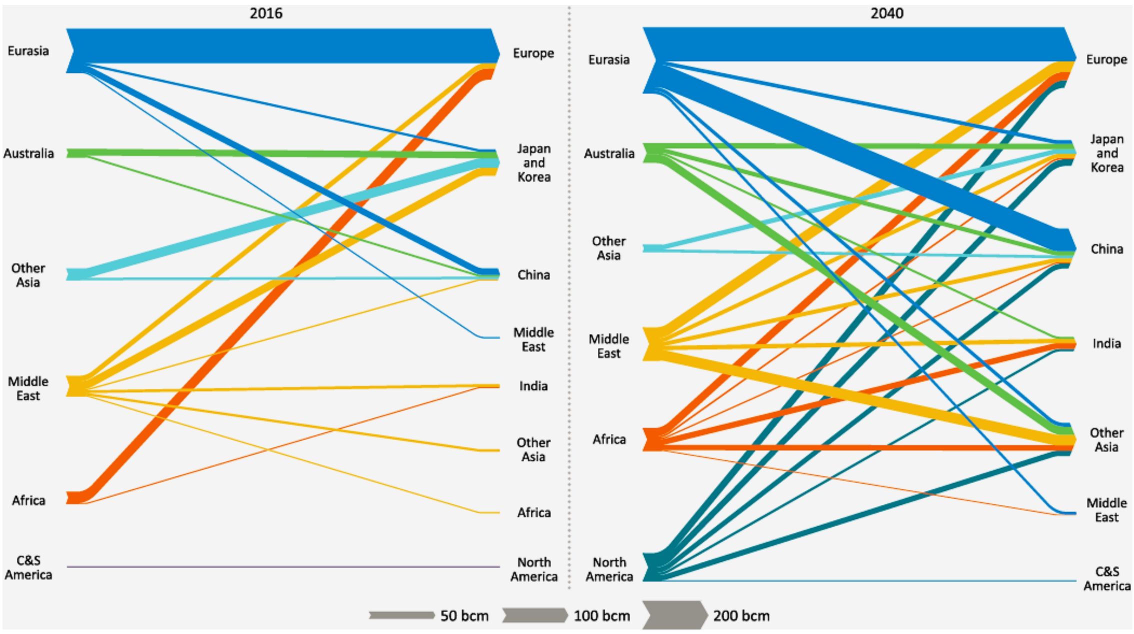
- Small and Medium Enterprises (SMEs)
- regional industrial development;
- attracting external funds and foreign investors;
- research and innovation at national or local level.

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

5. Market for LNG in the European Union

Gas use in European Union (EU) countries had a jump 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. As the EU has targeted to cut greenhouse-gas emissions by 40% (compared with 1990 levels) in 2030, many coal plants will be out of operation which gives space for gas in the power sector, even with growth of renewables share over the period to 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 to 2040. Natural gas consumption in the European Union stays around current levels for most of the projection period. Even with a flat demand outlook, the European Union's gas imports increase by 2040 as domestic output production experiences a considerable decline as seen in Figure 6.

As projected that 80% of the EU coal-fired capacity will retire, gas security gains more attention to remain an important topic on policy-makers' agendas. The projection that is illustrated in Fugure 6 indicates that EU gas import 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 of about 40%. Production in Norway, the second-largest source of imports, remains 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 gradually to decline towards the end of the Outlook period in 2040. As Norwegian drop, other suppliers get more chance into the European gas market. Chief among them are US LNG suppliers, who 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).

Figure 6 –Global Gas trade flows in the New Policies Scenario (bcm)

Source: World Energy Outlook, 2017

5.1. Trade and investment in LNG - Drivers

Global Inter-regional gas trade faces by 525 bcm in the period to 2040 in Figure 6, meaning yearly growth rate of 2.4% on average, near to the 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 the LNG is underpinned by some factors and the flexibility offered by LNG is one of these factors. Generally, growth of energy demand along with the political will to meet this demand with a clean and flexible sources are the key drivers for gas import rise in many countries worldwide (OECD/IEA, 2017).

6. Findings from GoLNG Project

It is essential to extend the value of LNG VALUE CHAIN along the entire chain (liquefaction, storage, transport, regasification) that allows the achievement of efficiency, through the minimization of costs and effectiveness, with the maximization of the services offered. In Table 1-7, a number of facilities is compiled and categorized according to location and LNG activity. The premise in compiling the facilities is their relationship to meeting the objectives that will make LNG competitive and a generator of economic growth: a key role will be played by technological innovation. The basis of these results is the achievement of a wider value chain, which also includes different types of transport from the maritime, railway, road and heavy industries, industries and the integration of biogas into gas networks that could also include biogas in the gas networks.

A fundamental role for the achievement of an LNG Value Chain is represented by the creation 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 (listed in Table 1-7), also to allow the achievement of adequate economies of scale.

Table 1 – LNG Export Terminals in BSR

Source: www.GoLNG.eu

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
LNG export terminals							
Norway	Risavika	From a storage tank LNG is loaded on board ships or tank lorries for further transport.	300,000 tons/y. Storage tank is designed for up to 28,000 m3.			Skangas	
	Melkøya (Snøhvit, Hammerfest)	LNG exported in custom-built LNG ships.	4.3 million tons/y			Statoil	
	Snurrevarden (karmøy)		0.0210 million ton/year			GASNOR	
	Kollsnes 1		0.410 million ton/year			GASNOR	
	Kollsnes 2		0.0810 million ton/year			GASNOR	
Russia	St Petersburg (2018/19)	Three non-self-propelled barges and three 700 cbm 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/y).	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 *106 t/year		GAZPROM		
	Shtokman-Teriberka FPU, Barents Sea Cyprus, Vassilikos Start-up: ------	Floating Production Unit	7.5*106 t/year		GAZPROM		
Denmark	Frederikshavn liquefaction plant Start-up:2018	small scale, with LNG bunkering and Flling station	0.05 * 10^{6} t/year		NORDLIQ		

From a strategic point of view it is essential to strengthen the achievement of the following objectives:

- Upstream Exploitation and marketing of natural gas reserves and also far from consumption centers
  Increased security in supplies
- To achieve a diversification of origin and producers, minimizing the risk of dependence on pipelines of traditional producers belonging to politically unstable countries
- 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.

Table 2 – LNG Import Terminals in BSR

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
LNG import terminals							
Lithuania	Klaipeda	FSRU Independence will provide gas to the national gas grid and for bunkering of vessels	170,000 m3	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 m3. The plant capacity will be increased from 5-7.5 bcm/y.	Qatar, Norway (June 2016), Cheniere Energy (US, May 2017).	PGNiG	Gaz-System's Polskie LNG (owned by state).	Inland waterways (potential - designed in
Lithuania,	**FRSU Independence**	Floating Storage and Regasication Unit	maximum hourly capacity: 460.000 m3(n)/h . nominal annual capacity:4,00 billion m3(n)/year		KN LNG terminal		
Estonia	Paldiski (2020)	large-scale facility onshore	Nominal annual capacity:2,50 billion m3(n)/year				
Estonia	**Muuga(Tallinn) -2018**	large-scale facility onshore	Nominal annual capacity: 2,00 billion m3(n)/year		Vopak		
Germany	Brunsbüttel start-up:-----	large-scale facility onshore	Nominal annual capacity 3,00 - 4,00 billion m3(n)/year		Oil tanking Vopak Gasunie		

Source: www.GoLNG.eu

Table 3 – Small Scale LNG Terminals in BSR

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
Small scale LNG terminals							
Finland	Pori Rauma (2017)	LNG tank, loading docks, process units (compressor and vaporizers), flare torch, three loading docks for road tankers, a transformer building, and a heat production unit. 12 km natural gas pipeline that connects the terminal to the local Industrial Park.	30,000 m3 10,000 m3	Norway	Skangas	Gasum, Oy Ab AGA	81 million Euros. The Finnish government supported 23 million Euros.
	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 Strat-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.
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 ton.	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 ton 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 LNG. In time, the LNG Terminal will also have the capacity to supply the existing gas grid with natural gas.			Swedegas and VOPAK		

Source: www.GoLNG.eu

Table 4 – Small Scale LNG Bunkering Facilities in BSR 1/2

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
Small scale LNG bunkering facility							
Denmark	Hov (Samsö)	Specific ferry	40m3 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 od 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 m3 tank, planning for a storage of 10,000m3.	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 m3	Russia (LNG Gorskaya)	LNG Gorskaya Overseas OU		
	Copenhagen/Malmö (2025)						
	Frederikshavn (2018/19)	Amongst the potential customers is Terntank A/S (Denmark) with the companies 4 LNG powered vessels.	To be scaled in accordance with costumer demand		UniOil and Bunker Holding		Bunkering is intended to be provided for both ship and truck.
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 a LNG center. It will consist of LNG floating storage, a specialized pier and other port equipment necessary for storage, bunkering of vessels.	Floating storage. Maximum capacity of 5,500-cbm. The bunkering vessel with tanks of 1.300-cbm.				Gas station for trucks and use of LNG in the municipal purposes are part of the plan.
	Tallinn (2025)						
Finland	Helsinki Hamin Kotka (2019)	The Tallink ferry Megastar bunkers in Helsinki's West Harbour. Skangas delivers LNG flexibly from the LNG import terminal at Tahkoluoto, Pori.		Gasum Russia (LNG Gorskaya)	LNG Gorskaya Overseas OU		2.65 million euros in EU funding, the four terminals are intended to reduce Finland's
	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)			
	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) Riga (2025)	Memorandum of understanding signed with Estonian company LNG Gorskaya Overseas		Russia (LNG Gorskaya)			
	Ventspils (2025)						

Source: www.GoLNG.eu

Infrastructure investments in Poland and Lithuania in connection with import terminals allow the two countries to access global LNG markets. From this derives the obtaining of diversification of supplies, ensuring greater security with regard to the energy supply, which would be lower in the case of monopoly by a single supplier. This would lead to an expansion of the portfolio of contracts underlying the development of small-scale LNG infrastructures:

- Small dimensions of the terminals
- LNG ships and tankers with maximum capacities

Table 5 – Small Scale LNG Bunkering Facilities in BSR 2/2

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
Small scale LNG bunkering facility							
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		
	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 example for Sweden that a tanker bunkered LNG.		Skangas (Norway)	Skangas	Swedegas	
	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)						

Source: www.GoLNG.eu

This translates into the possibility of LNG delivery to end consumers without a pipeline infrastructure replaced by a more flexible scheme represented by the development of a capillary network that allows access to LNG to various end users: road, maritime, industrial and energy in general.

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.

Table 6 – Liquefaction Plants in BSR

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
Liquefaction plant							
Denmark	Frederikshavn (2019)	Also has LBG in the plans. 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		EU will provide ~€3 million of TEN-T funding (of total €14.5 million).
	Hirtshals (2019)	Also has LBG in the plans. Maritime, industry and road sector.			HMN, Koch industries, Skangas		
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				
	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, CO2 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	
	Trondheim (Skogn)	LBG plant-will spare the environment annual emissions of about 30 000 tons of CO2 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 to deliver gas to local consumers as well as pump it into storage reservoirs. The FSRU will be subsequently replaced by the Baltic LNG project (Ust-Luga).	Maximum 2.4 million tons LNG/y				
	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 main customers now. Will spare the environment annual emissions of about 16 000 tons of CO2 from fossil fuels.	Maximum 60 GWh/y	Gasum	Air Liquide	Air Liquide	

Source: www.GoLNG.eu

Table 7 – LNG Bunkering Infrastructure of Heavy Vehicles in BSR

Country	Location	Function	Capacity	LNG Supplier	Operator	Owner	Other
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, we have 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 its goods terminal in Helsingborg. Between 400 - 500 trucks/day, which is expected to grow to 1000/day.		Biogas from Lidköping LBG plant.	Öresundskraft		
	Göteborg	50 % biogas.		Biogas from Lidköping 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, of which the food industry has most cars/trucks.		Biogas from Lidköping 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		

Source: www.GoLNG.eu

In a context as hypothesized above, there would be an increase in competition in the region that would bring with it the typical advantages of a competitive market. The profound changes illustrated in Tables 1-7 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 search for continuous innovation, which will result in developments in the LNG sector that will impact on the countries of the entire BRS area. Among the challenges we can also include the compression of costs as well as the orientation towards new approaches to sales and corporate structures. 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 LNG chains.

4. CONCLUSION

The work performed by the GoLNG project team and through the network of 400+ organizations, stakeholders, businesses, individuals and relative national and international bodies provided much information and material in conducting the analysis. Some major pointers that were identified in the report are summarized:

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 optimism on supply and demand in the region, represent the ideal basis for the whole area.

- Essential for an adequate development of the market in the various sectors is to start 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.
- It is important to push the LNG outside of the sea sphere: pressing the price in order to make the markets more accessible to consumers.
- More training and education on energy, sustainability, logistics, business and transport and the BSR LNG Competence Centre will guarantee an integrated training system.
- Individual national strategies must flow into a comprehensive development plan of the entire BSR area.

Acknowledgements

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