

Harbours review

European LNG outlook

EUROPEAN PORT SECTOR FORUM

Voices

- 14. Mantas Bartuška**
CEO of Klaipėdos nafta
- 14. Maciej Mazur**
Communications Manager at Polskie LNG
- 14. Isabelle Ryckbost**
ESPO's Secretary General

interview

- 16. Building the LNG momentum**
Emil Arolski
Project Manager of LNG in Baltic Sea Ports II
- 18. HEKLA enters the stage**
Mantas Bartuška
CEO of Klaipėdos nafta on the HEKLA initiative

- 37. editorial**
- 37. upcoming issues**
- 37. partnership events**

featured article

- 03. LNG in Baltic seaports and the latest on the LNG market – Report**
Monika Rozmarynowska, Consultant at Actia Forum
- 18. HEKLA enters the stage – Southern Baltic LNG transport and energy potential**
Aleksandra Plis and Maciej Kniter
- 19. On-the-road – HEKLA – Helsingborg and Klaipėda LNG Infrastructure Facility Deployment**
Marcin Włodarski, HEKLA's Project Manager Assistant
- 20. Will Europe drive the future LNG trade?**
Shresth Sharma, Senior Research Analyst (LNG and LPG Shipping)
- 23. Maritime eco-transition step-by-step**
Michał Bagniewski, DNV GL
- 25. LNG-ready**
– Complying with stricter sulphur emissions
Geoffroy Beutter, GTT
- 27. Opening the black gas box**
– LNG bunker pricing
Sergiu Maznic, Senior Consultant at SUND Energy AS
- 30. All-in-one**
– Answering LNG shipping questions
Mathias Jansson, Wärtsilä's General Manager Innovation & Product Support, Fuel Gas Handling, Ship Power & Mari Ottesen, Marketing Manager, Ship Power
- 32. The next LNG hotspot?**
– When and where will Germany benefit from LNG
Ralf Fiedler, Group Leader at Fraunhofer Center for Maritime Logistics and Services
- 34. LNG engine optimization**
– Optimizing LNG vessels engine usage
Kim Stenvall, Senior Product Manager at Eniram



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Świnoujście's outer port **unique potential**

In December, 2015, the tanker *Al Nuaman* moored at the brand-new quay in Świnoujście's outer port, bringing the first 210 thou. m³ gas shipment for cooling down and starting up the biggest LNG facility across the Baltic Sea region.

The Świnoujście LNG Terminal is the largest energy project in the history of Poland. By diversifying gas supplies, this strategic programme will have major economic as well as energy safety impacts on the national, but also regional and European levels.

Several companies and organizations have been deeply involved in carrying out the LNG project in north-west Poland.

The Szczecin and Świnoujście Seaports Authority – with the support of EUR 25 mln from the European Energy Programme for Recovery – has built an unloading platform together with the safe mooring system for LNG carriers, set up a trestle, a technological and fire water platform, as well as dredged the unloading platform's basin to 14.5 m, and to 12.5 m along the remaining part of the jetty. As such, Q-Flex tankers up to 315 m long, 50 m wide, 12.5 m in draught, and carrying 120-216 thou. m³ of LNG can smoothly call at the LNG Terminal in Świnoujście's outer port.



www.port.szczecin.pl

LNG in Baltic seaports and the latest on the LNG market

Report

by **Monika Rozmarynowska**,
Consultant at Actia Forum



Monika Rozmarynowska is a Researcher at the Gdynia Maritime University's Department of Transport and Logistics. She also works as a Consultant at Actia Forum, a company established in 2000 which is specialised in delivering events/meetings and consulting that match the needs of the transport & logistics industry.

Since January 1st, 2015, stricter limits concerning sulphur content in marine fuels have become a fact within the Sulphur Emission Control Area (North Sea, the English Channel and the Baltic Sea). There are several options that ship-owners can implement to meet the new regulation and LNG is one of them. Widespread use of LNG as a ship's fuel depends on many factors, among which the main are the existence of a special LNG infrastructure and the whole LNG fuel distribution system, the price of LNG and its relation to the price of alternative fuels and solutions (Maritime Gas Oil or Intermediate Fuel Oil coupled with scrubbers).

This report focuses on the main issues concerning the use of LNG as a ship's fuel. It provides the latest overview of existing LNG infrastructure in Europe and the Baltic region, plans and projects of small-scale LNG facilities within Baltic seaports (with a special focus on the activities carried out within the LNG in Baltic Sea Ports and LNG in Baltic Sea Ports II projects), LNG fuel prices and pricing mechanisms, an overview of the world's LNG-powered fleet, LNG synergies among energy and transport to increase demand.

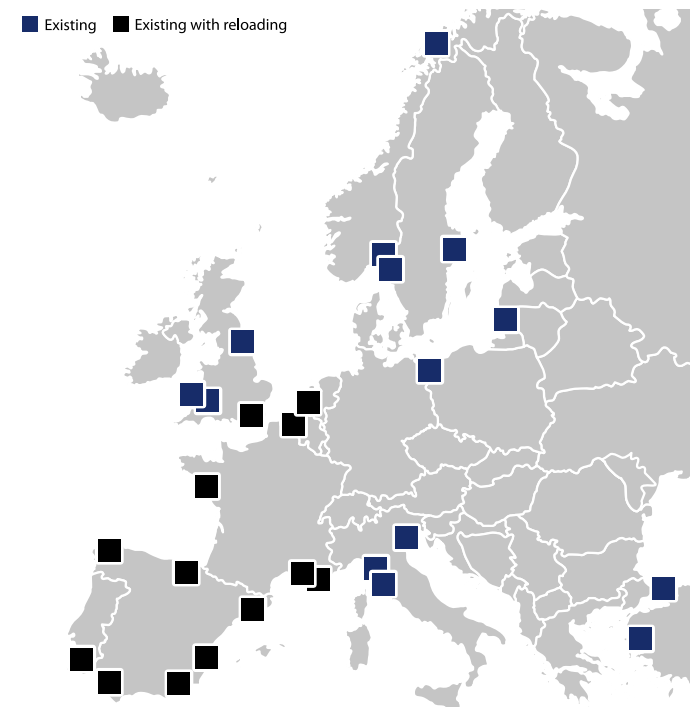
The report was prepared on the basis of the Baltic Ports LNG Forum that took place in Klaipėda on April 23rd, 2015. The forum was organised within the framework of Activity 7 (Harmonisation, LNG know-how transfer & training) of the LNG in Baltic Sea Ports II project co-financed by the EU TEN-T Multi-Annual Programme. The event gathered representatives from seaports, gas infrastructure operating companies, gas trading companies, governmental institutions, transport agencies, and other companies and organisations. Other sources have also been used to elaborate this report, such as: ship-owners' websites, websites concerning bunker fuels prices, ports' websites, etc.

LNG ports' infrastructure – the latest on the European and Baltic markets

Today LNG infrastructure in European ports comprises mostly large-scale import terminals. However, more and more small-scale facilities primarily dedicated to industrial users and shipping are being developed. Currently, there are 28 LNG import terminals in operation in Europe of a total annual capacity reaching around 210 bln m³ (Fig. 1). Most of them (24) are large-scale terminals (with an annual handling capacity of at least 1 bln m³), the remaining four terminals are small-scale facilities with a capacity ranging from 0.15 to 0.5 bln m³ per year. The European leader in terms of LNG import infrastructure is Spain with seven large-scale onshore LNG import terminals with a total capacity exceeding 68 bln m³.

Four LNG terminals are located in Great Britain (52.3 bln m³), three in France (21.65 bln m³), three in Italy (14.71 bln m³), two in Norway, Turkey, Sweden, whilst five countries have one LNG terminal (Belgium, Netherlands, Greece, Lithuania and Portugal). In the near future European LNG import infrastructure will enlarge by eight facilities. These will be two large terminals in Spain, one in Poland, one in France and four small-scale facilities in Finland. Altogether 26 other LNG import terminals are planned

Fig. 1. LNG import terminals in Europe



Source: Gas infrastructure Europe, www.gie.eu

within the whole of Europe (Tab. 1).

Looking closely at the Baltic market, three LNG import terminals can be indicated (one large-scale and two small-scale terminals). The first LNG terminal in the region was put into operation in Nynäshamn (Sweden) in 2011. The LNG terminal in Nynäshamn is a small size terminal (0.5 bln m³/year, 20 thou. m³ of storage), which supplies LNG to a neighbouring crude oil refinery and the Stockholm gas grid. From the terminal, LNG is distributed by truck and a pipeline. In 2014 a second small-scale

LNG import terminal was opened in Sweden. The terminal is located on the west coast of Sweden in Lysekil. The terminal is equipped with a storage tank of 30 thou. m³ and its capacity is 0.3 bln m³. The facility valued at EUR 83.5 mln is a joint project of Skangass and Preem. Gas from the terminal is delivered directly to Preem's nearby refinery with the use of a pipeline. However, there is the possibility of delivering to other land-based industries by tank truck as well as to marine clients.

The first large-scale LNG terminal within the Baltic Sea region was put into operation in December 2014 in Lithuania. The central element of Lithuania's LNG terminal is the Floating Storage and Regasification Unit (FSRU), which is permanently moored in the southern part of the Port of Klaipėda. The unit was ordered by the Norwegian company Høegh LNG, and then chartered to Klaipėdos nafta under a ten-year lease agreement signed in March 2012, which also includes an option for purchase. The FSRU is equipped with four storage tanks of a total capacity of 170 thou. m³. The maximum annual handling capacity of the terminal is 4 bln m³. Statoil is contracted to supply LNG for five years to cover the minimum operational needs of the terminal. In 2015, Statoil will supply 540 mln m³ of natural gas.

This year Baltic LNG infrastructure will be enlarged by another large-scale LNG import terminal. Currently, a large on-shore terminal is under commissioning in Świnoujście, Poland. The terminal has an unloading jetty for large LNG tankers, two storage tanks each of 160 thou. m³ and a regasification train. Its initial regasification capacity is 5 bln m³ per annum with the possibility to expand to 7.5 bln m³ per annum. The Świnoujście LNG terminal accommodates methane carriers ranging from 120 thou. m³ to 216 thou. m³ in capacity. On December 11th, 2015, the terminal hosted the first LNG tanker, *Al Nuaman*, loaded with 210 thou. m³ of Qatari gas to be used for commissioning and technical start-up. However, the terminal will be ready for commercial operations in the middle of 2016.

Construction of large-scale LNG import terminals has also been considered by Estonia and Finland. Initially, it was assumed that terminals would only be constructed in one of the two countries since the European Union intended to co-finance just one LNG terminal which will serve countries located within the southeast Baltic region. However, in autumn 2014 Finland and Estonia reached an agreement to build two LNG terminals, connected by a pipeline across the Gulf of Finland by 2019. A large regional terminal could have been built in Finland while Estonia would get a smaller gas distribution terminal. However, Finnish Gasum is no longer planning to build an LNG terminal in Inkoo (Finland) and the Estonian terminal will probably be located in Muuga. Estonia initially had two competing locations for the regional LNG terminal, Muuga near Tallinn where the state-owned Port of Tallinn was interested in developing it, and Paldiski in north-west Estonia where Alexela Energia wanted to build it.

Many more projects and initiatives can be indicated in the field of small-scale LNG infrastructure. Activities regarding small-scale LNG infrastructure are dedicated mostly to the shipping sector as well as industrial users. In most Baltic countries there are plans to establish at least one small-scale LNG terminal. Some plans are more advanced, some less. Below is a description of small-scale LNG initiatives within LNG in the Baltic Sea Ports I and II projects, as well as other small-scale LNG initiatives within the Baltic Sea region.

Tab. 1. Number of LNG import terminals per type

	Operational	Under construction	Planned
Large-scale (incl. FSRUs)	24 (3)	4	22 (7)
Small-scale	4	4	4
Total	28	8	26

Source: Gas infrastructure Europe, www.gie.eu

“Activities regarding small-scale LNG infrastructure are dedicated mostly to the shipping sector as well as industrial users.”

Fig. 2. Existing and planned LNG bunkering facilities within the Baltic Sea region



Source: Baltic Ports Organization

“The first large-scale LNG terminal within the Baltic Sea region was put into operation in December 2014 in Lithuania. The central element of Lithuania’s LNG terminal is the Floating Storage and Regasification Unit (FSRU), which is permanently moored in the southern part of the Port of Klaipėda.

Activities in ports participating in the LNG in the Baltic Sea Ports II project

The Port of Helsingborg (Sweden). The objective of Helsingborg’s activity within the LNG in BSR II project is to design a multi-functional bunker ship solution in southern Sweden. The main purpose is to identify a technical and functional solution for a bunker ship that can operate in the area. The bunker ship will be a multi-function ship that can provide LNG bunkering, MGO bunkering, as well as other ship supply services. The following shall be stated for the LNG bunker ship: size, number of fuel tanks, type of bunker fuel that the ship shall carry (the ship shall be running on LNG), type of other services that should be performed by the ship and its crew, bunkering devices and type of bunkering procedures, functional demand regarding bunkering (weather condition, wave height, safety devices, flow demands, ice class, etc.). The outcome of

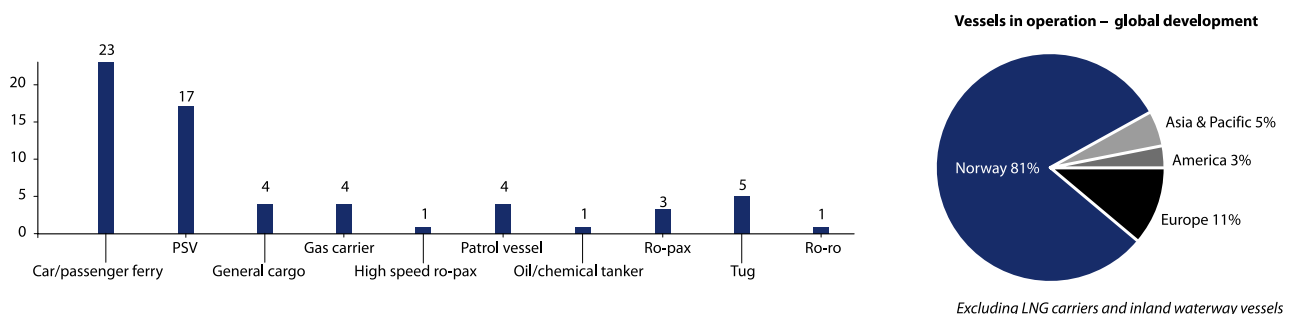
this activity will be the technical design of a multi-functional bunker ship that will satisfy all important stakeholders in the area. It will require that the conditions in the local ports must be analysed.

The Port of Trelleborg (Sweden). The port intends to build a ferry terminal adapted to ferries powered by LNG. Within the framework of the project, the port is going to do a basic design of a berth for ships. This activity will consist of a context analysis to identify among others existing bunkering possibilities; interest of customers in LNG bunkering; an assessment of safety and other regulations, containing risk assessment and a technical description of the final design for berthing incl. loading/uploading of ships and facilities to store and bunker LNG to ships. Another activity within the project concerns technical design of an LNG storage and bunkering facility at berth. The scope of this activity is to elaborate the project design, incl. existing LNG storage facilities, tank design, potential adjustment of berth, LNG demand forecast. This activity will also study the possibilities of LNG transport to the port storage facility- either by land or by sea.

The Port of Sundsvall (Sweden). The Port of Sundsvall is investigating the possibility to develop LNG bunkering infrastructure facilities in Sundsvall Logistikpark. The aim is to offer an LNG bunkering possibility for vessels. Secondly, the project will provide access to alternative fuel supplies for the logistics park and port work vehicles, to offer LNG to the region’s process industries as well as being a backup to the biogas. Within the project a comprehensive LNG infrastructure planning is going to be carried out. It will include design of an LNG bunkering infrastructure facility including an LNG storage and bunkering facility for ships with a possible option for bunkering of port vehicles and trucks (size, type of storage tanks, etc., to be studied), long tubing/piping, efficient transshipment and transport, risk assessment and safety aspects related to the above and the permit process.

The Port of Rostock (Germany). Within the project, the port plans to prepare all documentation for bunkering operations;

Fig. 2. Number of LNG-propelled vessels in service per vessel segment (as of May 2015)



Source: DNV GL

8-9 September 2016
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Tab. 2. LNG-propelled vessels in service per vessel type and owner (as of May 2015)¹

Year	Type	Owner
2000	Car/passenger ferry	Fjord1
2003	PSV	Simon Møkster
2003	PSV	Eidesvik Shipping
2006	Car/passenger ferry	Fjord1
2007	Car/passenger ferry	Fjord1
2007	Car/passenger ferry	Fjord1
2007	Car/passenger ferry	Fjord1
2007	Car/passenger ferry	Fjord1
2008	PSV	Eidesvik Shipping
2009	PSV	Eidesvik Shipping
2009	Car/passenger ferry	Tide Sjø
2009	Car/passenger ferry	Tide Sjø
2009	Car/passenger ferry	Tide Sjø
2009	Patrol vessel	Remøy Management
2009	Car/passenger ferry	Fjord1
2010	Patrol vessel	Remøy Management
2010	Car/passenger ferry	Fjord1
2010	Patrol vessel	Remøy Management
2010	Car/passenger ferry	Fjord1
2010	Car/passenger ferry	Fjord1
2010	Car/passenger ferry	FosenNamsos Sjø
2011	PSV	DOF
2011 ²	Oil/chemical tanker	Tarbit Shipping
2011	Car/passenger ferry	Fjord1
2011	PSV	Solstad Rederi
2012 ²	Car/passenger ferry	Fjord1
2012	PSV	Eidesvik Shipping
2012	PSV	Olympic Shipping
2012	PSV	Island Offshore
2012	General cargo	Nordnorsk Shipping
2012	PSV	Eidesvik Shipping
2012	PSV	Island Offshore
2012	Car/passenger ferry	Torghatten Nord
2012	Car/passenger ferry	Torghatten Nord
2012	Car/passenger ferry	Torghatten Nord
2013	PSV	REM
2013	Ro-pax	Viking Line
2013	Car/passenger ferry	Torghatten Nord
2013	Tug	Incheon Port Authority
2013	General cargo	Eidsvaag
2013	Ro-pax	Fjord Line
2013	High speed ro-pax	Buquebus
2013	Tug	CNOOC
2013	Tug	CNOOC
2013	Car/passenger ferry	Norled
2014	Car/passenger ferry	Norled
2014	Tug	Buksér & Berging
2014	Ro-pax	Fjord Line
2014	Patrol vessel	Finnish Border Guard
2014	Tug	Buksér & Berging
2014	Gas carrier	Veder Rederijzen
2014	Gas carrier	Veder Rederijzen
2014	Gas carrier	SABIC
2014	Gas carrier	SABIC
2014	PSV	Remøy Shipping

Year	Type	Owner
2014	General cargo	Egil Ulvan Rederi
2014	General cargo	Egil Ulvan Rederi
2014	PSV	Siem Offshore
2015	PSV	Harvey Gulf Int.
2015	Ro-ro	Nor Lines
2015	Car/passenger ferry	Samsø municipality
2015	PSV	Simon Møkster Shipping
2015	PSV	Siem Offshore

¹ LNG carriers and inland waterway vessels are not included

² Conversion project

Source: DNV GL

Tab. 3. Confirmed order book per operational area (as of May 2015)

Year	Type	Owner
2015	Ro-ro	Nor Lines
2015	Car/passenger ferry	Society of Quebec ferries
2015	Car/passenger ferry	Society of Quebec ferries
2015	Car/passenger ferry	Society of Quebec ferries
2015	PSV	Harvey Gulf Int.
2015	Oil/chemical tanker	Bergen Tankers
2015	Car/passenger ferry	AG Ems
2015	Car/passenger ferry	AG Ems
2015	Tug	CNOOC
2015	Tug	CNOOC
2015	Tug	Drydocks World
2015	PSV	Harvey Gulf Int.
2015	PSV	Harvey Gulf Int.
2015	PSV	Harvey Gulf Int.
2015	Tug	NYK
2015	Gas carrier	Chemgas Shipping
2015	Gas carrier	Evergas
2015	Gas carrier	Evergas
2015	Gas carrier	Evergas
2015	Bulk ship	Erik Thun
2015	Container ship	Brodosplit
2015	Container ship	Brodosplit
2015	PSV	Siem Offshore
2015	PSV	Siem Offshore
2015	Oil/chemical tanker	Furetank Rederi
2015	Container ship	TOTE Shipholdings
2016	Container ship	TOTE Shipholdings
2016	PSV	Harvey Gulf Int.
2016	Icebreaker	Finnish Transport Agency
2016	PSV	Siem Offshore
2016	PSV	Siem Offshore
2016	Gas carrier	Chemgas Shipping
2016	Oil/chemical tanker	Terntank
2016	Oil/chemical tanker	Terntank
2016	Oil/chemical tanker	Terntank
2016	Ro-ro	TOTE Shipholdings
2016	Ro-ro	TOTE Shipholdings
2016	Car carrier	UECC
2016	Car carrier	UECC
2016	Car/passenger ferry	Boreal
2016	Car/passenger ferry	Boreal
2016	Container ship	GNS Shipping
2016	Container ship	GNS Shipping
2016	Ro-ro	SeaRoad Holdings

this will include all necessary permits for the bunkering procedure itself as well as preparation of the technical design for an LNG bunkering and storage plant. The following design will be undertaken in relation to the port infrastructure development of an LNG bunker station: complete technical design of an LNG-import berth for bunkering purposes, complete technical design of an LNG-bunker berth, complete technical design of a pipeline connecting the storage with the berth and the road- and rail-load-

Year	Type	Owner
2016	Car/passenger ferry	BC Ferries
2016	Car/passenger ferry	BC Ferries
2016	Gas carrier	Ocean Yield
2016	Gas carrier	Ocean Yield
2016	Gas carrier	Ocean Yield
2016	Car/passenger ferry	Seaspan Ferries
2016	Car/passenger ferry	Seaspan Ferries
2016	Gas carrier	Navigator Gas
2016	Gas carrier	Navigator Gas
2016	Gas carrier	Navigator Gas
2016	Gas carrier	Navigator Gas
2016	Ro-pax	Baleària
2016	Dredger	DEME
2016	Dredger	DEME
2016	Cable layer	DEME Tideway
2017	Tug	Østensjø Rederi
2017	Tug	Østensjø Rederi
2017	Tug	Østensjø Rederi
2017	Ro-pax	Rederi AB Gotland
2017	Oil/chemical tanker	Groupe Desgagnés
2017	Oil/chemical tanker	Groupe Desgagnés
2017	Container ship	GNS Shipping
2017	Container ship	GNS Shipping
2017	Car/passenger ferry	BC Ferries
2017	Oil/chemical tanker	Terntank
2017	Container ship	Crowley Maritime
2017	Container ship	Crowley Maritime
2017	Car/passenger ferry	Tallink
2018	Container ship	Matson Navigation
2018	Container ship	Matson Navigation
2018	Container ship	Containerships
2018	Container ship	Containerships

Source: DNV GL

ing units, complete technical design of LNG storage and road-/rail-loading facilities, a safety analysis assessing the risks for the plants in the vicinity of the LNG bunkering facility location.

The Port of Klaipėda (Lithuania). Klaipėdos nafta, operator of the first LNG terminal in Lithuania, also plans to develop a small-scale LNG onshore reloading and bunkering facility. Within the project a technological design study is planned. Its aim is to perform a detailed analysis of current infrastructure and superstructure in the territory of Klaipėdos nafta in order to assess possibilities to develop new LNG infrastructure. The study will make recommendations for needed adjustments to the current infrastructure and superstructure, and would suggest

the optimal area for developing small-scale LNG infrastructure in the area controlled by Klaipėdos nafta. Within the technological design study also a description of possible technologies for small-scale LNG infrastructure will be provided concerning at least: a jetty, superstructure and infrastructure, cryogenic piping, LNG storage, LNG bunkering, LNG distribution equipment (suitable for trailers, trucks) which could be installed in the area. Within the project such activities will also be done as front end engineering design and Quantitative Risk Assessment, environmental procedures and permits.

Activities in ports participating in the LNG in the Baltic Sea Ports

The Port of Stockholm (Sweden). The Port of Stockholm is the first port within the Baltic Sea region where the LNG bunkering operation is performed. The port started to offer LNG bunkering operation in January 2013, when Viking Line's ship *Viking Grace* was put into service. Initially, *Viking Grace* was refuelled from a tank truck. However, at the beginning of April 2013 ship-to-ship bunkering started on the regular basis. The first vessel for bunkering purposes, Sea-gas, was formerly a passenger ferry vessel, however, it has been converted into an LNG bunker ship. The project was carried out by AGA AB in the Port of Stockholm. The bunker vessel is based in the Port of Stockholm and provides fuel to the newly LNG-powered *Viking Grace* ferry. The project cost EUR 1.3 mln, of which EUR 261 thou. came from the European Union's TEN-T programme. The LNG-fuelling vessel is classified under the same regulations that apply to oceangoing LNG-tankers. The fuelling vessel performs on a daily basis, supplying 60-70 tn of LNG to *Viking Grace*. The fuelling process takes just under an hour. The natural gas used as fuel for *Viking Grace* comes from AGA's LNG terminal in the LNG terminal in Nynäshamn.

The Port of Aarhus (Denmark). The Port of Aarhus has developed a feasibility study, showing the suitable size, location, approximate cost and type of LNG terminal. The subsequent activity is the design of a terminal area and the process of retrieving a permit from relevant authorities. The design and the permit process is currently ongoing and is expected to be finalized in 2015. The capacity of planned tanks will be 10 thou. m³. The terminal will be equipped with several semi-pressurized tanks of about 1,400 m³ each. The main users of the terminal will be ferries; it is going to be located within ferry terminal.

Copenhagen Malmö Port (Denmark/Sweden). A feasibility study has been carried out in the ports of Copenhagen and Malmö showing the needed volumes, possible locations of an LNG terminal and approximate cost. Three locations within the Port of Malmö were investigated and one has been chosen in the northern part of the port. The recommended solution for the terminals is semi-pressurised tanks with total volumes of 10 thou. m³.

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

“As of May 2015, there were 76 LNG-powered vessels on order worldwide. Most of these vessels are dedicated for the European and American markets.”

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

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

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

Initiatives in other Baltic ports

The Port of Gothenburg (Sweden). The LNG terminal in Gothenburg is a joint initiative of Royal Vopak, a specialist in the storage of LNG and other energy products,

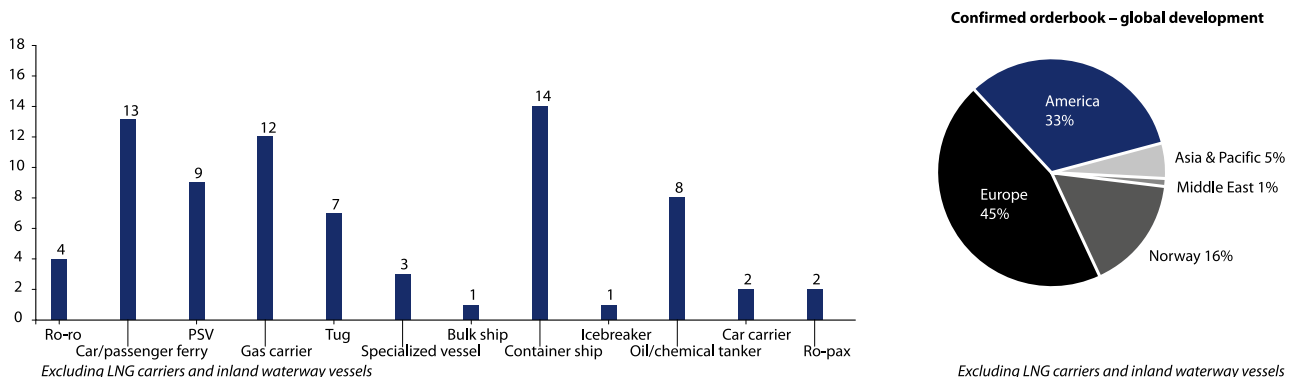
and the infrastructure company Swedegas, which owns and operates the gas grid in south-west Sweden. The LNG terminal in Gothenburg is also part of a project being run together with the Port of Rotterdam and Gasunie to create an efficient LNG infrastructure between Sweden and the Netherlands. The terminal will supply LNG to industry and shipping and will be open to all parties interested in the Swedish market. The planned storage capacity of the fully developed terminal is 30 thou. m³. The terminal is being built in the Skarvik Harbour. The facility is planned to be put into operation in 2015.

The Port of Gävle (Sweden). A small-scale LNG terminal is planned to be built in Gävle. The terminal will be built by Skangass; construction works are planned to start in 2015 and the terminal will be ready in 2017. The terminal will be equipped with one storage tank of 30 thou. m³ and will have a handling capacity of up to 500 thou. tn of LNG per year.

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

The Port of Hou on the island of Samsø (Denmark). In February 2015, the first gas-driven domestic ferry in Denmark was bunkered in the Port of Hou. The bunkering facility in the Port of Hou was delivered by Kosan Crisplant as a turnkey solution. Kosan Crisplant's complete turnkey solution included inter alia a cryogenic transfer pump unit built into a 20-foot container, a piping system including specially designed for LNG dry couplings, two specially designed LNG road tankers, a parking ramp for road tankers, a control system including a safety system. The LNG bunkering facility makes it possible to fuel a ferry for a whole day's operation in less than 30 minutes.

Fig. 3. Number of vessels on order per vessel segment (as of May 2015)



Source: DNV GL



Photo: Port of Helsinki

Finish ports of Tornio, Pori, Rauma and HaminaKotka. Within the next few years four small-scale LNG import terminals are going to be built in Finland. In 2014 The Finnish Ministry of Employment and Economy granted a total of EUR 92.8 mln for four new LNG terminals. The terminals are going to be located in Tornio, Pori, Rauma and HaminaKotka. The terminal in Tornio will be built by Manga LNG Oy and will be equipped with an LNG storage capacity of 50 thou. m³. It is scheduled to be put into operation in 2017. The terminal in Pori will be built by Skangass Oy. The Pori terminal will have an LNG storage capacity of 30 thou. m³. It is scheduled to be ready in autumn 2016. Rauma's terminal is going to be built by Oy Aga Ab. The combined storage capacity of the Rauma terminal's eight LNG tanks will be 10 thou. m³. Work on the terminal is set for completion in early 2017. The terminal in HaminaKotka will be built by Haminan Energia. The Haminan Energia LNG terminal, which is scheduled to be ready in 2018, will be equipped with one LNG tank of 30 thou. m³ and facilities related to receiving, unloading, storing and delivering LNG. It is planned that all terminals will supply LNG to industry, maritime transport and road transport.

The LNG-fuelled fleet

As of May 2015 there were 63 LNG-fuelled ships in operation and 76 ships on order. Still, over 80% of all LNG-fuelled vessels in operation are only sailing in Norwegian waters and mainly represent small ships such as small car/passenger ferries,

offshore ships (platform supply vessels, PSVs), tugs, patrol vessels (Fig. 2). However, now there are also several larger vessels powered by LNG in operation, such as large ro-ro and ro-pax vessels, general cargo vessels, gas carriers (excluding LNG carriers).

The first large LNG-powered vessel, the ferry *Viking Grace* owned by Viking Line, has been in the operation since January 2013. It is the first LNG-fuelled vessel that has been put into operation in the Baltic Sea. The 57,000 GT ferry operates between Turku in Finland and Stockholm in Sweden. It has a length of 214 m, a width of 31.8 m and is able to accommodate 2,800 passengers. The ferry is equipped with four Wärtsilä dual fuel (LNG/diesel) engines, of a combined power of 30,400 kW. *Viking Grace* consumes about 60 tn of LNG per day and about 22.5 thou. tn per year. The ferry cost around EUR 240 mln, of which EUR 28 mln came from a Finnish Government subsidy.

Large LNG-powered vessels are also operated by Fjord Line on the routes between Norway and Denmark. Fjord Line's two cruise ferries, Stavangerfjord and Bergensfjord, were built at Bergen Group Fosen. The first vessel entered into service in July 2013, while the second in March 2014. The 25,000 GT ferries are 170 m long, 27.5 m wide, and are able to accommodate 1,500 passengers. These vessels are the first and the largest cruise ferries in the world to sail with a 'single LNG engine' which means that they solely use LNG fuel.

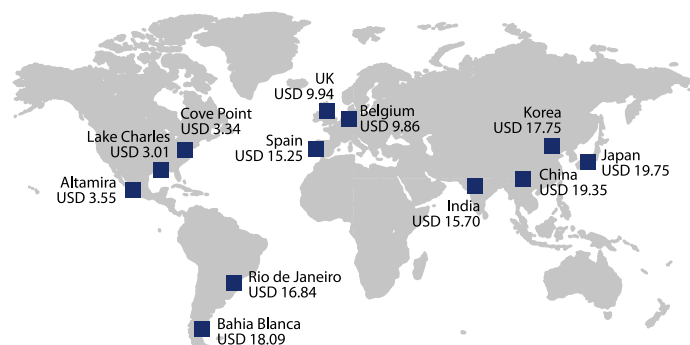
One of the LNG-fuelled ferries that was recently put into operation (March 2015) is

Samsø. The ferry was ordered by the Samsø Municipality (Denmark) and has been dedicated for a domestic Danish route, between mainland Hou (Jutland) and the island of Samsø. The ferry is an LNG double-ended ferry with dual fuel engines built in Remontowa Shipbuilding, Poland. The vessel is 100 m long and is able to carry 60 personal cars, or 16 lorries as well as 600 passengers.

As of May 2015, there were 76 LNG-powered vessels on order worldwide. Most of these vessels are dedicated for the European and American markets (Fig. 3). It can be indicated that among the ordered ships, the largest part constitutes four types of vessels: container ships, car/passenger ferries, PSV, and gas carriers (other than LNG). These types of ships together account for over 63% of the total order book. LNG propulsion is also chosen as a solution for eight chemical tankers, seven tugs, four ro-ro vessels, and three other specialized vessels. Besides, there are one to two orders for other types of ships.

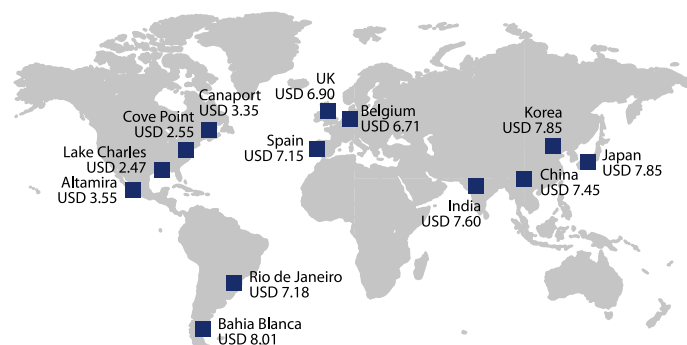
Most of the ordered LNG-powered container ships (eight) are dedicated for intra-European routes, and the rest (six) for intra-North American routes. It is expected that the first container vessels fuelled by LNG will enter into service in 2015; these will be two container ships ordered by Brodosplit and two container ships ordered by TOTE Shipholdings. The two vessels built for Croatian Brodosplit, fall within the size range of 1,300 to 1,500 TEU and are probably dedicated for intra-European feeder trades, whilst ships built for TOTE are dedicated for the US-Puerto Rico route.

Fig. 4. World LNG prices (March 2013)



Source: US Federal Energy Regulatory Commission

Fig. 5. World LNG prices (April 2015)



Source: US Federal Energy Regulatory Commission

Another four ships are ordered by the German ship-owner GNS Shipping/Nordic Hamburg. The vessels will later be chartered by the Finnish operator Container-ships. The 170 m long, 1,368 TEU (alternatively 639 SECUs) ships will be built by Yangzhou Guoyu Shipbuilding. Two ships are scheduled for delivery in the course of 2016 and the other two in 2017. Container-ships also ordered an additional two LNG-powered container ships with deliveries scheduled for 2018.

Among the confirmed orders are also four ships scheduled for delivery in 2017 and 2018 ordered by Crowley Maritime Corporation and Matson Navigation Company. These ships are dedicated for the North America route.

In the case of car/passenger ferries, five out of 13 orders are dedicated for European routes, and the rest for Canadian routes. Among these seven ferries are two ships ordered by the German ferry owner AG Ems, and scheduled to be delivered in 2015. The first order is a conversion project. The existing ship, *Ostfriesland* is being retrofitted with Wärtsilä's 20DF engines and an LNG-Pac. The ship is being rebuilt and its length will increase from 78.7 m to 92.7 m and will accommodate 1,200 passengers. The second ship, *Helgoland*, is a newbuild that is scheduled to be delivered in summer 2015. The cost of the new vessels is estimated at EUR 30 mln. The ships are dedicated for domestic German routes.

Investment in an LNG-fuelled ferry is also planned by ferry operator Tallink. In February 2015 AS Tallink Grupp and Meyer Turku Oy signed a contract for the construction of an LNG-powered fast ferry for the Tallinn-Helsinki route shuttle operations. The ship, with a gross tonnage of 49,000 will be about 212 m in length with a passenger capacity of 2,800. The fast ferry will cost around EUR 230 mln and will be delivered at the beginning of 2017. The remaining two ferries, dedicated for European routes, were ordered by Boreal Transport Nord AS. They are scheduled to be put into operation in 2016 on Norwegian waters.

In the case of liner vessels, there are also four ro-ro ships, two car carriers and two ro-pax ships ordered. Among the ro-ro ships one is dedicated for the Norwegian market and the others for the American and Australian markets. The ro-ro ship dedicated for the Norwegian market was ordered by Nor Lines AS, a Norwegian logistics and shipping company. The 5,000 dwt vessel is being built by Tsuji Heavy Industries (Jiangsu) in China and was scheduled for delivery before summer 2015. This is the second ship of its kind ordered by the ship operator; the first one was delivered in February 2015.

Two car carriers have been ordered by United European Car Carriers (UECC). The vessels will be 181 m long with a 30 m beam, able to take on-board approx. 3,800 standard sized cars across 10 decks. Both vessels will be dual-fuel, capable of operating on LNG or Intermediate Fuel Oil/Marine Gas Oil. According to UECC, its new car carriers will have the possibility to complete a 14-day round voyage in the Baltic using solely gas (incl. the main engine and auxiliary power generation). Deliveries of both new units are scheduled to take place in the second half of 2016.

One of the ro-pax ships was ordered by Rederi AB Gotland. The new ferry will be chartered to Destination Gotland, one of Rederi AB Gotland's subsidiaries, and put on its Nynäshamn-Visby line, replacing the two smaller and older high-speed crafts, *Gotlandia* (700-passenger capacity) and *Gotlandia II* (780 passengers). The investment (approximately EUR 160 mln) was placed in the Chinese GSI shipyard. The new 1,650-passenger capacity vessel is scheduled for delivery in the first half of 2017. Most recently Rederi AB Gotland placed a twin order, to be delivered one year after the initial LNG ferry.

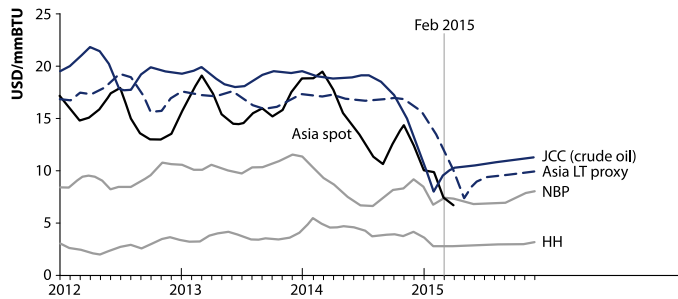
Another LNG-fuelled ro-pax ship was also ordered by Spanish operator Baleària. The LNG propulsion will be installed on-board the existing ferry Abel Matutes which operates between Barcelona and Palma de Mallorca.

LNG fuel prices

To build an overview of the LNG price issue, we will look a little bit closer at the prices of LNG on major global markets. As it can be seen in Figures 4 and 5, the LNG prices vary widely by region. The reasons for these differences is that the international gas market is fragmented by legal and regulatory requirements, it lacks international transparency and benchmarks, and there are different approaches to contracting. Generally, there are three major pricing systems in the current LNG contracts worldwide. First, oil indexed contract used primarily in Japan, Korea, Taiwan and China. Secondly, oil and oil products indexed contracts used primarily in Europe. And thirdly, market indexed contracts (price driven by supply and demand) used in the USA.

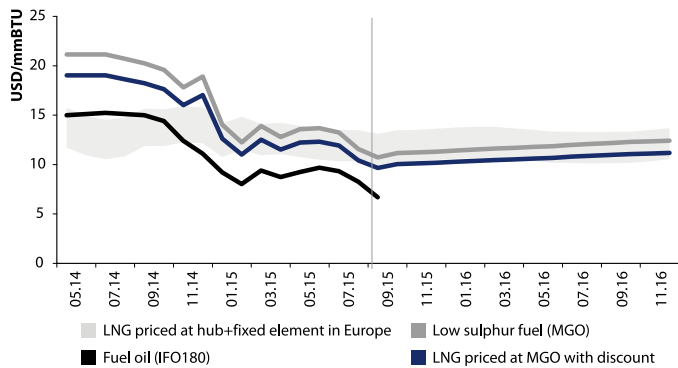
The highest prices for LNG are observed in the Asian Pacific market, which is currently dominated by long-term contracts indexed to oil prices. As a result, when oil prices were high, so were LNG prices (Fig. 4). In March 2013 Asian customers paid between USD 15 to 20 per mmBtu of LNG. The dramatic drop in oil prices across the globe due to weaker demand and increased supply (which started in the mid-2014), had its reflection in the decrease in LNG prices. In April 2015, LNG prices on the Asian Pacific market were at around USD 7-8 per mmBtu. The lowest prices for LNG have always been paid in USA, where the gas price is driven by supply and demand and further set by gas-to-gas competition. In March 2013 in USA one mmBtu cost around USD 3-3.5, while in April 2015 the price ranged between USD 2.5-3.5 per mmBtu. In Europe where the LNG gas price mechanism is linked to the crude oil and oil products prices, LNG prices are mostly somewhere in between the USA and Asian prices. In March 2013 the price for mmBtu of LNG was at around USD 15 (Spain) and USD 10 (the UK and Belgium), whilst two years later, in April 2015, it was around USD 7 per mmBtu, which means that the LNG prices in Europe were comparable with the Asian prices.

Fig. 6. Gas and LNG prices



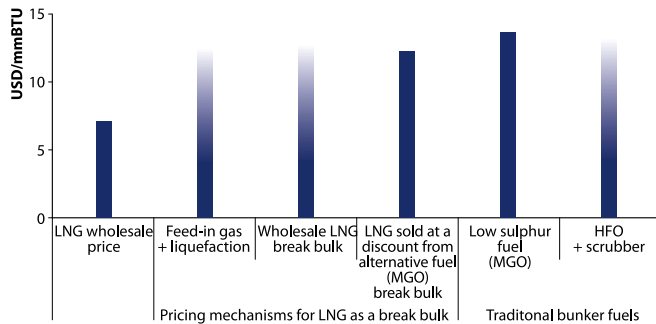
Source: BG Group

Fig. 7. Bunker prices: LNG vs. other fuels



Source: Sund Energy

Fig. 8. LNG pricing mechanisms



Source: Sund Energy

“Generally, the more steps the LNG fuel supply chain includes, the higher the final price is.”

LNG as a bunker fuel has already been available in some locations with-in the North and Baltic Seas. Currently, there is a possibility to deliver LNG to maritime clients in the southern parts of Norway, Sweden and Finland and in all of Denmark by Skangass. Bunkering of LNG-powered sea-going vessels is also possible in the Port of Zeebrugge and Rotterdam by the Dutch LNG supplier, LNG Europe. In some locations in Europe there is also the possibility to bunker inland-going vessels, and the possibility of sea-going vessels is investigated (for example: Amsterdam, Antwerp). However, still the LNG bunkering market is a niche market. LNG as a ship's fuel is sold on a small-scale to a few customers from shipping sectors, each ship-owner is treated individually and the prices are settled individually according to a customer's needs. Today, two main LNG fuel pricing mechanisms exist, namely LNG fuel price index to Hub prices or LNG fuel price index to MGO prices.

For example, Skangass is able to index the LNG price to HFO prices, MGO prices or Gas Hub prices, the choice depends on its clients' preferences. Generally, after discussions with one of its client from the maritime sector, it usually ends up with the gas index price. Skangass offers both spot supplies and long-term contracts. Spot supplies are popular among PSV vessels operators in Norway. In agreements with these operators there are no fixed volumes, and the company delivers LNG to the vessels when they need it. The other company that is able to deliver LNG to maritime clients, LNG Europe, quotes LNG at the Zeebrugge Hub price. They mainly focus on long-term relations but are also open to other forms of cooperation.

In the first half of 2014, the price of the LNG index to MGO, was generally 30% to 80% higher than the LNG index to Hub prices. The situation started to change in the second half of 2014, when prices for MGO began drifting down significantly, which was related to the drop in oil prices across the globe. As a consequence, the price for the LNG index to MGO and price of the LNG index to Hub became comparable and in some cases it was possible to get a lower price indexed at MGO than the Gas Hub price (Figure 19). The lower prices for MGO made the LNG index on Hub less competitive than it was before the decrease in prices of bunker fuels.

When LNG is indexed to MGO, it means that some discount to the price of MGO is made, to compete with LNG. When LNG is indexed to the Hub price it means that the whole price includes the LNG price at Hub and additional costs connected to the LNG fuel supply chain, such as costs of storage, cost of transshipment to local port facilities and further to the end user. Generally, the more steps the LNG fuel supply chain includes, the higher the final price is. Hence, it is indicated that the lowest price possible to offer import terminals or large liquefaction plants depends on the access to cheap gas. The final price also depends on the LNG bunkering solution (ship-to-ship, track-to-ship, onshore installation). Different solutions generate different costs, which affect the final LNG fuel price. Moreover, the future LNG fuel price levels depend on a series of different factors which are characterized by high uncertainty. The most important among these factors are: the level of demand, the level of supply, the oil-gas price relation, development of alternative fuels, and geopolitical developments.

Additionally, analysing the prices of LNG, two different sources of LNG have to be indicated, which can have an impact on the final price for the shipping sector. In the first model the basic supply chain link is the LNG import terminal. From the terminal LNG is transported to the place of bunkering via tank trucks or bunker vessels or LNG from a hub is transported to a smaller scale LNG terminal, where it is unloaded to the storage tanks and then loaded onto bunker ships or tank trucks that carry LNG to the place where bunkering operations are performed. In addition, small LNG terminals may be constructed in the vicinity of the quay where LNG-powered vessels are moored. In such case, the bunkering operation can take place from fixed onshore tanks via a pipeline system.

The second model assumes that LNG terminals for bunkering purposes are supplied from the land side and not from the sea side (in such case the supply chain

does not include a hub terminal). In this case, gas is sent via a pipeline system to the liquefaction plant, which is connected to an LNG bunker station. This supply chain is characteristic for Norway. In most European countries the first model will be dominant.

LNG synergies among energy and transport

More and more often possible LNG synergies between energy and transport are indicated. Generally, it would be more beneficial to create synergies between different users in one particular area rather than concentrate on one market segment with a wider regional focus. This would be beneficial for both LNG terminal operators (optimisation of operational cost) and users (improvement of LNG pricing). Besides maritime transport, terminals' capacities can also be used by land transport users, industry and gas systems.

Today LNG as a fuel for land transport applies mainly to the heavy on-road trucks and busses (especially city busses). All major truck manufacturers offer natural-gas engines, either as dedicated (mono-fuel) Otto-cycle engines or as Diesel-cycle engines. While dedicated Otto-cycle engines run exclusively on 100% natural gas, dual-fuel engines run on methane-diesel mixtures with diesel substitution rates of 50 to 95%, according to the German Energy Agency DENA. The following operators are already using an LNG-powered fleet: Rolande, DHL, UPS, Coca Cola, Tesco, ASDA, Simon Loos, and VOS Logistics. The average fuel consumption of a typical LNG-fuelled truck equipped with a dedicated mono-fuel engine of power in a range 200-250 kW can be at around 26-28 kg/100 km.

In Europe LNG-fuelled trucks are already operating successfully in the

Netherlands, Spain, the UK and Sweden. It seems that the leader in the number of LNG-fuelled road vehicles is the Netherlands. In June 2014, 231 LNG-fuelled trucks were running in that country (which accounts for about 0.3% of the total truck fleet). It is forecasted that in 2020 there will be approximately 40 thou. such vehicles. Today (as of October 2014) there are eight filling stations for trucks. In Spain, approx. 150 trucks use this fuel at the moment, but forecasts suggest that about 5,000 LNG-powered vehicles could be on the Iberian Peninsula by 2028, 3% of the total fleet. In the case of LNG-powered busses it seems that Poland is the pioneer. In October 2013 Gazprom Germania and Solbus introduced Europe's first 11 LNG-city busses in the Polish city of Olsztyn. In the first quarter of 2015, five LNG-fuelled busses were in the Polish capital of Warsaw.

Today, the use of LNG as a fuel in land transport is limited by the low number of refuelling points. However, according to an EU Directive on the deployment of alternative fuels infrastructure an appropriate number of LNG refuelling points accessible to the public should be put in place by December 31st, 2025 at the latest, at least along the TEN-T Core Network existing at that date and, after that date, on the other parts of the TEN-T Core Network where these are made accessible to vehicles. The Directive indicates that the necessary average distance between refuelling points should be approximately 400 km. This allows for the assumption that in the future LNG becomes a more and more popular fuel for land transport.

In the future LNG can also be used by port terminals to power ports' handling

equipment such as terminal tractors, reach stackers, empty container handlers and RTG. Currently, LNG fuel terminal tractors have been used for example in USA. In Europe, within the framework of Sea Terminals which is coordinated by the Valenciaport Foundation, the prototypes of Eco-RTG based on dual LNG/diesel fuel (SEA-RTG Dual Fuel) will be developed.

LNG from the terminal can also supply land-based customers. The main land-based customers that may generate the most significant demand for LNG are first of all industrial customers such as power plants, refineries, chemical industry, and steel manufacturers. Further comes the potential demand from households or non-households application such as hospitals, schools, hotels, etc. LNG to the final users can be transported by tank truck in liquid form, if the user has his own LNG storage and regasification facility or by pipeline infrastructure, especially if the user is located in the vicinity of the terminal as such infrastructure is built. Moreover, the terminal can also supply the port's town gas grid.

Analysing the market of potential clients from land-based sectors of the proposed LNG terminal, boil-off gas should be taken into account. Boil-off gas is formed during the transfer and storage of LNG. LNG is handled at an ultra-low-temperature of -160°C, partial gasification due to natural heat input from the outside cannot be avoided in LNG facilities. Generally, the boil-off gas rate is about 0.05% of tank volume per day. Boil-off gas can be re-liquefied and returned to the storage or compressed and sent as natural gas, for example, to the city's gas companies or industrial consumers of gas located nearby the terminal. ■



Photo: Wikimedia Commons



Maciej Mazur

Communications Manager at Polskie LNG

ately, the most dynamic development across the global gas market was observed on its Liquefied Natural Gas (LNG) part. LNG is anticipated to substantially contribute to EU's energy security and improve competition on the gradually consolidating energy market. The forthcoming years will be also pivotal for the development of the LNG market in Poland. The LNG import terminal in Świnoujście is one of the greatest Polish energy projects in recent years and it has been recognized by the Polish Government as strategic for the country's energy security. This facility will allow for receiving natural gas delivered by sea from almost every direction in the world. By acquiring access to the global LNG market, Poland will be able to improve its security by the means of fuel supply source diversification. The newly established natural gas receiving system may be used not only to 'fuel' the domestic market, but also contribute to the development of the Baltic Sea region as well as other countries of Central and Eastern Europe.



Isabelle Ryckbost

ESPO's Secretary General

The European Sea Ports Organization (ESPO) considers LNG as a very promising alternative fuel for shipping with great potential to reduce harmful exhaust emissions and reduce greenhouse gases. As such, European ports are ac-

tively engaged in projects making LNG a reality.

Cleaner transport and the transition to a low carbon energy landscape is a high priority for the European Union. It is clear that LNG has to play an important role to achieve this goal. The European Commission has taken different initiatives to boost the use of LNG in transport, ranging from the Directive on deployment of alternative fuels infrastructure, the creation of a Sustainable Transport Forum to the financing of projects on alternative fuels under the Connecting Europe Facility. These initiatives will certainly incentivise the deployment of LNG in the transport sector, but more is needed.

In general terms, one can state that energy, like transport, relies on a network. Consequently, the alternative energy network can only work efficiently if there is a "network" and if many are using it. So I do believe that Europe alone cannot be the driver of LNG trade. Therefore, strong international cooperation is needed involving all industry stakeholders. Even if the short-term outlook is "bleak", we should look a little bit further: The demands in energy in the long-run, the sustainable energy policy targets in the US, etc., could change the demand for LNG very rapidly. A sudden rise in oil prices could be another game changer. For European ports, which are to become hubs for demand and trade of LNG, and their investors, it remains in any case a big challenge to cope with these realities.



Mantas Bartuška

CEO of Klaipėdos nafta

As a part of Europe's consumers the Baltic region is a brand-new market for LNG suppliers. In this respect it is an evidently growing market with unfolding potential. Lithuania plays a leading role in developing a regional gas market foremost by

launching the first full-scale LNG terminal in Klaipėda port in December 2014, and secondly – by developing small-scale LNG activities such as vessel bunkering and inland truck LNG distribution right now. It is a big step in cutting off dependency from gas monopolies and a visible makeover for energy sources in the region.

Therefore, in general, the LNG supply outlook is positive. LNG trading created a competition that has already affected traditional natural gas suppliers and prices. The Baltic market is about to grow rapidly within the coming few years as several mid- and small-scale LNG terminals are being planned or are already under construction. What's more, market liberalization in the region is also moving forward and increasing demand is foreseen in the industry sector. Shipping is also one of the key factors promoting gas consumption since the Baltic Sea is a low sulphur emission zone. As such more shipping companies and ship-owners see natural gas as a viable alternative fuel source, given the abundance of supply and the relatively stable prices.

Of course, we should keep in mind that it will take time to develop the Baltic gas market and make it flow into the "wider waters", but there is a favourable outlook for LNG demand taking into account that a lot of investment-related LNG promotion has been made recently, especially in the transport sector.



08

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Building the LNG momentum

by Aleksandra Plis



Emil Arolski, Project Manager of LNG in Baltic Sea Ports II

The first phase of the LNG in Baltic Sea Ports project has successfully ended, delivering valuable input. And as the project came to its conclusion, its follow-up took up the baton. We talk with Emil Arolski, Project Manager of LNG in Baltic Sea Ports II, about the first part's reception, the main differences between the projects, the follow-up's objectives as well as an outlook for LNG.

■ **The first part of the 'LNG in Baltic Sea Ports' project kicked off in 2012. In your opinion what has changed regarding the Baltic LNG issues over the years?**

The Baltic LNG initiative, whose idea was introduced for the first time by the Baltic Ports Organization back in 2011, set off one year later in September with seven partner ports with the aim of developing a harmonized approach towards setting up LNG infrastructure in the Baltic Sea region (BSR). Thanks to numerous meetings and the so-called stakeholders' platforms, I can say with full confidence that the LNG situation in the Baltic has matured a lot over the past several years. As a clear sign of this, we now have four new partners who have joined the project with already concrete small-scale LNG infrastructure plans. On the seaside, however, the current state of affairs lingers behind since there are only two LNG-driven ships in the Baltic, the cruise ferry *Viking Grace* and the *Turva* patrol vessel of the Finnish Border Guard, but more will come in the more or less distant future.

■ **How has Europe recognized the final outcomes of the project's first part?**

Both parts of the 'LNG in Baltic Sea Ports' fit well within the EU initiative of establishing LNG bunkering facilities throughout the TEN-T network and surely the projects' expertise and know-how will come in handy in other corners of the Community in due time. Moreover, the first project as well as its follow-up have been granted the EUSBSR Flagship Project status by the Danish Maritime Authority which heads the Priority Area on Clean Shipping of the EU Strategy for the BSR, acknowledging the projects' high macro-regional cooperation and eco-friendly impacts. Overall, we have received recognition for our accomplishments from the side of high officials from the European Commission, TEN-T and INEA (Innovation & Networks Executive Agency), not to mention interest shown by other stakeholders like LNG America and Fundación Valenciaport.

■ **In what way does the follow-up project differ from the first one?**

Firstly, there are four completely new partners, of which two aren't strictly ports as in the first part. The Sundsvall Logistikpark is a partnership company of various stakeholders focused on



in Baltic Sea Ports II

PROJECT INFO

Project Leader: Per-Olof Jansson,

Chairman of the Steering Group, Port of Helsingborg (SE)

Project Manager: Emil Arolski,

Head of International Development, Actia Forum Ltd. (PL)

Partners I: Port of Aarhus (DK),

Copenhagen Malmö Port (DK/SE), Port of Helsingborg (SE),

Port of Helsinki (FI), Ports of Stockholm (SE),

Port of Tallinn (EE), Port of Turku (FI)

Timetable: January 2012–December 2014

Partners II: Port of Helsingborg (SE), Port of Trelleborg (SE),

Sundsvall Logistipark (SE),

Port of Rostock (DE), Klaipėdos nafta (LT)

Timetable: January 2014–December 2015

FOR MORE INFORMATION:

www.lnginbalticseaports.com



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

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environmentally-friendly development, while Klaipėdos nafta is a Lithuanian oil & gas major and operator of the floating LNG terminal *Independence*.

Secondly, the project partners have tabled many more concrete actions to be undertaken than doing just pre-feasibility studies. For instance, the Coordinator of the follow-up, the Port of Helsingborg, is to develop an LNG bunkering vessel design, naturally for construction and operation in the future. Both Trelleborg and Sundsvall will carry out engineering and technical studies concerning the set-up of LNG infrastructure. The Port of Rostock aims at obtaining all relevant LNG bunkering infrastructure permits in order to cater to the market with a bunker station. Klaipėdos nafta will execute technological studies together with going through a full environmental procedure as well as getting other necessary permits in order to choose the best location for a bunkering facility. These are the partners' direct objectives and according to their development reports there are no particular critical delays.

■ From your perspective, what will the LNG Baltic market look like in 10 years' time?

I'm very optimistic to see all TEN-T core ports having LNG ship bunkering

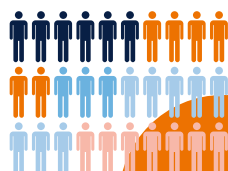
infrastructures in place by 2025. In turn, we'll most likely experience a significant growth in LNG demand as marine fuel, not only in the Baltic, but also Europe-wide. There were, however, very optimistic estimations done by DNV GL in the past of more or less 1,000 ships running on gas by 2020, undermined nowadays to some extent by falling prices of traditional bunkers. Nonetheless, this forecasted downtrend in my mind is only temporary as we'll most likely experience a more positive development in years to come. What's very interesting as well, is the potential upswing in LNG demand on the landside. LNG is discussed more and more as a viable and cost-saving alternative fuel, be it for heavy-duty industries like power stations and refineries (Preem's LNG terminal in Lysekil is a good example here), for overland transports (LNG-driven trucks), as part of container terminals' vehicle fleet (LNG-powered reachstackers, tractors and dual-fuel gantry cranes) or in the overall oil-to-gas transition. Therefore, most likely the future will bring even more LNG projects and promotional campaigns supported by the European Commission as well as win-win synergies among various stakeholders.

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HEKLA enters the stage

Southern Baltic LNG transport and energy potential

by **Aleksandra Plis** and **Maciej Kniter**

“Finding a solution for today and for the future at the same time is the biggest challenge,” Roland Brodin, Project Manager of the Helsingborg part in the jointly-led Port of Helsingborg-Klaipėdos nafta HEKLA project, stressed during the LNG Transport Forum in Valencia. Liquefied Natural Gas is believed by many to be the answer to this task, and while some are already ahead of implementing LNG solutions in the Baltic, by teaming up with others, one can make double leaps.

The first edition of the Baltic Ports Organization-initiated LNG in Baltic Sea Ports project, lasting from January 2012 till December 2014, focused chiefly on harbour LNG pre-investment studies with the potential also to offer bunkering services to marine clients in the future. As such the activities in the Port of Helsingborg involved market and profitability analyses together with meetings with stakeholders, finding the proper location, basic quay and terminal designs, investment calculations, risk assessment as well as preparations for permits and arranging tender documentation.

The project's follow-up is still in progress, this time also with the involvement of HEKLA's second initiator, the Lithuanian company Klaipėdos nafta, operator of the country's floating, storage and regasification unit *Independence* moored in the Port of Klaipėda. Helsingborg, apart from continuing technical studies on LNG port infrastructure, has turned its attention to the sea part of LNG, too, working on the design of a multifunctional LNG-powered ship able to provide LNG and MGO bunkering as well as other ship supply services.

“Our goal is to establish an LNG/LBG infrastructure in the south of Sweden,” Per-Olof Jansson, concisely pinpoints HEKLA's aim. This is to be done in three steps. Firstly, by setting-up a liquefaction plant in Helsingborg, which should be ready by the end of 2017. Secondly, by constructing an on-shore reloading station in Klaipėda, intended to be in place by 2017's beginning. And finally, by building the above-mentioned multifunctional bunker vessel, worth EUR 30 mln and operational in 2019/2020.

“There's no ‘silver bullet’ to make an LNG investment an instant success story,” Per-Olof Jansson explains and lists key factors to be ticked off such as the right location with both a significant number of vessels passing by and calling at the port; as precise as possible value chain assessment and data-mining before making a final decision on the business model; and last but not least – fruitful cooperation with partners and stakeholders to have things done step by step in the right direction, at best with the help of the EU. ■



Mantas Bartuška

CEO of Klaipėdos nafta on the HEKLA initiative

■ **Why did you pick the Port of Helsingborg as your partner?**

First of all because of its proximity – Helsingborg is a Baltic seaport and we have always supported all currently ongoing Baltic LNG-related initiatives. When we set-up the large scale terminal in Klaipėda, we came to know that the southern Baltic is in fact a great location for expanding our activities. We are therefore more than content that together with Helsingborg we have managed to obtain EU funds for the HEKLA project and that everything is going according to the plan.

■ **What do you want to achieve thanks to this project?**

Once we have completed the large scale LNG terminal, we believe that we will have gained new competences in LNG terminal development as well as on the operational side. In the very short time of six months we have managed to prepare all documentation regarding small-scale activities and succeeded in getting EU funds (40% of co-financing, the maximum available, which not only gives us the necessary EU funding backbone, but also reaffirms our standing as a solid business partner). In August we made the final investment decision on constructing the reloading station. We plan to finalize the whole scheme by the beginning of 2017, a short period of time indeed, but we believe that we can pull it off. We also believe that we have opened the “gas gate” for the Baltic and that LNG will become more and more available to inland customers, be it various industries in the first instance, followed by other applications in the future like LNG as truck fuel. We see not only a great potential for development in the two other Baltic States, in northern Poland as well, but also in the whole of the BSR. In general, turning our eyes towards the sea, both when it comes to large- and small-scale LNG, has opened up new synergy opportunities and become a very promising item in Klaipėdos nafta's strategy.

On-the-road

by **Marcin Włodarski**, *HEKLA's Project Manager Assistant*

Until recently, the use of Liquefied Natural Gas (LNG) has been considered mostly in terms of states' energy security or as an alternative fuel for onshore applications. Along with the enforcement of the 0.1% Sulphur Directive in northern Europe, as well as varying prices of oil, LNG has become an attractive ship bunker option, too. As such, the HEKLA project aims at establishing proper LNG bunkering infrastructure in the Baltic Sea region, hence lending a helping hand to the development of a broader market for LNG uptake as vessels' fuel.

Besides LNG's well-known environmental benefits, there's an important economic factor tipping the scale in favour of gas, namely price levels of LNG as fuel being below that of traditional and low sulphur bunkers. Nevertheless, the rollout of the Baltic LNG market – so as to approach customers interested in a sound and secure supply chain of this alternative fuel either for maritime or other onshore purposes – requires actions stimulating the development of relevant infrastructure within the BSR.

“The rollout of the Baltic LNG market requires actions stimulating the development of relevant infrastructure within the BSR.”

At the moment, only three LNG terminals are up and running in our corner of the world – two in Sweden, Nynäshamn on the east, and Lysekil on the west coast, as well as the Floating Storage and Regasification Unit *Independence* of Klaipėdos nafta moored in the Lithuanian Port of Klaipėda (however, it does not yet offer bunkering).

Framework for action

HEKLA stands for Helsingborg and Klaipėda LNG Infrastructure Facility Deployment, and is a project aimed at providing a framework for practical

implementation of model solutions to be conducted by the Port of Helsingborg and Klaipėdos nafta.

HEKLA constitutes part of the so-called Global Project, consisting of three phases, in order to stimulate the LNG fuel market development across the Baltic Sea. Investment activities to be carried out within HEKLA were preceded by two projects, both co-financed by EU TEN-T money, which facilitated the preparation of the pre-investment studies for the implementation part. The projects LNG in the Baltic Sea Ports and its sequel LNG in the Baltic Sea Ports II were dedicated to the elaboration of such documents as environmental impact assessments, feasibility analyses, project designs, regional market studies, and safety manuals.

The HEKLA project as such assumes implementation of LNG bunkering infrastructure at the Port of Helsingborg and within the premises of Klaipėdos nafta in the Lithuanian harbour. Major activities to be conducted by the first include building a liquefaction plant with a storage tank, groundworks to extend storage capacity, purchase of an LNG bunker vessel, extending the existing berth where LNG activities are to take place, building a full-scale LNG facility and dismantling and relocating steel tanks to other sites, as well as setting up a new jetty for tankers up to 40,000 m³. The new facility in Helsingborg will enable the supply of LNG to ships and other stakeholders, including overland transports and industry.

The Port of Klaipėda, although it is the third recipient of LNG in the Baltic Sea and the host for the large LNG floating terminal *Independence* (operating there since the end of 2014), does not have relevant infrastructure for fuelling vessels with gas. In order to change this situation, Klaipėdos nafta plans to set up an onshore LNG re-loading station, thus making it possible to directly bunker ships from tank, as well as offer downstream gas supplies by injecting LNG into tank trucks for off-grid customers. The pre-investment stage, including a feasibility study, design of LNG infrastructure and an environmental impact assessment, has been completed within the LNG in the Baltic Sea Ports II project.

Keepin' it posted

Development of the LNG infrastructure in the ports of Helsingborg and Klaipėda will be accompanied by an information campaign addressed towards all stakeholders interested in taking advantage of using LNG as fuel. A crucial part of this activity will be the so-called HEKLA on-the-road campaign, foreseeing visits, promotion and presentation of LNG solutions and showcasing the project's advancements.

It is expected that the provision of comprehensive information will encourage stakeholders to replicate these solutions. The campaign will be finalized by holding two large events in Helsingborg and Klaipėda within the LNG Baltic Transport Forum.

Will Europe drive the future LNG trade?

by **Shresth Sharma**,
Senior Research Analyst (LNG and LPG Shipping)



Shresth Sharma is a Senior Research Analyst with Drewry. He is the lead author for the globally acclaimed Drewry LNG Forecaster. He is also the lead author of LPG Forecaster, published quarterly, which has a comprehensive coverage of global and regional LPG shipping and trade markets. His views on LNG and LPG shipping and trade gets regular coverage in the business media. Shresth has a post graduate degree in Economics.

This article is based on excerpts from Drewry's recent publication – Drewry LNG Forecaster, published quarterly. Data on trade and shipping have been sourced from www.lngoneworld.com. LNGOneWorld, a wholly owned subsidiary of Drewry Shipping Consultants, is an established brand within the LNG market place. LNGOneWorld for over a decade has been providing industry professionals with rich and in-depth coverage on the LNG value chain helping them keep abreast of the trends in the industry. It provides the latest news, editorials along with the latest trade and shipping data. LNGOneWorld's subscriber base includes oil & gas majors, ship-owners, shipyards, terminal operators, traders, risk managers, analysts, and industry leaders.

It's no secret that as of late growth in LNG supply has been outpacing the growth in LNG demand. We are at a juncture where Asian demand, which is otherwise robust, is slowing down. Japan, which has been a major driver of LNG trade post-Fukushima, has re-started its first nuclear reactor, while South Korea, another prime buyer has brought back all of its nuclear reactors. Demand from China could also slow down as the economy is going through a rough patch.

With such a bleak scene in Asian demand, the question is, can we see Europe as an alternative hub? Can Europe be the game changer? This article discusses that the recent fall in oil prices has made LNG competitive to piped gas which in turn will create more demand for LNG in European countries as they try to diversify their supply base. However, a growing preference for renewable sources of energy and weakening domestic gas consumption will cap any major surge in LNG demand in Europe, thus leaving Asia as the hub for LNG demand and trade.

Global LNG trade slowing down

The LNG market is changing swiftly as new countries continue to join the importers' club. The latest entrant is Egypt, which started its first Floating Storage & Regasification Unit in April and became the 31st LNG-importing country. Nevertheless, the changing market also brings in new challenges as once a supplier-driven market, LNG is no more the same. The supply of cargo has been increasing gradually as new plants come online in Australia, but demand is unable to keep pace with the rising supply. Global LNG trade has remained stagnant around 240 mln tn over the last four years after a strong compound annual growth rate (CAGR) of about 9% during 2006-10.

The onus of poor growth can primarily be attributed to European countries, where LNG demand declined at a CAGR of -18% during 2011-2014. Although, Asian imports increased at a CAGR of 5.4% during the same period, the pace of growth slowed down drastically from 11% during 2006-11, with Japanese demand stagnating after the peak in 2011. With a steep decline in European imports, the region's share in global trade declined from 27% in 2011 to just 15% in 2014. However, the share of Asian imports increased during this period from 63% to 73% compensating for the decline in European trade.

Is the Asian demand outlook bleak?

Although Asian countries currently drive the majority of LNG trade, we are not so optimistic about future demand growth in the region. Let us first start with Japan, which at present is the biggest buyer of LNG in that region. The enormous increase in Japan's LNG demand since 2011 was spurred by the shutdown of nuclear power plants. However, imports have remained more or less stable in the last three years, as the gas-fired plants are already running at high capacity. Going forward, with re-start of its nuclear reactors (one reactor at Sendai nuclear plant has already started) the demand for LNG is expected to fall. Meanwhile, South Korea has brought back all of its nuclear

Fig. 1. LNG trade development

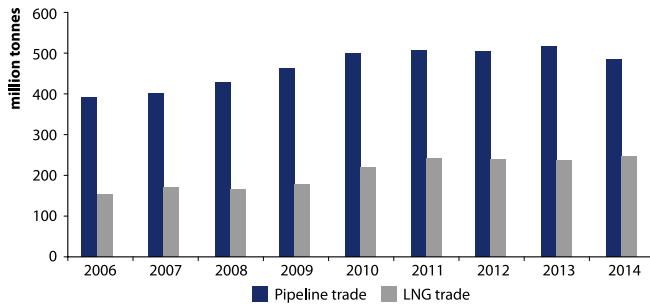


Fig. 2. Share in the world's LNG imports

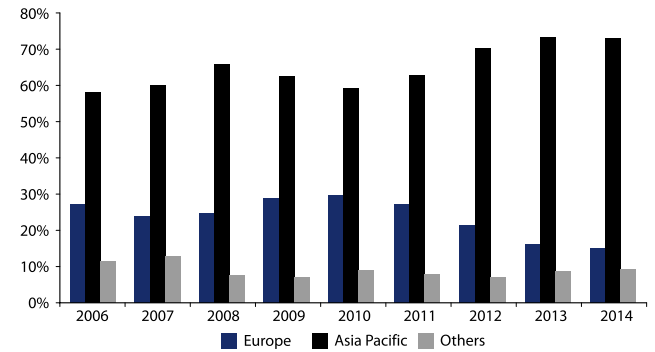


Fig. 3. EU Fuel consumption

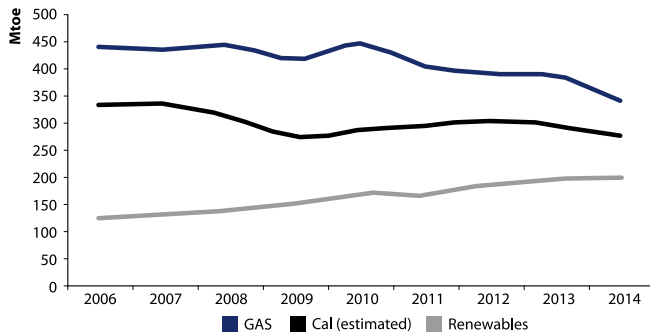
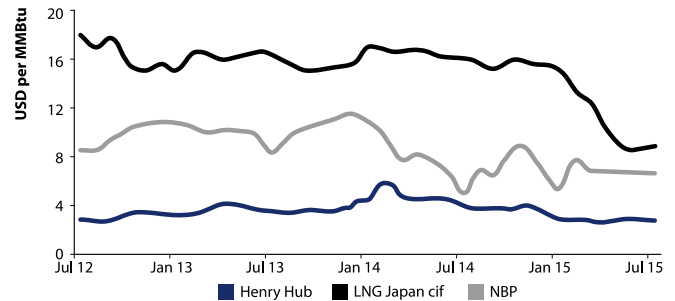


Fig. 4. Gas prices comparison



With continued progress in energy efficiency and greater preference to renewables in the energy mix, gas consumption in the EU has been declining after peaking in 2010.

Pipeline is still a major source of European gas supply as almost 87% of the EU's gas imports are through pipelines.

reactors that were shut down last year due to a fake certificate scandal. LNG imports by China, which has also been a major driver of global LNG trade in the last five years as its imports have grown at a CAGR of 21%, could also slow down due to the weakness in its economy. The slowing economy might impact LNG demand as almost 50% of gas in China is consumed by the industrial sector.

Can European countries provide a new impetus to LNG trade?

Gas consumption in the EU is highly skewed with almost 80% of consumption coming from seven western European countries, primarily Germany, UK, Italy, France, the Netherlands, Spain and Belgium. With continued progress in energy efficiency and greater preference to renewables in the energy mix, gas consumption in the EU has been declining after peaking in 2010. Low carbon prices have also kept the coal-intensive industries and power utilities from showing a major shift towards gas. Thus, poor demand for gas was reflected in lower LNG imports.

The other major factor, which determines the extent of LNG imports, is the competitiveness of LNG vis-à-vis natural gas. After the Fukushima disaster, the surge in demand by Japanese buyers bolstered the LNG prices in Asia, popularly referred to as the Asian premium. As a result, LNG became very expensive in relation to natural gas in Europe, thereby hampering the demand for the former. Traders after seeing the hefty premium in the Asian market preferred to sell cargoes

to Asian countries, thereby reducing the cargo sent out to European countries.

The lower price of competing fuels is also hurting European LNG imports. Coal is still the preferred choice of fuel by many power utilities in Europe owing to its low price, and since the carbon price in the current Emission Trading System is so low, utilities do not find any major incentive to move towards cleaner burning gas.

Moreover, pipeline is still a major source of European gas supply as almost 87% of the EU's gas imports are through pipelines. Russia and Norway are the biggest suppliers of pipeline gas to EU Member States. Russia supplied almost 42% of EU gas imports in 2014, while Norway supplied almost 38%. At a time when gas demand is falling in Europe, high pipeline imports have also been driving down LNG demand. A well-developed pipeline infrastructure and the low price of piped gas has been supporting pipeline trade.

With large importing capacity and declining LNG imports, the utilisation rate of terminals is declining. Currently, nine EU Member States have large-scale LNG import infrastructure with a combined capacity of 132 mln tn per annum. A further 15 mln tn/year of capacity is under construction.

In 2014, more than half of the technical regasification capacity of each country remained unutilised. Thus, in order to improve the terminal utilisation rate, terminal operators are providing additional services such as reloading, truck loading, small ship loading, and bunkering.

The outlook for Europe's LNG demand suddenly looks brighter and the prime

Fig. 5. EU LNG vs. coal imports

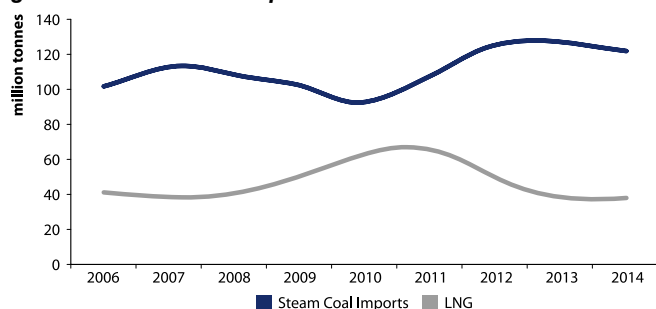


Fig. 7. Terminal utilisation rates

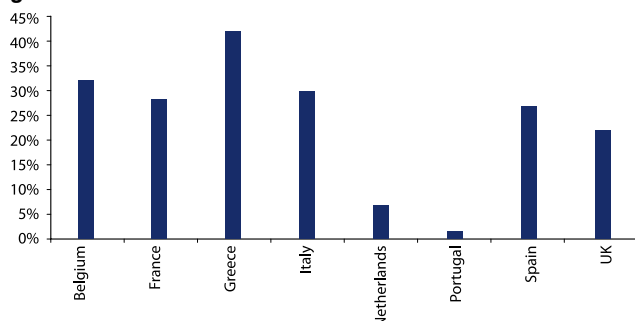
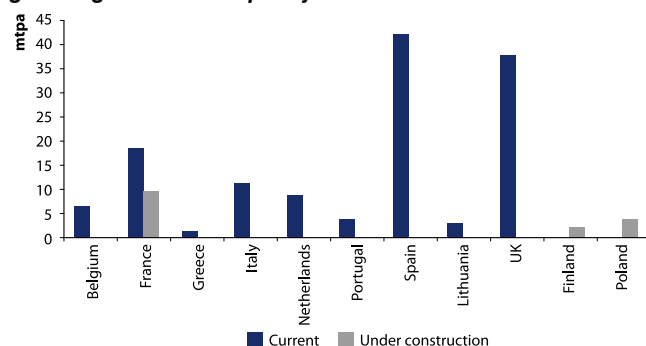


Fig. 6. Regasification capacity



Tab. 1. LNG imports forecast (million tonnes)

	2010	2011	2012	2013	2014	2015	2016	2017	2018
Spain	20.0	17.6	15.1	10.9	11.3	10.4	11.2	11.6	12.4
France	10.2	10.6	7.5	6.4	5.2	5.0	5.2	5.4	5.5
Italy	2.1	6.4	5.2	4.0	3.3	2.0	2.6	2.8	3.0
Belgium	4.8	4.8	3.3	1.9	2.1	3.4	3.5	3.6	3.6
UK	13.6	18.5	10.0	6.8	8.3	9.8	11.5	12.8	14.0

reason is the continuing standoff between the West and Russia since the Ukrainian crisis. European countries are looking to diversify their supply sources in order to strengthen their energy security. The other major reason for increased interest in Europe's LNG demand arises from the fall in LNG prices. As mentioned earlier, the divergence between Asian LNG prices and Europe's gas prices has led to a large number of cargo being exported to Asia. However, as the Asian gas premium has almost been fully eroded after the fall in oil prices, people are speculating on the revival of LNG demand in Europe. We believe that the recent fall in LNG prices will motivate European buyers to buy more LNG, as they are trying to diversify their supply sources. Since the Asian demand is also not showing any major growth, traders and aggregators might also like to find markets in Europe.

“The outlook for Europe's LNG demand suddenly looks brighter and the prime reason is the continuing standoff between the West and Russia since the Ukrainian crisis. European countries are looking to diversify their supply sources in order to strengthen their energy security.”

However, dwindling gas consumption in most of the European countries is expected to restrict the growth in LNG imports by European countries. In addition to this, pipeline supply of gas from Russia

would also cap the region's LNG imports as we believe that the Russian pipeline supply is and will remain a major source of gas to European countries. The first reason is that many countries especially in Eastern Europe do not have any LNG import infrastructure and the second reason is Russia keeping the gas price competitive so that it does not lose too much of its market to LNG. While countries such as Finland and Poland are building LNG infrastructure to reduce their dependency on Russian supply, we believe the LNG import infrastructure is mainly meant to increase the bargaining power of the countries and will not completely drive away the Russian supply. For example Lithuania, which started its first import terminal last year, was seen diverting LNG cargoes as Russia reduced the price of piped gas. So, even in the future, LNG trade will be determined by economics and not politics.

So the only country which is showing greater potential for LNG demand is the UK. The carbon floor price in the country was recently doubled from USD 10.78 to USD 20.43 per tonne of CO₂, and this has substantially eroded the attractiveness of coal-fired power generation. This is leading to increased gas demand and the country's imports surged by 62% in the first half of the current year, over the last year.

Challenging times ahead for LNG shipping

As of now, it is quite clear that Asian countries will remain the top players within LNG trade in the near future. But since LNG demand from Asia is also showing signs of weakness, immediate challenges to LNG

shipping exists. The rates have already come down drastically from the highs of 2012 due to weakening demand and rising fleet supply. In August 2012 a Dual Fuel Diesel Electric vessel was earning USD 150,000 per calendar month (pcm) in the spot market, whereas now its earnings have lowered to as little as USD 30,000 pcm.

At present around 30-40 vessels are sitting idle, while 23 more vessels are expected to join the fleet this year in addition to 42 next year. Drewry expects no improvement in rates anytime soon despite the huge liquefaction capacity coming online in Australia, expected to reach around 49 mtpa within the next two years. Almost 75% of the above capacity has been contracted by Asian buyers and that too mostly by the big three – Japan, South Korea and China. Last year, these countries bought almost 38 mln tn of LNG from the spot market. The Middle East, which was previously their major source for spot cargo, helped in providing substantial employment to LNG vessels.

However, at a time when Asian demand is not rising, contractual supply from Australian projects will substantially reduce the dependency of Asian buyers on the spot market. Moreover, since the Far East is nearer to Australia than the Middle East, the tonne-mile demand for shipping LNG will decline. We believe 50 vessels will be sufficient (assuming two days for loading and discharge time) to carry the entire supply from Australia. So importers in Asia, in addition to their own vessels, can easily take vessels from the long list of uncommitted vessels in the spot market without having any major impact on rates.



Photo: Ports of Stockholm

Maritime eco-transition step-by-step

by **Michał Bagniewski**, *DNV GL*



Michał Bagniewski is responsible for business development of the oil and gas activities within DNV GL energy services. He places particular emphasis on overseeing regulatory and administrative procedures of the industry and issues related to the use of LNG fuel on-board ships. Michał graduated as a naval architect and during his over 20 years of employment at DNV has been dealing with quality and project management in the shipbuilding industry. Currently, he is managing a newbuilding project for polar container carriers.



“Presently, 85% of the world's transport is realised on waters, mostly at sea. Globally, ships emit 2-3% of the total amount of CO₂ produced worldwide, 10-15% of NO_x (the high percentage is a result of wide utilisation of high pressure diesel engines on-board ships) and 4-9% of SO_x (due to burning HFO).**”**

Clean air, fresh water and healthy food have been always indispensable conditions for the healthy existence of all entities. Tens of thousands of ships are sailing every day emitting and discharging harmful substances. One of the biggest pollutants is fuel oil. The global consumption of fuels by ships is estimated to exceed 330 mln tn annually. Over 80% of this amount is Heavy Fuel Oil (HFO) with a high content of sulphur.

during combustion of fuel large quantities of CO₂, SO_x, NO_x (created at high temperatures in engine cylinders from nitrogen included in combustion air), particulate matters (PM) and other harmful substances are emitted. In addition, an oil spill, when it happens, is always a great threat to the environment.

Requirements

Since the beginning of the 1970s, pollution has been restricted by a number of regulations introduced to shipping. The International Maritime Organization (IMO), the UN maritime agenda in its MARPOL convention, limits pollution in water with oil and air pollution respectively in Annexes I and VI.

Discharge of oil to water has been completely outlawed, with a few minimal exceptions. However, emission to air can't be completely eliminated, therefore, IMO and different administrations have introduced several restrictions to air pollution. Presently, there exists a global limit of sulphur content in ship fuel of 1.5%. A 0.5% global limit will be obligatory from the beginning of 2020 (with the possibility of postponement till 2025 – to be decided in 2018). The EU Commission has decided not to postpone implementation of the new limit for ships on European waters.

The IMO has also established special Emission Control Areas (ECAs) on some sea waters. The one in Europe covers the North and the Baltic Seas as well as the English Channel. There, the present limit to the sulphur content in exhaust gasses from ships is max. 0.1%. Emission of nitrogen oxides, NO_x,

from marine engines is also limited. Ships built after the 1st of January 2016, when sailing on ECA waters, will have to cut such emission by 80% compared to the present level.

MARPOL set mandatory measures to reduce emission of greenhouse gases (GHG), e.g. CO₂, from international shipping. Presently, the new ships of specific types and sizes have to reduce GHG emission by 10%, in 2020-2025 by up to 20%, and after 2025 – by 30%.

Most likely, quantities of the emitted CO₂ will be measured, reported and verified (MRV) on-board all ships sailing on European waters starting in 2018. Two years later, the requirement should be global. Other possible limitations, e.g. on black carbon (soot) and volatile organic compound (VOC; gases emitted from cargo and fuel) regulations will follow after 2015.

Solutions (at hand)

What can be done to comply with the above requirements if sea trade is not to be reduced, especially within the ECAs? Presently, 85% of the world's transport is realised on waters, mostly at sea. Globally, ships emit 2-3% of the total amount of CO₂ produced worldwide, 10-15% of NO_x (the high percentage is a result of wide utilisation of high pressure diesel engines on-board ships) and 4-9% of SO_x (due to burning HFO).

The following technical solutions are possible. Firstly, light low sulphur content oils (MGO – Marine Gas Oil) are used as ship fuel. Such fuel should contain less than 0.1% sulphur when in Sulphur Emission Control

Area (SECA). From 2020, a maximum of 0.5% sulphur will be allowed in fuel burnt on-board elsewhere. This option requires minor modifications of the machinery due to the decreased viscosity of fuel. In some cases cooling installations might be required instead of heaters, installed for more heavy fuels. Also modifications of fuel systems and tanks are necessary when other fuel is used outside the areas of controlled emission. The MGO fuel price has presently almost doubled when compared to HFO. However, this option is the most popular one in shipping within SECAs despite the fact that no other emission restrictions except the sulphur limit are met.

Secondly, installation of exhaust gas scrubbers. So far ship-owners have insufficient long-term experience, but devices may remove even 90% of SO_x and PM from the exhaust gases (but not the other pollutants). This solution is relatively expensive, increases fuel consumption by 2-3%, requires space for the scrubber and creates problems with a ship's stability (additional weight put at a height) and with the removal of liquid and solid contaminants. A significant increase in scrubber installations on-board ships built prior to 2016 is expected around year 2020 when the 0.5% sulphur limit is introduced.

Thirdly, selective catalytic reduction (SCR). Nowadays SCR is the only feasible solution for reducing NO_x to the required levels. Further modifications of the marine engines are not able to decrease the amount of NO_x by 80%. The exhaust gas cleaning installation includes a catalyst chamber where NO_x is removed with the use of anhydrous ammonia or urea. However, there are drawbacks to this solution. The catalyst material pores are easily plugged by a variety of compounds like PM, ammonia sulphur compounds and other compounds present in combustion/flue gas. The catalyst is also very sensitive to various "poisons" like halogens, phosphorus, chrome, copper and different alkali metals destroying its efficiency. Unfortunately, the combination of a catalyst chamber with a scrubber in one unit has proven unsuccessful so far.

Fourthly, ship electrification solves almost all issues related to the exhaust

emission into air at least while at sea. Electric batteries may be charged while a ship is at its berth (so-called "cold ironing") or by fuel cells using "clean" fuel such as e.g. hydrogen, methane, methylene, etc. Battery-powered propulsion is already used on-board small ships. The bigger ones with so far the biggest maritime battery installation of 2.7 MWh capacity are supposed to work in hybrid propulsion installations. A significant growth in the hybrid ships' size and number might be expected in the coming years among vessels operating as harbour tugs, offshore service and relatively small car and passenger ferries. High cost – presently even 1,000 USD/kWh including installation and integration and a short operating period of up to 10 years are important disadvantages. Fortunately, the price of Li-Ion battery cells is expected to drop by 60% or even 70% by 2025 compared to 2013.

And finally, Liquefied Natural Gas (LNG) propulsion which appears to be the most promising fuel solution for ships and above all for the newbuilds. LNG fuel is technically verified and operationally safe, has been in marine use since 2001 without any reported accidents. There is no other fuel (except hydrogen) which can compete with LNG on the least emission of burning products in the exhaust. Its use reduces emission of SO_x by 100% since there is zero sulphur content in LNG (sulphur is eliminated during the liquefaction process). NO_x may be reduced by 40-85%. The first result is reached by low speed, two-cycle Diesel engines. In this case however the SCR and EGR (exhaust gas recirculation) systems are to be used for the 80% reduction to be reached. An over 85% reduction in NO_x can be achieved by running low pressure engines in Otto cycle on lean LNG/air mixture. There is an increased content of air and a more homogeneous solution compared with oil fuel reducing the burning temperature of the mixture, cutting the amount of NO_x production down. The quantity of CO₂ produced by engines may be decreased by at least 20%, and up to 30% compared to HFO. This result can be achieved by LNG fuelling the high pressure engines. Such engines are additionally less sensitive to

LNG fuel quality. Emission of PM and soot is reduced by 95-100%.

The use of gas as a fuel in shipping is a young technology, with not a lot of engines burning LNG. The current, worldwide numbers of LNG-fuelled vessels reach about 70 ships in operation and about 80 ships on confirmed order. Presently, 81% of ships operate in Norway, 11% in Europe and 3% in America. The remaining 5% of ships operate in Asia and the Pacific. The situation is changing rapidly. The orderbook shows a different picture where 16% of ships will be built for Norway, 45% for Europe, 33% for America and 5% for Asia and the Pacific. This clearly indicates an increasing interest in the shipping industry's worldwide use of LNG as a fuel, mainly among operators of ships trading in ECAs for a significant period of time. The first LNG distribution terminals already exist in the ECAs, including the Baltic and there are plans for their further construction. The EU Commission suggests 10% of the European ports to have LNG bunkering facilities in the several nearest years.

It is worth mentioning that the present, low level of crude oil price has put the LNG vessels' ordering rate into slow motion. Definitely, it will recover and an increase in oil fuel prices will resume, even though the decision to install LNG equipment for LNG fuel raises the investment by 10-15% in the case of four stroke, low pressure engines and 20% in the case of two stroke, high pressure engines. However, the payback time of LNG compared to MGO is the right measure for checking its attractiveness. The payback period compared to fuel switched to MGO at e.g. 60% parity of the LNG price seen as a percentage of the cost of MGO (per unit energy) could be seven years at 50% of time spent in ECAs and three years at 100% of the sailing time in the areas of the restricted emission.

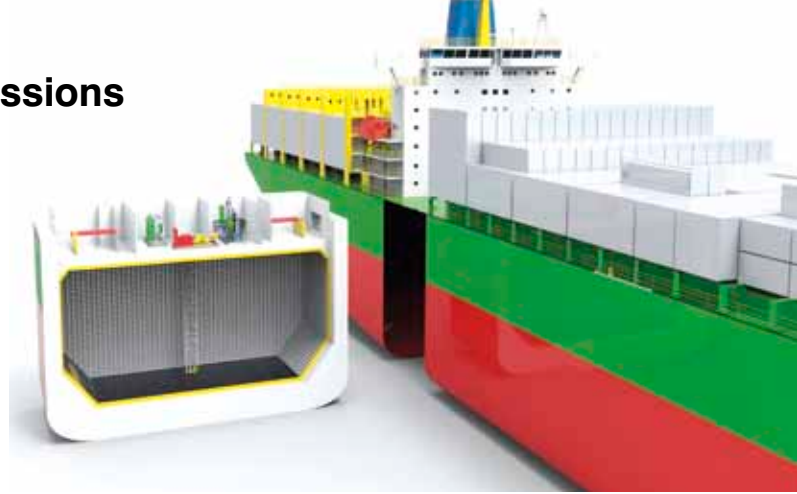
Undoubtedly, all of us will benefit from the introduction of clean fuel used on ships, which produces a minimised amount of air and water pollution. LNG seems to be the most optimal choice considering its impact on the environment during its production and utilisation. ■



Photo: LNG Outargas

LNG-ready

Photo: GTT



by **Geoffroy Beutter**, *GTT*



Geoffroy Beutter is in charge of the business development of GTT in Africa and Middle-East since November 2014. He joined GTT for the development of Small Scale projects and LNG as fuel applications in October 2013.

Graduated in Mechanical Engineer from Ecole Polytechnique Universitaire de Lille in 2007, he worked two years as Naval Architect at ALLAIS Shipyard.

He joined Bureau VERITAS as Machinery Surveyor in 2009. Between France and Korea, the experience made him dealing with a large scope of retrofitting and newbuilding projects (VLCC, LNGC, FPSO, jack-up). In the meantime, he graduated in MBA from IAE-La Sorbonne.

GTT (Gaztransport & Technigaz) is a worldwide specialist in cryogenic membrane containment systems used for the transport and storage of LNG. For over 50 years GTT has been offering technologies which allow to optimize storage space and reduce the construction and operation costs of ships or tanks. GTT operates across the LNGCs (Liquefied Natural Gas Carriers), VLECs (Very Large Ethane Carriers), multi-gas carriers, FLNGs (Floating Liquefied Natural Gas units), FSRUs (Floating Storage and Regasification units), onshore storage tanks as well as the use of LNG as a fuel sectors.

By reducing the authorized ships' bunker sulphur content to 0.1% in the Emission Control Areas (ECA), 2015 is the first of the important milestones for the enforcement of regulations on exhaust gas emissions. Bull's eye investment timing is everything for ship-owners and operators since we'll see more ECAs in the future. The question remains: Which solution to choose?

It is planned to have the 0.5% global application in five years' time, however, this date may be postponed to 2025, as it was already schemed since the creation of the sulphur calendar. This delay was quite easy to forecast: When one has two deadlines, the latter is usually preferred except if there is a significant benefit to choose the earlier one. Is this the case of the 2020 ECA? Rather not, instead time is needed in order to allow the different stakeholders to make up their minds.

Is LNG the only choice?

Many, if not most, of the ship-owners as well as bunker suppliers agree that Liquefied Natural Gas (LNG) is the marine fuel of the future. This is confirmed by the planned or already in place bunkering facilities in Europe (Poseidon Med LNG, LNG in Baltic Sea Ports I & II, Rotterdam's Gate terminal, to name but a few projects) as well as the ongoing 'LNG-ready' newbuilding programmes (such as the series of 17 VLCCs for the United Arab Shipping Company).

All these signs bring the future closer to us, hence the wide-spread use of LNG as marine fuel is just a question of time. But here the chicken and egg dilemma pops up. The egg takes its time to grow up to become a hen (the decision-making process of LNG ship conversion/order, in other words) as well as the chicken to lay an egg (namely to develop a gas bunkering facility). Nevertheless, the riddle is apparent; when the market will reach a certain critical maturity mass, nobody will remember who – the chicken or the egg – solved the dilemma.

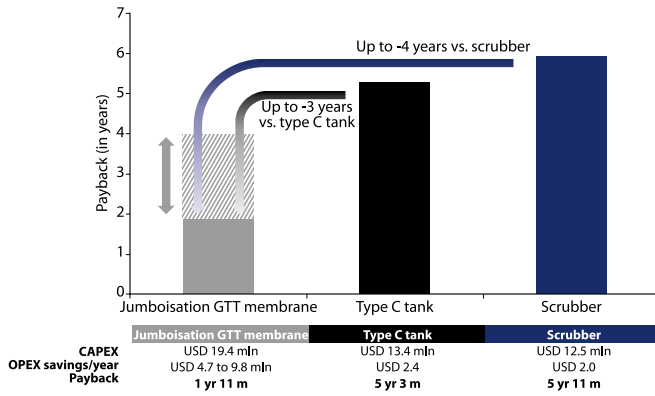
We at GTT have been watching and actively supporting this process since 1964, be it offshore (floating LNG) production sites, deep-sea gas carriers, the development of very large tanks for land storage as well as very small tanks for local supply chains, set-up of harbour facilities and most recently – construction of gas bunker ships and LNG-fuelled vessels.

Benchmarking different ECA solutions

A 14,000 TEU capacity Asia-Europe trade lane container ship spends around 20% of its time in an ECA which is roughly 2,000 NM (five days en route together with a whole week in harbours) counting from the entrance to the British Channel through the Baltic Sea and back. To be compliant in the existing ECAs, the vessel can run on Heavy Fuel Oil (HFO) coupled with a scrubber exhaust gas cleaning system, burn distillates such as Marine Diesel Oil (MDO), Marine Gas Oil (MGO) or ultra-low sulphur heavy fuel (or practically anything, incl. hybrid bunkers, that ensures 0.1% ECA compliance) or utilise LNG on-board (either stored in a C-type or GTT membrane tank).

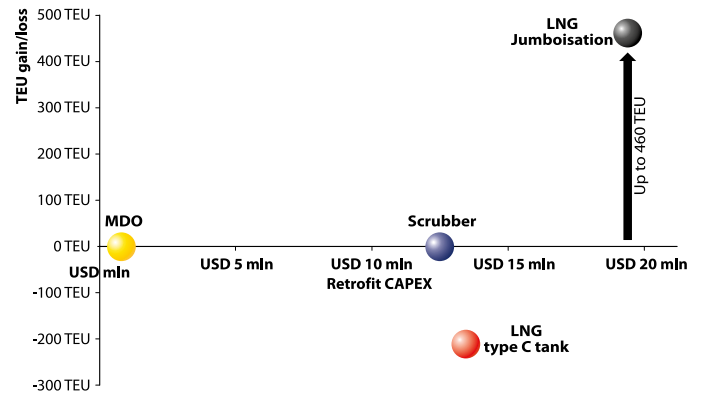
Let's then start with the first solution, i.e. scrubbers. Here the capital expenditure still remains fairly high (between USD 10 mln and 15 mln, depending on auxiliary engines' power source – HFO in ECAs or a shift to MDO), but the operational expenditure is pretty good (as long as oil prices remain relatively low and the HFO-distillates split is profit-yielding). Indeed, except the maintenance of the equipment itself, there are no more fees included. Therefore, scrubbers look like a good sulphur solution at first glance. But there are opinions

Fig. 1. Payback by solution vs. MDO



Sources: Advancy, GTT

Fig. 2. Retrofit CAPEX and TEU gain/loss hypothesis



Sources: Advancy, Wärtsilä, GTT

“In the view of GTT LNG is definitely the long-term and sustainable solution as burning gas can reduce up to 98%, 80% and 20% of SO_x, NO_x and CO_x emissions, respectively.

“Considering both the CAPEX and the gain of TEU, the payback period is estimated to be less than two years for the jumboisation solution.

“Taking into account a possible fuel price scenario of Brent returning to the level of USD 80/barrel by the end of 2016, the bunker prices delivered on-board could be around USD 12/mmBTU for HFO, a little bit more for LNG (USD 13/mmBTU), and USD 18/mmBTU for MDO.

saying that this equipment definitely remains a short-term solution, or even voices like the one expressed by the German NGO NABU which does not beat about the bush proposing to reject scrubbers as they do not solve the pollution problem, but sweep it under the rug. All because the scrubber technology is a specific 0.1% SO_x solution; to meet the IMO Tier III NO_x limits (applicable in ECAs from January 1st, 2016), a vessel fitted with scrubbers must also be equipped with a Selective Catalytic Reactor, in general an additional expensive and heavy equipment to be mounted in the funnel, thus generating extra issues for storage on-board and disposal of waste products.

Next, the MDO way out. Burning diesel remains the smallest CAPEX and the easiest technical stop to retrofit a ship (only some additional piping and dedicated storage tanks are required). The fuel changeover procedure has to be well-defined and rigorously followed by the crew in order to save the fittings, particularly engines and boilers, due to different ignition and combustion characteristics, viscosity, density, heating values and lubricity. One major difficulty is the temperature variation from hot HFO to cool MDO (up to 100°C). In order to achieve a safe temperature gradient of less than 2°C/min., the changeover procedure can take about an hour. Furthermore, to avoid cold corrosion in the slow speed engines, the ships using two grades of fuel will also need to use two types of cylinder oil. Several Loss of Propulsion (LOP) issues have been reported in North America and the EU since January 1st of this year (about one every three days on average!) due to fuel injection pumps blocking. Last, but not least, MDO remains a fine distillate for which the worldwide refining capacities should be adapted to match the future global demand. At Rotterdam, combined sales of MGO and MDO reached 125,000 tn last December alone, whereas 45,000 to 50,000 tn would have been the norm. This would mechanically set the price at a high level following offer & demand.

And finally – LNG. In our view this is definitely the long-term and sustainable solution

as burning LNG can reduce up to 98%, 80% and 20% of SO_x, NO_x and CO_x emissions, respectively. To be ECA LNG-powered with bunkering taking place only once, a typical 14,000 TEU container ship needs 3,000 m³ of LNG. Considering pressurized tanks, this capacity should be stored in at least two type C tanks (1,500 m³ each). This in turn corresponds to a space loss of more than 200 TEU.

The loss of a container slot on-board can be very damaging to a ship's payback time. This can be avoided with the so-called jumboisation. By lengthening the ship with a prefabricated block section equipped with an LNG tank and the fittings to handle and supply gas to the engines, the solution proposed by i.a. GTT offers an enhanced cargo capacity of up to 460 TEU. This solution can be installed during a retrofit operation lasting about four weeks at a shipyard. Indeed, while feasible from a structural point of view, this solution is a more CAPEX-intensive option, nonetheless, it allows more cargo transportation and a positive impact on the revenue flow (OPEX).

Taking into account a possible fuel price scenario of Brent returning to the level of USD 80/barrel by the end of 2016, the bunker prices delivered on-board could be around USD 12/mmBTU for HFO, a little bit more for LNG (USD 13/mmBTU), and USD 18/mmBTU for MDO. Considering both the CAPEX and the gain of TEU, the payback period is estimated to be less than two years for the jumboisation solution compared to five years with the type C tank, and almost six years for the scrubber solution.

When to say 'Yes'

All things considered, due to LNG and relevant technology prices, jumboisation is more attractive than other solutions. Now, the main headache is to identify the most eligible vessels to be upgraded. A too old one would deserve to be retrofitted with the smallest CAPEX, but what about the youngest, those to be operated for a further 15 years or more? Indeed, time is needed to make the right choice at the right time.

Opening the black gas box

by **Sergiu Maznic**, *Senior Consultant at SUND Energy AS*



Sergiu Maznic is an Oslo-based energy consultant providing commercial and strategic energy advice for companies, authorities and other stakeholders in the Nordics, the EU and globally. The main focus is natural gas: Market (prices, contracts, trading, supply/ demand), new resources (shale, biogas), LNG (including small-scale solutions and use as marine fuel). He has a Master Double Degree in Financial Economics and has previously worked in stock trading and brokerage.

Liquefied Natural Gas for bunkering has been discussed at length over the past few years as a potential win-win game for both producers and ship-owners. Today, a steady increase can also be noticed in the attention paid by large LNG producers to small-scale LNG. Ruthless competition from coal in power generation has made wholesale LNG prices less attractive in many regions, and the higher margins of retail small-scale LNG can no longer be ignored.

apart from the small pioneers in the small-scale LNG game like Gasnor (now Shell), Skangass and AGA, today we also have heavyweights like Statoil, Gazprom and many others looking into this market. We at SUND Energy are encouraged to see that more diverse and numerous players are finally taking small-scale seriously. However, there are some solutions needed for LNG to grab a firm foothold as the easy to use marine bunker.

The good, the bad and the ugly

Using LNG for bunkering has, so far, been a promising segment, due to the strong environmental drivers, first thanks to reduced NO_x emissions as the main incentive in Norway and later to new and stricter regulations which enforced the set-up of the 0.1% Sulphur Emission Control Areas (SECA). As a result, some infrastructure is now in place in many countries and there is even some competition.

Nonetheless, to this day I'm surprised to see that, with some exceptions, the LNG bunkering game is chiefly played on the eco-benefits pitch, whilst the commercial case is often being overlooked. Even worse, I've countless times seen graphs comparing Henry Hub (the US benchmark price) to Marine Gas Oil (MGO), concluding that LNG is an attractive bunker fuel in Europe! This kind of misleading approach only harms market development.

LNG is a relatively new product for the shipping world and in order to make it

interesting for a ship-owner, the business case needs to be attractive, clear and honest. This is one reason why the majority of ship-owners and operators have chosen the simple solution of switching to MGO to reduce sulphur emissions rather than taking a long-term leap into gas.

The problem with LNG for bunkering is that the pricing of it is a black box for most potential buyers. LNG sellers have been slow to adapt to buyers' needs, pushing for long-term agreements with complex pricing formulas inherited from the traditional gas world.

In the early days, the small-scale LNG sellers were primarily offering a cost-plus price, including the expense of feed-gas (oil-linked first and later some hub-indexed), cost of liquefaction and transportation, plus of course a margin.

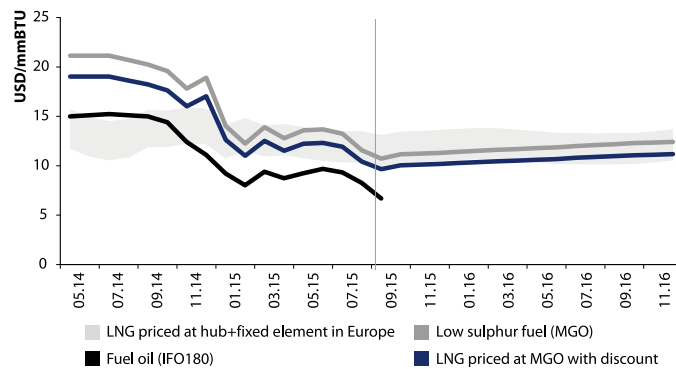
Alternatively, the retail price would be linked to the competing fuel, MGO, with a 10-20% discount. Such rebates were intended to compensate consumers for the conversion costs of engines.

Both models were relatively attractive in the high oil price environment, offering room for an enticing margin to LNG sellers at high oil prices. However, some potential customers dropped off in the process, as it was cumbersome, less transparent and flexible than the oil market they were familiar with.

Today, the business case for LNG is not as clear. The slump in oil prices has not been matched by an equal fall in 'retail'

“The problem with LNG for bunkering is that the pricing of it is a black box for most potential buyers.”

Fig. 1. LNG vs. other fuels bunker prices [USD/million British thermal unit]



Source: SUND Energy AS

“After a long period of backwardation we are now seeing a contango on the forward curve, where forward periods are priced higher than near periods, or spot. Without trying to predict the oil price, it seems that the market is pricing in a recovery and some of the losses of last year have already been regained. A contango market indicates that the trend for strengthening prices could continue.”

LNG prices. Therefore, despite the implementation of the 0.1% sulphur regulation in the Baltic and North Seas as well as in the English Channel, LNG for bunkering is not an easy and obvious solution. At today's price levels, the end user price is competing with traditional bunker fuels in a narrow range, as shown in the bunker prices graph (Fig. 1).

This raises the million-dollar question for a ship-owner choosing the future fuel: Should the fleet be powered by MGO, Heavy Fuel Oil with a scrubber, LNG, or maybe dual-fuel?

LNG strikes back

There's a set of factors to be considered by every shipping company individually, and future pricing is a significant one, especially in light of the tough times ship-owners are currently finding themselves in. The unpredictability of oil prices, opaqueness of the wholesale LNG price and complexity of the small-scale LNG end-user price tag, they all increase the complexity of the 'go-for-gas' decision.

Nevertheless, it would by all means be a jumping and unfair conclusion to call LNG a dead business case. There are several aspects making the shift worth considering.

Firstly, oil prices. After a long period of backwardation we are now seeing a contango on the forward curve, where forward periods are priced higher than near periods, or spot. Without trying to predict the oil price, it seems that the market is pricing in a recovery and some of the losses of last year have already been regained. A contango market indicates that the trend for strengthening prices could continue.

Secondly, lower wholesale LNG prices. Running counter to what we have seen in recent years, the global gas market is now facing an oversupply of LNG. With the additional, uncommitted supply arriving over the coming years, we are in a

'buyer's market', and increasingly we are seeing more LNG being sold at 'low' gas-hub price levels. More of this cheap LNG will reach the small-scale market in step with the development of break-bulk facilities, where higher margins are possible than in the wholesale market/hub.

Thirdly, increased competition. The small-scale LNG market has gradually attracted more players from different parts of the value chain. Greater competition should only bring benefits to gas buyers, as the market becomes more efficient, bringing with it transparency and eliminating the excessive profit margins seen when the market was more closed.

And, last but not least – infrastructure costs. Competition and innovation have had a positive impact on reducing cost on the small-scale LNG market. Today we see more standardised technical solutions coming at a much lower cost than just a few years ago. This comes together with an increase in demand volumes creating a 'virtuous circle' – more volumes, more infrastructure, lower costs, more volume. We are seeing an increasing interest from the deep-sea segment for LNG as bunker fuel as well, and that could bring a significant demand-driven push to the market that today relies primarily on LNG demand from the side of ferry companies (although the world's first LNG dual-fuel cruise ships order recently placed by the Carnival Corporation may somewhat break the 'regional barrier' of gas-powered vessels operating only across particular strings).

Like in a gas station

In conclusion, fuelled by environmental drivers, LNG as a marine fuel is starting to win its share of the bunker market. After mainly ferries and short-sea, we now see deep-sea/long-distance ships being built 'LNG ready'. Transparency would drive demand further forward and I believe that this should be the main focus for small-scale market players. LNG sellers need to learn to adapt even more to this changing market.

What buyers want is flexibility, price discovery and competition in order to make business decisions simpler. Even with a positive outlook for the small-scale LNG market, it will still take several years until it will be possible to buy LNG in the same way as traditional bunker fuel today, i.e. available in any port and at a transparent price.

Until that time, there is still a great number of opportunities, but the key for any buyer is to understand the market fundamentals, be tough in negotiations, and figure out the best options that fit their companies. ■



Photo: Ports of Stockholm

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Answering LNG shipping questions

All-in-one

by **Mathias Jansson**, Wärtsilä's General Manager
Innovation & Product Support, Fuel Gas Handling, Ship Power
& Mari Ottesen, Marketing Manager, Ship Power

Changing long-established ways of doing things is never easy, but in a free market economy based on simple economic calculations money has the last word and has always been the stimulus for change. However, today's economy is not only under the influence of cash. Challenges which the modern shipping industry must face are unprecedented, remembering that the switch to LNG as a ship's fuel is gaining momentum at a rate that few could have forecasted.

The Nasdaq Helsinki-listed Wärtsilä is a provider of complete lifecycle power solutions for the marine and energy markets. By using technological innovation and total efficiency, the company maximizes the environmental and economic performance of the vessels and power plants of its customers. The company has operations in more than 200 locations in nearly 70 countries around the world, employing approx. 17.7 thou. people. For more info on Wärtsilä's marine and energy solutions as well as services, visit www.wartsila.com.

“Fuel prices are constantly fluctuating, and while the cost of oil is currently rather low, there is no guarantee that this will be the case next year.”

The reasons behind this move of shipping into the gas age are essentially fourfold, namely environmental, economic, technological, and perhaps most significantly – infrastructural. Let us then dig into their details one after another.

The environmental factor

Environmental legislation has had an enormous impact on the marine sector. Local and international regulations have forced owners and operators to make critical decisions as to how to achieve compliance, while at the same time maintaining cost-efficient operations. It is an ongoing challenge, and one that has produced a broad diversity of alternatives. LNG, however, is the only option within reach that appears to fulfil all the long-term requirements.

To make a long story short, when a ship's engine is running in gas mode, with LNG as the primary source of energy, CO₂ emissions are reduced by some 30% compared to conventional liquid fuels, NO_x emissions are cut by approximately 85%, SO_x emissions are almost completely eliminated (since natural gas contains no sulphur), whereas particle production is practically non-existent thanks to the efficient combustion of natural gas, a fuel with almost no residuals.

We, at Wärtsilä, have been trying to answer questions regarding environmental compliance for the past decades. As a

result, Wärtsilä's dual-fuel (DF) engines in gas mode are already compliant with the IMO's Tier III regulations without a need for any secondary exhaust cleaning systems (in conventional liquid fuel oil mode, all of Wärtsilä's DF engines are fully compliant with the IMO's Tier II regulations).

The economic factor

Fuel prices are constantly fluctuating, and while the cost of oil is currently rather low, there is no guarantee that this will be the case next year. What is more, high fuel oil prices were at the heart of the industry crisis that began in 2008.

How then does the LNG price differ from the oil price? Liquid fossil fuels and natural gas are normally priced using various measuring units. Marine diesel fuels are quoted based on a price-per-mass quantity, the common unit being “US dollars per tonne of liquid fuel” (USD/tn). Natural gas prices, on the other hand, are usually set by the traded energy content, the commonly utilised unit being “US dollars per million British Thermal Units” (USD/MMBTU). To compare these prices, a common energy unit (MMBTU) should be used.

Results show that natural gas has always been cost competitive against other marine fuels, and its price has consistently been lower than any other single liquid fuel alternative (however, LNG



bunker pricing can be another kettle of fish, something highlighted by SUND Energy's Sergiu Maznic in his *Opening the black gas box* piece, pgs. 27-28).

The technological factor

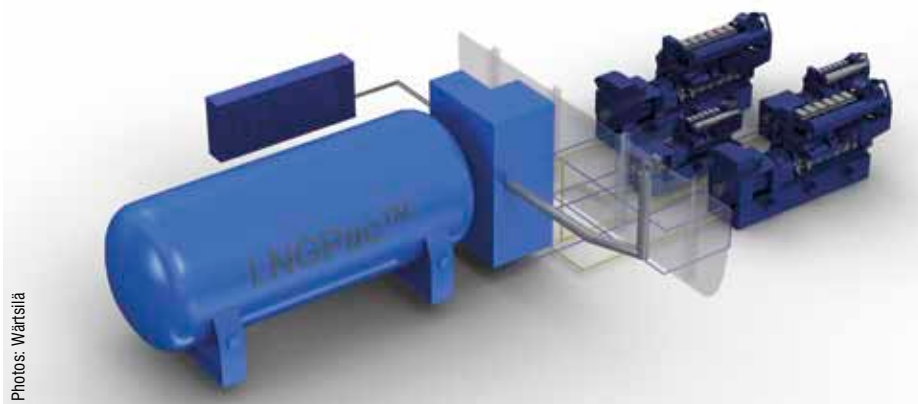
While driven by economics and regulatory compliance requirements, the move to LNG as a marine fuel has been made possible and is supported by technological development. A good example of this is the advanced dual-fuel technology, which allowed either gas or liquid fuel to be burned in the same engine, launched for the first time in the early 1990s for usage in land-based power plant applications. The first marine installation came a decade later and this sparked the beginning of the current trend. For example, since its introduction more than 65% of all new LNG carriers have been fitted with Wärtsilä DF engines.

However, LNG as a ship's fuel isn't something reserved solely for newbuilds. For instance, the world's first LNG conversion project was carried out already in 2011. This involved switching a chemical tanker, the *Bit Viking* owned by Tarbit Shipping of Sweden, from conventional heavy fuel oil (HFO) to LNG using Wärtsilä DF engines and fuel supply systems.

When we introduced our low-speed, 2-stroke, dual-fuel gas engine technology in 2013, the benefits of the dual-fuel technology (already proven on 4-stroke engines) were made available to the broader marine market. This was a truly significant breakthrough. An important advantage of the low-pressure DF technology is that it allows stable operations on gas across the entire load range. This means that at low loads (below 15%), there is no need to switch to diesel as is the case with other technologies. Most importantly, no investment is needed for exhaust gas cleaning systems in order to comply with the IMO's Tier III environmental regulations.

Then again, the widespread acceptance of the use of LNG fuel for ships has come about because the technology development did not end with the dual fuel

engine. To be truly viable, efficient on-board storage and supply systems were essential, so Wärtsilä patented its so-called LNGPac system, introduced in 2010. The set in question comprises a complete system for LNG fuel handling, including a bunkering station, a storage tank and a tank connection area with the process equipment, a heating media skid, as well as a control and monitoring system. This unique innovation has proven



Photos: Wärtsilä

to be a valuable enabler for the switch to gas in marine applications.

The infrastructural factor

One of the main arguments against the adoption of LNG fuel is its scarce availability in harbours. Bunkering was, therefore, considered to be difficult with safety being a prime consideration. This situation has changed dramatically in recent years and continues to evolve even further.

Liquefied Natural Gas carriers move massive quantities of natural gas from liquefaction terminals to regasification terminals all around the globe (LNG tankers most probably having the best ship safety track record from among the shipping world). LNG is available at all these on-shore facilities. Marine LNG import and export terminals are now to be found virtually everywhere, meaning that LNG is basically available anywhere in the world and new terminals continue to come on-stream.

Wärtsilä has delivered both floating and onshore receiving and storage facilities. For example, a floating LNG receiving terminal was supplied for the Petronas terminal in Melaka, Malaysia. We are also in the process of building a land-based terminal in Tornio, Finland, a project combining a number of the company's in-house competences.

In fact, we have been heavily involved in developing both the onshore infrastructure as well as the entire value chain. The gas chain extends from the initial gas exploration and drilling processes, to the production and liquefaction of LNG, which then has to be transported to storage and distribution facilities. Wärtsilä has developed products and solutions that are relevant to each of these stages.

The questions answered

Clearly, not all shipping operations are the same and no single solution applies to all. Vessels sailing short sea routes, such as container feeders or ferries constantly operating between defined ports, are the

main beneficiaries of LNG-fuelled propulsion. This consideration becomes even stronger when the routes involve sailing in the Emission Control Areas (ECAs).

Nevertheless, it can be assumed that the environmental, economic and technological advantages that LNG fuel operation offers will eventually extend across all sectors of the industry. Newbuilds will increasingly be fitted with DF engines and on-board LNG storage and supply systems, whilst the number of retrofitting projects is likely to continue to increase, too.

As this trend gains pace, the benefits of one-stop-shopping are becoming more and more apparent. By being able to take responsibility for the complete fuel storage, processing, distribution and use on-board, companies such as Wärtsilä provide owners, operators and shipyards with a single interface partnership. This unique capability is an important enabler for the use of LNG as a marine fuel. ■

When and where will Germany benefit from LNG

The next LNG hotspot?

by **Ralf Fiedler**, *Group Leader*
at *Fraunhofer Center for Maritime Logistics and Services*



Ralf is a Transport Market Assessment Group Leader at Fraunhofer Center for Maritime Logistics and Services (CML), responsible for carrying out research and development projects both for private and public customers from the maritime industry, including ports, terminal operators, shipping businesses and logistic providers. Fraunhofer CML helps to develop and optimize processes and systems along the maritime supply chain thanks to practically oriented research projects. Previously, Ralf was Regional Manager Logistics at Logistik-Initiative Hamburg, Senior Project Manager at BMT Transport Solutions, and Project Manager at TFK Transportforschung.

“In Germany, there is already demand for LNG from industry sites which have no access to pipeline gas and want to profit from small-scale LNG solutions.”

Belgium, Lithuania, Poland, Sweden, the Netherlands – it seems that northern Europe already has its Liquefied Natural Gas (LNG) import infrastructure in place. Capacity extensions are underway, too, while new projects are either close to being commissioned (e.g. Finland’s Pori next year) or scheduled. However, not yet in Germany. How come? Isn’t there enough demand? Is Germany to remain a white spot on the European LNG map?

A study recently carried out by Fraunhofer CML shows that a German LNG import terminal could take advantage of significant opportunities, both from the demand side and regarding diversification of gas supply for the country. The study confirms that the location Brunsbüttel (situated in Schleswig-Holstein on the mouth of the Elbe River, constituting the western entrance to the Kiel Canal) offers potential for the supply of industrial, transport and energy demands.

Why Brunsbüttel?

Well, the location has several advantages. Firstly, regional market demand coming from the largest chemical industry area within Schleswig-Holstein, which can use gas not only as a suitable replacement for oil as fuel, thus cutting down its emission and lowering the CO₂ tax, but also as a basic material for the production of ammonia. Local industry consists of world companies such as Yara and Sasol, already having global experiences in replacing naphtha by gas. This factor differentiates Brunsbüttel from other locations.

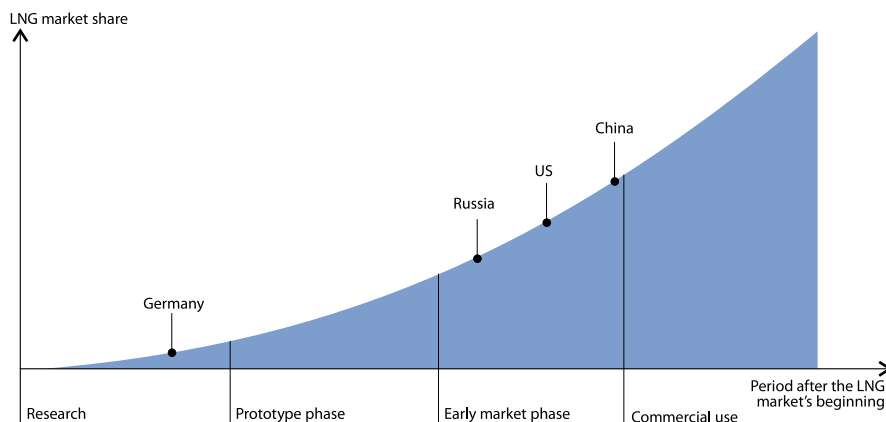
Secondly, North and East German industrial sites, as well as southern Germany, Austria, Switzerland and Central and Eastern Europe, can be supplied with LNG via Brunsbüttel by truck, barge or even rail as the company VTG has already developed

LNG rail wagons. In Germany, there is already demand for LNG from industry sites which have no access to pipeline gas and want to profit from small-scale LNG solutions. Today, all LNG for German customers, even for those in ports, is trucked from established import terminals such as Zeebrugge and Rotterdam. Interestingly, it still seems to be competitive.

Thirdly, the site can provide current and future LNG vessels on the Kiel Canal and the Elbe with an opportunity to bunker LNG. Where would more vessels pass a port location than on the junction of the Kiel Canal and the Elbe? In addition, supplying ships calling at the Port of Hamburg with LNG barges from Brunsbüttel is a realistic option. Obviously, the enthusiasm for equipping vessels with LNG has declined since oil prices have decreased considerably. Yet, this shouldn’t be interpreted as LNG is off the agenda. It will certainly play its role beside other options such as methanol, ethanol or electric propulsion, since the need for reducing emissions remains high. The introduction of the Sulphur Emission Control Areas this year should be regarded only as a first step. The truth is, however, that today’s limited demand from the shipping sector limits the economic viability for new LNG bunker stations – unless they are attached to larger means, such as import terminals with industries in their hinterland.



Fig. 1. LNG development – from research to commercial use



Source: Fraunhofer CML after the German Energy Agency (dena) (2013)

Obligated but lagging behind

According to the EU Directive 2014/94/EU, the supply of LNG to the TEN-T Core Corridors is a task to which the Federal Republic of Germany is obliged (alike every EU Member State). It demands a strategic plan and a future supply both for sea and inland ports as well as for overland corridors. However, the use of LNG in trucking has not yet developed in Germany. As of today, no single publicly accessible LNG station exists in the country, while there's only one truck manufacturer, Iveco, which already has a licensed truck for Germany in its offer. What does the situation look like in other countries (Fig. 1)? China is pushing the development towards LNG trucks heavily, in North America LNG trucks are already operating, whereas in Europe, the Netherlands is the leading country shaping this future trend (e.g. we can spot on the Rhine newly built LNG-powered barges, a recent development supported by the Dutch).

any further? Germany's HGV toll on highways has two goals; one is to refinance the use of infrastructure by its users, whilst the other is to support the use of cleaner vehicles. The second goal could only be maintained by supporting cleaner vehicles than Euro VI, which is technologically hard to achieve with diesel engines.

“As far as the need for emission reductions is concerned, we need to not only think about exhaust gases but also noise.”

But there are even more opportunities to fuel the LNG demand. For instance, a potential peak shaving gas power plant at a site nearby a terminal would be an additional and constant LNG consumer. It could in turn contribute to a successful energy policy as well, as such peak shaving gas power plants are required to make use of renewable energy in large shares possible. However, also within this area, regulations have to come first to make these plants feasible.

Shall Germany import LNG like all the countries mentioned at the beginning? We see a chance here, too, since an LNG import terminal would in any case have a positive impact on the security of energy supply of the Federal Republic of Germany. For diversification reasons, more attention should be paid to alternative sources of gas. With declining import volumes from the Netherlands and dropping domestic gas production, the question remains: Shouldn't Germany make itself more independent from Russian gas imports? Lithuania provides an excellent example of how the negotiating power changes once alternative gas sources are available. It's now up to the federal government to decide how to prepare the country for this future energy source.



Photos: Brunsbüttel Ports

As far as the need for emission reductions is concerned, we need to not only think about exhaust gases but also noise. In this context, which technology will bring the truck Euro VI emission class

LNG engine optimization

Photo: Wikimedia Commons

by **Kim Stenvall**, *Senior Product Manager at Eniram*

Eniram's product development team has been working for years to understand and solve LNG vessels-related operational issues, the Eniram Engine™ tool being the newest solution meant to optimize engine usage on-board tri-fuel diesel-electric (TFDE) and dual-fuel diesel-electric (DFDE) LNG carriers, thus simply saving fuel. While designing this software we have also gathered valuable data on the intricacy and operational restrictions LNG vessels face.



Eniram provides the maritime industry with energy management technology to reduce fuel consumption and emissions with solutions ranging from single on-board applications to comprehensive fleet analysis. Eniram's products are used by small and large shipping companies across cruise liners, tankers, LNG carriers, container ships, bulkers and ferries.

“It is the insight that counts, the insight upon which captains, engineers and officers can act.”

The goal when developing the Engine tool was to “hide” the complexity of the algorithms and often knotty, sophisticated computations, in order to show recommendations in a simple, understandable and concrete way. From the very beginning we've been trying to use a data-driven approach, too, so as to improve operational efficiency. This path resulted in collecting nowadays 1.9 billion measurements from 275 vessels per day, something that comes in handy when reducing costs, not to mention all the new possibilities it creates along with it.

The next wave

After developing the Eniram Speed™ and Eniram Trim™ tools for LNG TFDE carriers, we took up the lingering questions on fuel burned in engines as well as ways engines were operated to produce the required power. We were aware of the high fuel operating cost and that more than ever it pays to know if a vessel is using more fuel than needed due to sub-optimal engine operation.

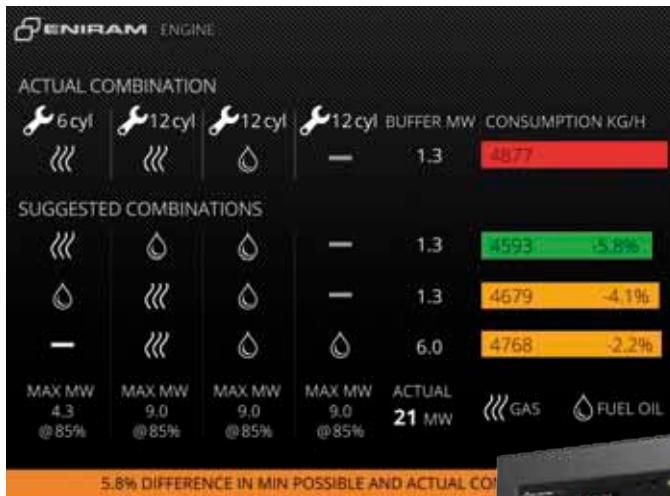
It was obvious that the next step was to create a product that could provide recommendations on the engine use in a very complex environment of LNG carriers with tri-fuel engines, possible sudden increase in power, boil-off gas (BOG) management, fuel modes and with operational practices uncommon for any other vessel type. If

successful, the outcome would be a very useful tool offering recommendations on optimal engine operations to save fuel and foster best practices.

Since simplifying is always a challenge, but also a must when working with extremely big amounts of data, the Eniram Engine solution needed to show actionable insight and suggestions of better engine operation alternatives, not thousands of data points collected every 30 seconds, complex algorithm computations or the statistical models used. It is the insight that counts, the insight upon which captains, engineers and officers can act. So, here's how we have tackled these issues in Eniram Engine for TFDE LNG carriers.

What became of the Engine?

To properly address the issue with different operational modes, Eniram Engine was developed to take into account how the engines are operated and what fuel each engine uses, both in real-time. Based on this, our software suggests more optimal engine combinations. The recommendation also includes which fuels are to be used. This means that the actual operational mode is taken into account in the proposals that the Eniram Engine gives to the engineers on-board. In practice, for instance, if fuel oil is used to supplement boil-off gas as a fuel for the ship's propulsion and energy systems, Eniram Engine will provide



Photos: Eniram

“Using real data from TFDE LNG carriers together with the algorithms, shows that Eniram Engine saves on average 2-4% of fuel.”

only suggestions with this mixed fuel usage. Furthermore, if the carrier is equipped with a re-liquefaction plant, and the BOG is re-liquefied, while fuel oil is used for the engines, only then are suggestions with fuel oil usage provided.

There are situations when engineering officers need to be prepared to quickly increase a ship's power output. However, they have to be sure, too, that the engine combination in operation allows for this kind of buffer. To accommodate this need, we added a buffer feature, straightforwardly called Eniram Engine's Buffer, which allows engineers to understand how much operating reserve power, or buffer, they have available for each suggestion compared to the actual operating profile, in case there is a sudden requirement to increase power output.

Mathematical algorithms are used to calculate in real-time the optimum fuel and engine alternatives in order to save bunker. The data that are used by the algorithms include several different fuel flows and power measurements. As an effect, the real-time data calculations ensure that recommendations are given almost instantaneously, whereas it's also crucial in making sure that the recommendations are relevant and valuable when making operational decisions on the spot.

Engine nest egg

Obviously, tracking the savings that are achieved thanks to the Eniram Engine solution for LNG carriers is crucial for customers. Therefore, a savings report was developed at the same time and made an integral part of the solution, offering a possibility for longer-term monitoring and analysis of vessel specific fuel savings; it allows for a fleet wide comparison as well, and eventually also for introducing best practices.

Using real data from TFDE LNG carriers together with the algorithms, shows that Eniram Engine saves on average 2-4% of fuel. On certain voyages the fuel savings potential can be much higher, but a



conservative average savings figure is between 2% and 4%. Moreover, one can obtain similar – or even better – outcomes also when it comes to tri- and dual-fuel diesel-electric carriers by combining our Dynamic Trimming technology with Eniram's Speed and Engine, achieving in such a way fuel savings of up to 10%. This in turn helps shipping companies to decrease their emissions and keep up with environmentally-friendly best practices.

“Real-time data calculations ensure that fuel saving recommendations are given almost instantaneously.”

Eniram Engine's pilot part is coming to an end and the mass rollout phase has started. The pilot has been running on several LNG TDFE vessels and the results have been encouraging with voices from captains saying, “As a general feedback we can say that Eniram Engine is a useful tool for an efficient voyage planning.”

Rollout to numerous other LNG vessels will take place later this year, and surely thanks to the feedback we'll get as well as our own observations, we will certainly learn more about the additional benefits to the LNG maritime industry. ■



HEKLA – Helsingborg & Klaipeda LNG Infrastructure Facility Deployment

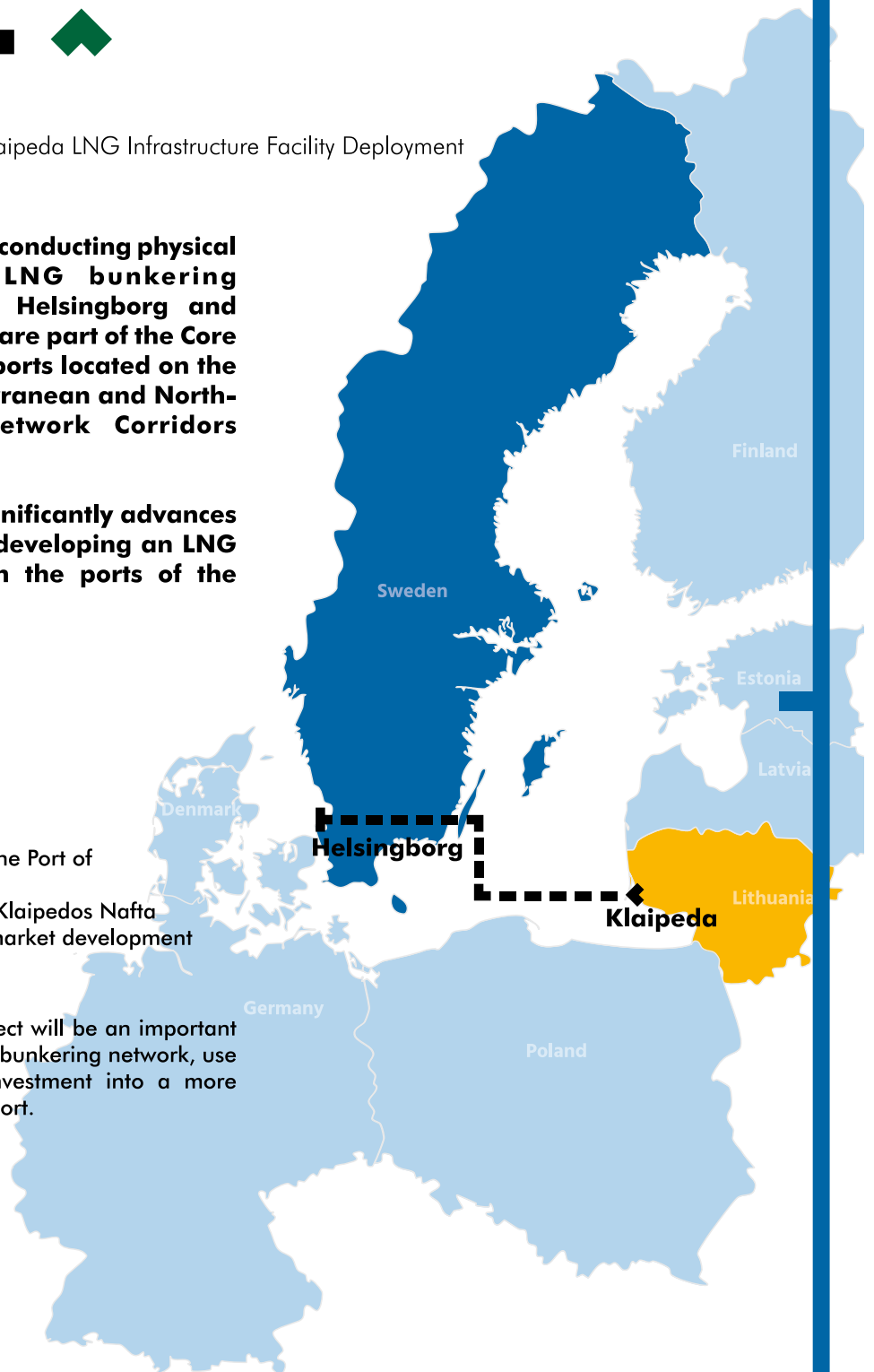
HEKLA project aims at conducting physical investments into LNG bunkering infrastructure in the Helsingborg and Klaipeda ports, which are part of the Core Network of Maritime ports located on the Scandinavian-Mediterranean and North-Baltic Sea Core Network Corridors respectively.

Their development significantly advances the Global Project of developing an LNG bunkering network in the ports of the Baltic Sea Region.

Activities include:

- LNG liquefaction plant in the Port of Helsingborg
- LNG Reloading Station by Klaipedos Nafta
- LNG campaign and LNG market development
- Project management

The completion of the Project will be an important step towards creating LNG bunkering network, use of which will stimulate investment into a more sustainable maritime transport.



upcoming issues

HR#9

Ports role in developing the offshore wind energy business

HR#10

Onshore power supply

HR#11

Cruise industry

HR#12

Silk road

- **PUBLISHER** ▪ **Baltic Press Ltd**, ul. Pułaskiego 8, 81-368 Gdynia, Poland ▪ tel. +48 58 627 23 21/95
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HR#5

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