DNV·GL

GAS CARRIER UPDATE

No **01 2015**

Höegh LNG

Gaslog

Teekay

CONTENT

DEAR READER,

Johan-Petter Tutturen
Business Director Gas Carriers
Johan.Petter.Tutturen@dnvgl.com

In October last year, we could celebrate 50 successful years of commercial LNG trade. More than 80,000 voyages have taken place with no onboard fatalities. According to the Society of International Gas Tanker and Terminal Operators (SIGTTO), only 40m^3 of LNG have been spilt over these years. No other industry can match this unprecedented record. If we look into the rear mirror, the price of an LNG carrier ten years ago was approximately USD 200 million, the same as today. Apart from the Q-Max and Q-Flex vessels, the size at that time was 145,000m^3 while today the standard size (at least among the Korean yards) is 174,000m^3. The fuel consumption ten years back was 180-190 tons per day, whereas today it is approximately 100 tons. The corresponding boil-off rate (BOR) has been improved from 0.15% to 0.085% over these past ten years. In other words, the LNG carrier industry has significantly improved over the past 50 years, not to mention the last ten.

And this improvement will certainly not stop here. DNV GL and other industry-leading partners (HHI, GasLog and GTT) decided 12–18 months ago to join forces, utilizing the latest available computer tools and other available technology to meet future market demands by creating a concept design with the working title "LNG carrier for the future". Later, the project name was changed to "LNGreen". You can read about how the project went in this magazine and you will certainly not be disappointed.

The gas industry is not only focused on transporting gas from A to B. We have in this edition of GAS Carrier Update profiled a few other companies with a strong desire to improve their environmental footprint, utilizing the latest available technologies to focus on efficiency and challenge new frontiers. They share the same goal as DNV GL: they want to be the best in everything they do.

Enjoy the read!

GAS CARRIER UPDATE

Published by DNV GL
Maritime Communications

Editorial committee:
Johan Petter Tutturen
Magne A. Røe, Editor
Lisbeth Aamodt, Production

DNV GL – Maritime
1322 Høvik, Norway

DNV GL – Maritime
20457 Hamburg, Germany

Front cover photo:
© Höegh LNG AS

Design and layout:
coormedia.com 1510-025

Text: Magne.A.Roe@dnvgl.com

LNG PIONEERS WITH STRONG FUTURE AMBITIONS

"We actually contracted the prototype back in 1968," says Gorm O. Hillgaar, SVP and Head of Fleet Management at Höegh LNG. This was the first spherical LNG tanker ever, better known as the Moss design. At the time, this was a joint industry project between Höegh, DNV and the Moss Shipyard, located just south of Oslo in Norway. "The first vessel, *Norman Lady*, was in active service from 1973 to 2013. We can safely claim that we have the longest experience in LNG transport, including the use of LNG as fuel. We have specialized in FSRUs (Floating Storage and Regasification Units) and own and operate five of these, in addition to the four LNG carriers that we operate. We have an additional three FSRUs on order, and two of those are already committed to a project. We aim to have 12 FSRUs by 2019.


INDEPENDENCE

"Working with DNV GL is not just a matter of technology, but also of safety. On complex vessels like an FSRU, safety is always the key operational focus."

Gorm O. Hillgaar,
SVP and Head of Fleet Management, Höegh LNG

"It was quite a change for us to start operating FSRUs after being used to operate only LNG carriers. Operating an FSRU is more like an offshore activity, with very high demands as to operational availability. It is normally at the same location year in and year out, with extensive operational documentation and procedures, but at the same time it is also a ship that must be ready to go on short notice if, for instance, the weather conditions should force us to move temporarily. The process equipment for regasifying LNG is complex and needs extensive crew training. We cannot just take crew from other ship segments for most onboard positions without proper training. With our growth, we will also be filling many land-based positions here at our operational headquarters in Oslo," says Hillgaar. "

Gorm O. Hillgaar, SVP and Head of Fleet Management, Höegh LNG

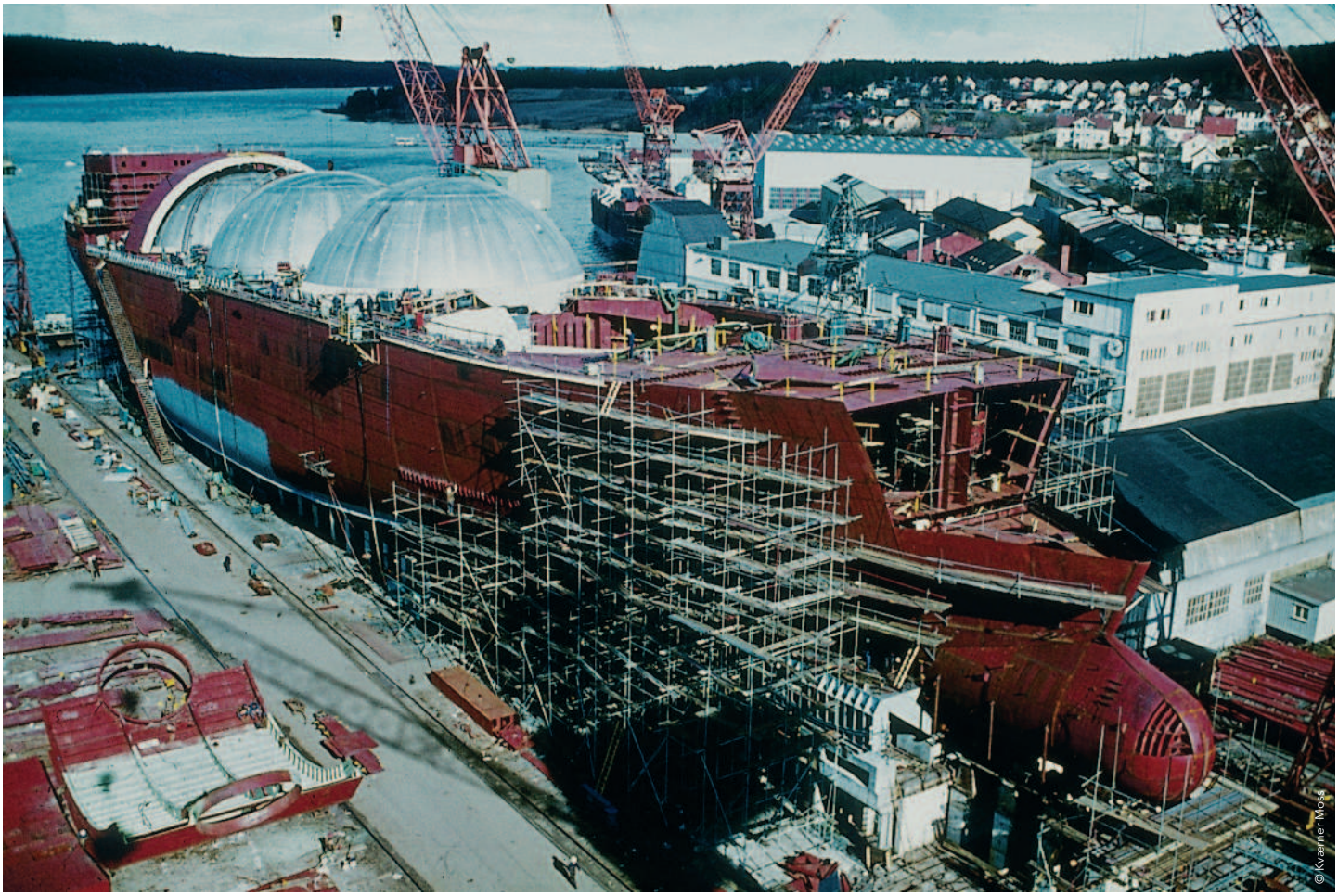
"Our FSRUs are located at many sites world-wide, including Egypt, China, Lithuania and Indonesia. The fact that gas as a commodity has become cheaper over the past few years has made it a viable and rather 'green' alternative. An FSRU is a good way of ensuring a stable supply of gas and is relatively easy to implement as it requires little infrastructure compared to many other power solutions, so we see that the market for FSRUs is growing fast worldwide.

"FSRUs are technically complex and have a lot of specially made equipment on board. The technical developments over the last ten years have been not just evolutionary but also revolutionary. We have moved from steam turbines to diesel-electric, high-voltage solutions. We have vastly lowered the boil-off rate and must also reduce our vessels' environmental footprint. Our customers challenge us to provide the latest solutions and technology and we pressure the yard and also DNV GL to be and remain at the forefront of technology," says Hillgaar.

"Working with DNV GL is not just a matter of technology, but also of safety. On complex vessels like an FSRU, safety is always the key operational focus. We have to put safety at the forefront, something we always do through training and daily focus. Our track record is great - no accidents or incidents - and we must ensure that we keep it that way," concludes Hillgaar. ∎

Höegh LNG Holdings Ltd.

Höegh LNG Holdings Ltd. (Höegh LNG or The Company) provides floating energy solutions and operates world-wide with a leading position as owner and operator of floating LNG import terminals; Floating storage and regasification units (FSRUs). The Company has developed low-cost solutions for floating liquefaction terminals (FLNG) and is one of the most experienced operators of LNG Carriers (LNGCs). Höegh LNG's vision is to be the industry leader of floating LNG terminal solutions and the strategy is to continue to focus growth plans on the FSRU and the FLNG market, with the objective of securing long-term contracts with strong counterparts at attractive returns.



HISTORY AND INNOVATION

The LNG story - unleashing our innovation
The bulk seaborne transport of liquefied gas is older than often realised. The first dedicated liquefied gas tanker, Herøya, was built to DNV class in 1949 at the Horten yard in Norway. She had pressurised cargo tanks for the transport of LPG and ammonia. DNV thus became involved in setting safety standards for this type of ship at a very early stage, and in 1962 was the first classification society to publish comprehensive rules for gas carriers.

Membrane tanks
DNV's first involvement with LNG carriers was in developing a membrane-type tank system in a project with Norwegian ship owner Øivind Lorentzen and the Bennet Group of Dallas in 1959-62. A number of designs were considered, including the waffle-type membrane tank invented by DNV. A 32m³ test tank was constructed in 1962 and tested successfully using liquid nitrogen.

Spherical tanks
The Moss spherical tank design was developed by the Kvaerner Moss Group in Norway between 1969 and 1972, with a significant contribution from DNV. The spherical containment system had already been pursued as one of the alternatives studied in the 1959-62 project with Øivind Lorentzen, and he ordered an LPG vessel to this design - the Mundogas Brasilia delivered by Fredrikstad Yard in Norway in 1961.

The basic design criteria for LNG ships were formulated by DNV in its 1972 rules, setting the standard for the subsequent development of the 1976 International Gas Code for both spherical and prismatic tanks.

Designs for an expanding LNG market
The classification of new ship designs calls for active involvement in the development process and in formulating a technical basis for the design. DNV GL closely studies new tank designs, both independent and membrane types, together with designers, operators and shipyards and carries out model testing of sloshing loads and also investigates the strength of insulation systems through materials testing and numerical analysis. ▮

Text: Magne.A.Røe@dnvgl.com

GASLOG EXPANSION

"I've seen more technological advances in the last several years than in the previous 30," says Graham Westgarth, COO at London-based Gaslog. "The shipping industry has clearly demonstrated that it has more than enough intellectual horsepower to make significant technological advances," he adds. Gaslog has a modern fleet of 27 LNG carriers, 19 of which are in operation while the additional eight are on order. "The industry has not been given sufficient credit for its environmental advances in reducing emissions over, for instance, the last decade. Our ships are some 50 per cent more efficient than they were just a few years ago. In my view, this reduction is significant, but the industry seldom gets any public credit for such efforts.

Expansion with a focus on technology and reducing the environmental footprint

"Safety, quality, innovation and technology are main focus areas for us and our chairman, Peter G. Livanos. We are prepared to invest in innovation and do so on a continuous basis. We take part in joint industry projects like the LNGreen project, where the result is a ship with a five per cent increase in cargo capacity, 0.085 per cent boil-off rate (BOR) and an average eight per cent increase in overall efficiency. But this is based on making incremental adjustments to the traditional basic design. What we may see in the future are designs and vessels that may be somewhat different from the ships trading today given that as the LNG infrastructure

Gaslog Seattle, Hamilton, IMO 9634036

is built out ports and trading routes are likely to change. In the LNGreen project we worked hard on optimizing the hull, propulsion, machinery, generators and containment system. What was most surprising was that there was much to gain from optimizing the containment system. We actually obtained a larger cargo space while achieving improved operational characteristics," says Westgarth. "To summarize: the results of our efforts surpassed our expectations, proving benefits for both us as the operator and charterers."

Graham Westgarth, COO at Gaslog

Looking a little more into the future, traditionally LNG transport has been a 19.5 knot industry when it comes to vessels. This is the design speed they have been built to for the last 20 plus years. LNG designs were originally of the Moss type with steam turbine, a capacity of 135,000m3 and a boil-off rate of 0.25 per cent. These have been replaced by vessels with a capacity of 174,000m3, a boil-off rate reduced to 0.085 per cent and two-stroke diesel engines giving a total efficiency improvement of 50 per cent. However, we are still at 19.5 knots. In the future, we may see different speed options and thus ships designed with a new optimum speed of 16-17 knots.

"As I mentioned, I have seen many changes over the last years. Where do we take it from here? I feel that Big Data is the answer in order to further improve performance. Using remote monitoring and diagnostics depending on the broadband speed will be the way forward. We can do real-time, online performance monitoring based on collected data. We can potentially learn from the car industry, where the self-driving car is becoming a reality. The self-driven ship may soon be a reality as well. Then the question is of course: do we want that? Or is there a role in there for human beings? I believe that the role of the individual will be more and more in the direction of monitoring the processes and operations – here we can look to the airline industry, where aircraft operations are mostly monitored by the crew while the individual aircraft mainly flies itself from a to b. But security is paramount to both the shipping and airline industries and remote operations are not an option as long as systems may be hacked into and taken over. We will never take any actions that may have a negative effect on the industry's excellent track record," says Westgarth. "With new efficiency measures, new and novel designs and the improved availability of data, the future is bound to be interesting!

"Our target is 40/17," he continues. "This means that, by 2017, we will have close to doubled our fleet. This again means that we are very optimistic about the future LNG and FSRU markets. We will be in both. ▮

Text: Rachel.Carmichael@dnvgl.com

TEEKAY PREPARE TO TAKE OWNERSHIP OF THE NEW ME-GI

About Teekay

For more than four decades Teekay has continued to evolve from what was, a regional shipping supplier to what's seen in today's market as one of the largest marine energy transportation, storage, and production companies in the world. Teekay is now shaping the industry as a leader that explores innovation, monitors new trends, tests viable solutions, and executes on proven innovation.

The company has grown organically and expanded into various new markets. Most recently, Teekay has stepped into a leadership role in shaping the LNG space. Today they "own a fleet of 50 LNG vessels, including new builds, which makes (them) one of the largest, independent LNG owners in the world" explains Nicholas Schneider, Teekay's Research Projects Manager. Nick oversees commercial research and analysis for Teekay's gas market. As a major owner and leader in the LNG space, the team at Teekay is

driving the industry forward by taking ownership of the first ever ME-GI LNG newbuild vessel. Looking back to 2006, the ME-GI engine was first introduced as a solution for a major gas export project. This captured their attention and Teekay's leadership team began exploring the concept and weighing the overall importance of how this new engine would fill gaps in what was already a successful LNG market.

Adopting ME-GI technology

After completing the initial research phase in 2010, Teekay decided to further pursue the concept and began developing plans. In 2012, they placed an order for two M-type, Electronically Controlled, Gas Injection (ME-GI) LNG Carrier Vessels. The ME-GI is a two-stroke engine that uses high-pressure gas injection.

Looking back, in 2004 Teekay owned zero gas vessels. It took over a decade, but Teekay is now leading the maritime industry, and in 2016, the company is taking delivery of the first ever ME-GI LNG newbuild carrier. Being the first-to-market means Teekay was forced to foresee the challenges that come with this new technology. The greatest challenge, as with any new technology, is ensuring that the team is fully prepared and crews are trained. This required Teekay to develop two simulators within their in-house training facility. "Today, we currently have both a full-bridge simulator and a full-engine room simulator designed specifically for the gas injection technology. So in terms of being prepared to bring this new ME-GI technology to market, we have put in the specific training packages and the platforms necessary to ensure our crews are ready," said Tony Bingham who heads up LNG projects for Teekay. Currently, Teekay has 21 LNG ships on order, all of which will be delivered before 2020. This means Teekay must also address the need to train crews for all of these vessels. Tony continued, "These simulators provide us with the ability to fill training needs without using any third-party resources."

The new ME-GI vessels will provide crews with the most advanced technology in a simplified form. To achieve this, the Teekay team took a holistic approach and each partner (or vendor) was involved in the various stages of brainstorming, design, and multiple rounds of HAZID/ HAZOP studies. Tony explained that the final "HAZID/HAZOP study was included to ensure they had not introduced further technical issues into the final design." It was very much a team-focused approach that ensured the systems were integrated, and that what they delivered was a "complete system, rather than a collection of individual suppliers providing components on the ship" Tony continued.

One aspect that differentiates the ME-GI design from a traditional dual-fuel diesel-electric (DFDE) engine is the fewer electronic components. Tony explains that, "if you take a DFDE LNG carrier you have transformers, converters, switchboards and motors; each one of those contributes to an efficiency loss in the power train. If something goes wrong it is very difficult to find the individual component causing the system to collapse without the need for external intervention. By moving to the ME-GI, we've removed all of the complex electrical equipment between power generation and the propeller. We've actually made it a much simpler vessel to

Creole Spirit

Oak Spirit

Galicia Spirit, LNG

operate when it comes to performance." Offering a less complex vessel has made it easier for the Teekay team overall. When they set out to create the new

ME-GI vessel design the team agreed that this must make things simpler for the crews. It is clear that this was addressed throughout every phase.

In addition to simplicity, Teekay's ME-GI vessel design sets itself apart with higher cargo tank pressures, which allows greater flexibility. When asked how this could impact operations Tony answered, "It all depends on how you look at it. We don't intend to use the high pressure settings when coming up to a loading or discharge terminal. The high pressure set point is mainly to do with ship-to-ship transfer. It allows for greater flexibility. We actually have three bar settings, 0.7, 0.35, and 0.25. The cost for achieving the 0.7 bar was negligible so we went for the higher tank pressure setting to give our vessels more flexibility throughout their life." Tony further explained, "The secondary reason for taking the higher cargo tank pressure is that it provides additional redundancy in the unlikely event that the compressor were to malfunction (bear in mind that the compressor is only used during a loaded voyage). But from what we've seen the reliability and availability studies that have been done on the compressor, we're not expecting any issues at all."

With this new vessel, "we've got probably the lowest boil off available of the systems currently on the market. The quest for lower boil off becomes an issue in that you pay for the privilege of having the lower boil off. Then you just have to force the additional amount of gas needed into the engine. So it's really a balancing act. You want to have the right amount of boil off for the engine, you don't want to undersize it, and obviously you don't want to oversize it so that you end up with a reliquefaction plant needed – It's a balancing act" explained Tony.

The new vessel contains a partial reliquefaction system on board. It was developed in 2011 and 2012 in conjunction with DSME. Tony explained that when they "take the boil off gas and pass it through the compressor, it's up to 300 bar and that is sent to the engine and allows the ship to move at 19 knots. When you start to slow down to 15 knots you have extra gas at 300 bar. We had to come up with a solution addressing what we do with this extra gas at slower speeds." To solve this, Teekay looked for technology outside of the marine space. This is where they found Joule-Thomson Valves. This valve has been widely used in the industrial liquefac-

tion of gas for many years. "It's a well proven technology on land. Working with DSME it was marinised. The pressure on the extra gas is dropped from 300 bar to 3 bar, which reduces the temperature of the gas and returns it to a liquid state. This allows the ship to recapture 70-80% of the excess gas" said Tony.

Although this ability to control pressure somewhat eliminates the need for a GCU, the vessel still has a 50% capacity Wärtsilä IGG/GCU on board. This solution is dual-purposed. Many ships carry around an extra inert gas generator (IGG). This inert gas generator is rarely used unless they go into dry dock. Rather than have two pieces of equipment on board (an inert gas generator and a GCU) the Wärtsilä solution made the most sense. Tony further explained that "given the partial reliquefaction and the ability to permit a slight pressure build up – we didn't need a full size gas combustion unit."

Shaping the charter industry

The ME-GI's greatest selling point for charter companies is the cost savings it passes along to the customer. "At 19.5 knots it burns 25 tons per day less fuel. When you work that out into a unit freight cost it's the most efficient ship on the market at the moment," said Tony. In all, ME-GI engines save 20% of fuel costs compared to DFDE LNG vessels and more than 30% of fuel savings compared to traditional steam LNG vessels. Nick further explained that this, "significant cost reduction is passed on directly to (Teekay's) customers adding value year over year throughout the life of the vessel."

Although the team at Teekay cannot predict the future of charter parties, and more specifically spot trading, Nick commented that what they're currently seeing is "the tendency toward shorter term charters. As the LNG market has become more of a buyer's market, LNG buyers are looking for more flexibility and for shorter-term contracts. They want to match that flexibility with shorter-term ship contracts." Today Teekay sees growth in the medium term contract length of around 5 years. Nick continued, "But that doesn't mean there still aren't a lot of long-term 15-20 year contracts out there." Of the 29 ships Teekay currently has in operation, only two are on trading on the spot market; the remaining vessels in their fleet are on medium to long term charter contracts.

When asked about market demand for various sizes of LNG vessels Teekay noted that today they operate only two vessels that are around 88,000 cubic meters in size. These vessels are popular in niche markets for ship-to-ship transfer and for brining gas into

markets where draft is restricted. Teekay has explored the option of both 100k m^3 and 80k m^3 vessels for specific markets but the occasional request does not drive the demand. Nick explained the economics behind this by saying, "Currently, there are more than 130 LNG vessels on order - all of them are 145k m^3 or larger. There may still be the occasional new project requiring a smaller vessel, we are still seeing good niche demand for our smaller vessels, but the market is tending towards the efficiencies of our 170k m^3 design."

Exploring CNG as a new market

In addition to moving the LNG industry forward, Teekay is currently involved in exploring the future of Compressed Natural Gas (CNG) shipping. They are operating a partnership with Sea NG of Calgary using the Cosselle™ technology which is a large-volume, high-pressure gas storage module. Teekay continues to explore new opportunities with Sea NG. Ultimately, the company doesn't view CNG as a threat to the LNG market. They see LNG as the most cost effective means for moving volumes long distance. The gap that CNG fills is in short distance trade. It is possible that CNG will open up new trades which are uneconomical for LNG given the higher capital costs. Nick explained that Teekay sees CNG and LNG as, "complementing each other and supplemental in nature – but not a threat."

What's next with FSRU

Teekay currently has several projects underway for Floating Storage and Regasificaiton Units (FSRU). Although some bids on past projects have not come through, Tony added that the team has "several projects they're actively working on and (they) look

Teekay Glasgow - LNG Training Centre

forward to hopefully announcing something soon." The team at Teekay continues to monitor the market and tender on possible projects. It's clear that there's a growing demand within the market for regas ships. Nick explained that, "there are a few trends driving this. The lower price of LNG is encouraging new buyers around the world and new countries are considering importing LNG and FSRUs are the quickest way to bring this into a new country. It's become the solution of choice for new importers and we see that continuing."

Exporting LNG

When asked about the export market for LNG Nick commented saying, "the U.S. will become the third largest exporter by the end of this decade, behind Australia and Qatar. There are already five U.S. projects with the capacity of around 60 million tons per annum that are in construction. Several more are being developed and intending to take a final investment decision (FID) within the next few years, although the lower price of LNG and energy right now is making FID decisions more difficult for some projects." Within Canada the picture is similar. "There are still several projects in Canada at an advanced stage and two which are intending to take FID in 2016. Both of these projects are a bit more challenging due high greenfield construction costs and today's low energy prices." In the meantime, companies that operate within the space must wait to see if the projects successfully come to FID.

Teekay's roadmap for the foreseeable future

Moving forward Teekay Gas Partners is clearly focused on executing on current projects. The organization currently has several billion dollars of newbuild projects. This includes the first two ME-GI ships on charter to Cheniere Energy and completing the remaining 19 LNG new builds. Teekay is focused on building continuous growth in the point-to-point LNG business, as well as growing their joint venture with EXMAR in the LPG space. Finally, the team is looking at developing in the Floating Storage & Regasification Unit (FSRU) space. As energy prices remain low, Teekay recognizes that it'll be a challenging market for some operators in the next few years which could open doors for acquiring on-the-water assets.

In addition to business growth, Teekay is committed to driving safety throughout the LNG industry. The team clearly understands the importance of keeping safety on the forefront of their own organization, and partnering with Class to ensure that new companies entering the LNG space uphold the industry's exceptional safety record.

As new technologies continue to drive the industry it is essential that Class organizations partner with companies who are investing in these developments. Tony agreed stating that Teekay "doesn't expect Class organizations to engineer solutions but when you find a problem – come to the table with ideas," for how the two organizations can overcome the obstacle. ▮

Text: Magne.A.Roe@dnvgl.com

ENVIRONMENTAL FOCUS FOR LEADING LPG PLAYER

With the ink barely dry on the contract for two VLGC newbuildings, Solvang's Fleet Director Tor Øivind Ask is quite optimistic about the future.

© Solvang

"The new ships for delivery in 2017 from HHI in Korea will have a cargo capacity of 78,700m^3 and be on a ten-year time charter to an oil major. These two ships are a great addition to our fleet as there are currently only four ships of this kind in the world – and we have two of them, meaning that we are absolutely the market leader in this small niche market. Right now, we have 50 per cent of the market, and we'll have two-thirds after the newbuildings are delivered. The new ships, to be built to DNV GL class, will have a beam that meets the current Panama Canal maximum of 32.25m. The new canal's maximum breadth will be wider at 49m, but then we don't know exactly when the new canal will be opened – there have been delays so far," says Ask, who holds a PhD and Master of Science degree in engine combustion and emission.

Solvang has a fleet of five VLGCs, nine LGCs - of which three have been delivered from HHI this year - and six ethane/ethylene carriers, all to DNV GL class. The company's headquarters are in Stavanger on the Norwegian south-west coast, with a commercial and operational team sitting in Oslo. "We are characterized by being a family-owned company with our roots here in Stavanger dating back to 1936," explains company CEO Edvin Endresen. "Our focus is to build, own and manage our fleet in a life cycle perspec-

tive, with a 20-plus-year investment horizon," continues Endresen. "We do not use any fleet management companies to run our ships – everything is done in-house here in Stavanger and in Oslo. In addition, we have a crewing office in the Philippines. To us, crew manning and training are essential factors and we're proud of our track record, having close to zero LTI (Lost Time Incident) frequency. We've invested a total of USD 1.4 billion in new ships since 2008 and our fleet average age is currently about 7 years, and the newbuildings will make the average age even less."

Most of the Solvang LPG fleet is on time charter while the ethylene ships are mainly operating in the spot market. "Although we are fairly traditional, we like to view ourselves as pioneers too, and we were among the first to go to the size of 17,000m^3 for our ethylene fleet. We were the first to have Panamax VLGCs for the old Panama Canal and first to install a full scale exhaust gas cleaning system on a VLGC" says Endresen.

"When it comes to safety and operational availability, our track record is very good and can be documented down to the smallest figure," adds Endresen. "So how do we do this? First of all, we have demanding customers, we have five ships on medium- to long-term LPG time charters for Statoil, including a 20-year ethane contract until 2021. We have four ships on medium- to long-term time charters for Koch Industries and ethylene carrier on a time charter for Marubeni – to mention just a few of our contracts. Our two newbuilds for delivery in 2017 have been chartered out to a major oil company for ten years after delivery. To put this into a perspective; in2014 the Solvang vessel transported 5.1 mill tons of cargo (to a value of about 2 billion USD), and sailed 63 times around the world with a consumption of 165000 ton of bunker fuel.

"The key to our success is that we measure and document all we do, put up new targets, together with action plans, and again measure the results. All in all Solvang have apr 90 KPI which is used for evaluating the quality on the different aspects related to the vessel operation. We also have a high crew-retention rate. Vessel performance monitoring 24/7 is one of the key parameters, and the proof is very low to zero off-hire figures, good audit results and our unique track record. Our biggest advantages as an operator include years of experience with ethylene, ethane and LPG, being a family-owned company with no third-party managers and our core in-house expertise in construction, technical and maritime operations," says Endresen

"We have worked with Solvang for decades and this is really one of my favourite customers," says DNV GL's Area Manager for South West Norway, Eirik Jacobsen. "The company is very professionally run and they always challenge us on operational questions and environmental performance as well as on the design and features of new ships. We have to do our utmost to ensure that our DNV GL colleagues at the yard site office in Korea can match the Solvang standards."

"Solvang spends considerable amounts on reducing its environmental footprint," says Einar Westlye, who is the DNV GL Key Account Manager and, in this capacity, the DNV GL expert on Solvang's operational profile. "Solvang is fortunate to have one of

Facts about Solvang ASA

Solvang ASA dates back to 1936. From very modest beginnings, the shipping company has now developed into one of the world's leading transporters of LPG and petrochemical gases. Solvang ASA has its headquarters in Stavanger, with offices in Oslo and the Philippines.

Solvang has a fleet of modern and efficient vessels, all built in the accordance with the most up to date specifications and fitted with new and efficient technology. Perhaps of greater importance than the modern technology is the way in which the vessels are operated – the people onboard. Good seamanship represents the very core of their business, and they place a firm focus on this area in the form of education, working on attitudes and training.

© Solvang

Tor Øyvind Ask, Fleet Director, Solvang

the few individuals, if not the only one, in Norway who holds a PhD in ship engine combustion. He can challenge any engine supplier and is instrumental in optimizing the performance of the entire Solvang fleet."

Tor Øyvind Ask is the Fleet Director with the PhD in ship engine combustion and he very enthusiastically explains his views and how the fuel consumption for fully loaded large LPG ships cruising at 16 knots has been halved from 1979 to the present day. NOx emissions have similarly fallen from 0.51 grams per ton cargo per nautical mile to just 0.18 grams – and CO_2 emissions from ships under the same operational conditions have also been halved since 1979. "Shipping is going through a quiet revolution," says Ask. "This will continue into the future and the answer to environmentally friendlier operations lies in continuous improvement in technology, knowledge and awareness. It is also crucial that it is the life cycle emission which is evaluated, i.e. it is the emission and energy consumption from "well to propel" which is important for mother earth.

"We have a global market and, with the new sulphur emission requirements stated for ECAs and SECAs, as well as EEDI requirements in addition to any local requirements, we believe that Exhaust gas cleaning (scrubber)is a natural choice for us both as a retrofit on existing ships and for our newbuildings. This is based on very careful evaluation of environmental, safety and economical aspects. It gives us very good fuel flexibility, lowest possible CO_2 footprint and a very economical vessel to operator for our customers. The experience from operation of the Exhaust gas cleaning systems (scrubbers) for more than two years, are that the discharges to sea and air is far below all requirements and technical reliability is very good.

Two of our VLGCs were the first newbuildings in the world with a full scale Exhaust gas cleaning system, and were the first vessels in the DNV GL system which got full term EIAPP certificate with Exhaust gas cleaning. The technical aspects of getting the exhaust cleaning systems to work were fairly straight forward. The challenge was to interpret the IMO rules and in getting approval of the system. The current certification process with DNV-GL is a result of the learning process on these two vessels. One of these VLGCs was also awarded as the most eco-friendly LPG carrier in 2013 (The Royal institution of Naval architects). The new ships also have an optimized hull shape, extensive heat recovery, special antifouling, Mewis duct, and other operational improvements.

The other main factor which decides the environmental performance of a vessel is the actual operation. A vessel is only as good as the crew onboard, and continuous improvement is the key word. Every month the performance of the vessels is benchmarked against its sister vessels and best practices are shared in the fleet. This has over the years given large benefits, and one example is the optimisation of the cylinder oil consumption where the fleet average consumption was reduced by approx. 40% in four years. ▮

ENVIRONMENTAL INVESTMENT 2012-2015

- Retrofit new oily water separators (2012–2014)
  5 ppm centrifugal type 10 vessels approx. 1,5 mill USD.
- 1 Retrofit exhaust gas cleaning and heat recovery
  (save more than 500 ton) fuel per year etc. 2014 approx. 5,5 mill USD.
- Hull treatment and advanced antifouling (silyl type)
  2012–2014 (13 dry-dockings) approx. 2 mill USD
- Environmental investment (ECO) New buildings
  2013–2015 5 vessels approx. 25 mill USD

IN 2014 (2013) SOLVANG VESSELS;

- Sailed 1.35 (1) million nautical miles, or 63 rounds around the Earth (Equator)
- Lifted 5.1 (4.5) millions tons cargo
- Burned 165 000 (135 000) tons bunkers
- Used 1 060 000 (870 000) liters lube oils, released 515 000 tons CO_2; 0.5‰ of the World Fleets total CO_2-emission, or 0.017‰ of the global CO_2-emissions*

**In 2007 – MEPC 63/INF.2, 2011*

Text: Martin.Davies@dnvgl.com

LNGREEN – LNG CARRIER OF TOMORROW

Martin Davies, Principal Consultant
DNV GL

Since the *Methane Pioneer* carried the first cargo of LNG from the USA to the UK in 1959, leading to the first purpose-built LNG ships – the *Methane Princess* and *Methane Progress* - entering service in 1964, the vessels carrying these cargos have often been considered flag-bearers of innovation, safety and quality in the merchant shipping fleet.

Traditionally, these vessels have run on steam turbines, using the boil-off gas from the LNG cargo as fuel. More recently, medium-speed diesel engines have been favoured, even more so with the development of dual-fuel (gas and diesel) engines. Now, two-stroke gas engines have been introduced and the impact they will have on the industry has yet to be seen.

In terms of cargo containment, the membrane-type has become the most prevalent in recent years, with over 90% of the world LNG carrier fleet presently on order being built with a GTT membrane containment system.

The LNG market has developed significantly over recent years, and the amount of LNG supplied is now approximately 30% more than in 2009 (source: IEA).

This has resulted in new trading patterns and requires new thinking when planning the LNG carrier of tomorrow. Historically, LNG carriers have operated on long-term charter contracts (often with a 20-year duration); however, we are now seeing a growing short-term, or spot, market developing. This is currently in the region of 25% of the total market (source: GIIGNL).

The world's energy supply and demand are undergoing turbulent times at the moment. Shale gas from the USA has been a game changer, and the impact of this development is yet to be seen. At the same time, traditional LNG importers are considering reducing their volumes. Large LNG export projects are coming online in the USA and Australia. Some sources currently predict that LNG demand may even double within the next 10 years. Some claim there are not enough LNG carriers in the fleet, others claim the opposite.

What is certain is that modern, more environmentally friendly and economical vessels will be just as attractive in the future as they have been in the past.

The expanding spot market requires LNG carriers that are flexible in their operation and not restricted by specific design features that optimize them for one particular trade.

With this in mind, DNV GL initiated a Joint Development Project with HHI, GasLog and GTT to develop tomorrow's LNG carrier using the latest developed technology and within the bounds of existing shipbuilding methods – "LNGreen".

Summary
LNGreen has investigated how the efficiency and performance of an LNG carrier may be improved by considering actual operational conditions and optimising the ship in terms of hydrodynamics, machinery and system configuration.

LNG carrier machinery systems are highly complex configurations featuring a number of tightly integrated sub-systems and components, including but not limited to the BOG compression trains, gas management system, reliquefaction (if any), propulsion and/or generating engines, economizers and boilers. The primary fuel, i.e. boil-off gas, has variable properties (heating value and composition) depending on the cargo type and in-voyage boil-off rate conditions.

In addition, the ships usually operate in a number of trading routes and with varying operating profiles in terms of speed, propulsion and electricity and heat demand. The above features have been analysed by GasLog, whose operational experience helped not only to identify a number of operating parameters and restrictions that should be included in the design but also to define realistic future trading patterns and scenarios.

DNV GL COSSMOS has taken account of this versatility in a rigorous model-based approach that allows the integrated machinery system to be assessed under realistic operating conditions and then evaluates the resulting performance and efficiency.

The hydrodynamic performance evaluation was carried out by comparing CFD simulations by HHI and DNV GL. Different CFD codes were applied to compare the resistance and self-propulsion performance but various scale effects were also considered.

In the case of added resistance, different codes were applied to make sure the required power was sufficient for the ship to operate in the target environmental conditions.

GTT considered the cargo containment aspects, including tank shapes, necessary reinforcements and boil-off rate calculation.

Conclusions

The LNGreen project identified the importance of designing a vessel for its intended trading operations and of considering it as an integrated unit. Traditional optimization has focused mainly on the hull form, propeller and rudder design – which LNGreen has too – but the inclusion of a system evaluation in the development process has produced significant benefits.

The project developed an LNG carrier vessel concept which is about 8% more energy-efficient than conventional designs and has a 5% larger cargo volume capacity. The LNGreen concept ship delivered here is more suited to the trading operations now envisaged and is optimized to be more efficient than current state-of-the-art vessels whilst making use of currently (or soon to be) available technology.

The LNGreen concept provides the content necessary for an owner or shipyard to develop its specification and/or detailed design. It is important to note that each owner and shipyard will have its own requirements which must be considered too. In addition, the vessel's proposed trade will have to be considered in each specific case –as what has been developed in LNGreen highlights further the importance of considering the vessel's actual purpose and intended operation. ∎

LNGREEN

LNG CARRIER OF TOMORROW - JOINT DEVELOPMENT PROJECT

©HHI/DNV GL

TARGETS

Maximise hydrodynamic performance

Utilise twin-skeg hull form

Maximise cargo volume & minimise boil off

Utilise GTT Mk III Flex system

Increase overall machinery and system efficiency

Base case for comparisons is a DFDE LNGC, model-based assessment using COSSMOS

RESULTS

5%

Increase of cargo capacity

0.085%

Achieved boil-off rate per day

8%

Increase of overall efficiency and reduction of fuel costs

Text: Kathy.Zhang@dnvgl.com

AN EMERGING FORCE IN THE EPC MARKET

Registered in Hong Kong, JHW Engineering & Contracting Ltd (JHW) is a newly established EPC company serving the oil & gas market. During a recent visit to China, DNV GL's Business Director for Gas Carriers Johan Petter Tutturen interviewed Kevin Zhu, CEO of JHW.

85K VLEC

"JHW is made up of three partners. 'J' stands for Jaccar; 'H' means Hartman, our technical support side for all the projects, especially the 85K VLECs, and 'W' comes from our Chinese construction partner WOE," said Mr Zhu.

Headquartered in Shanghai, JHW operates through internal platforms which include JHW Trading, with a staff of 12, and engineering companies Econovo, which has 14 engineers, and Cryolobe, which is especially used for the gas tank and gas handling system linked to the WOE construction yard. WOE is located in Qidong, 1.5 hours by car from Shanghai. The yard is now building a big workshop especially for the tri-lobe tanks for the 85K VLECs. The workshop will be completed by the end of this year and ready for the first project in March 2016.

"We separate the whole project into different stages," said Mr Zhu, explaining his company's business model. "The marine side is taken charge of by Econovo, while on the gas side we have Cryolobe to take all the responsibility for the gas technology from the basic design until final construction - including technical support to the yard, and all the other project management and procurement work is dealt with by JHW Trading Shanghai, which handles all the critical equipment and special material procurement in China and the international market.

"This is how we organize different teams to work together, especially when focusing on gas carriers," said Mr Zhu.

85K VLEC project

JHW has recently placed an order for five 85K VLECs (very large ethane carriers) with a Chinese shipyard. These vessels will be the largest ethane carriers yet constructed. The initial delivery is scheduled for the first quarter in 2018.

"As a company, this (85K) is not the first time that we go out ordering together. In early March 2015, we placed two orders with Yangzijiang Shipyard for the last two of a series of 27.5K LNG carriers. In total, in the Jaccar Group, we have eight vessels on order - six under construction at Sinopacific and the last two at Yangzijiang," said Mr Zhu.

Gunnar Rød, Senior Principal Specialist, DNV GL, Ling Deng, Group Leader, DNV GL, Johan Petter Tutturen, Business Director Gas Carriers, Kevin Zhu, Chief Executive Officer, JHW Engineering & Contracting Ltd. and Chen Jingwei, General Manager Econovo Marine Engineering.

This type of 85K VLEC is not only the largest ethane carrier but also represents a series of technical design innovations. One is its cargo tanks – the world's biggest tri-lobe tanks. The vessel will be equipped with four tanks. Tank 1 is an independent cylindrical C-type tank while tanks 2-4 are independent C-type tri-lobe tanks each holding 23,100m3 and weighing around 1,900kg. The cargo tank construction material is 5% Ni Steel. "The tri-lobe tank concept came from our current 36K ethane carrier project. We have completed the fabrication of the first tri-lobe tank for the 36K ethane carrier, which is half the size of today's tank for the 85K VLEC. So we know the technical challenges facing us. Based on this, we will enlarge the tank for the 85K," said Mr Zhu.

In addition, this new design meets tier III and all new IMO requirements. It uses a MAN engine with EGR. Fuelled by its cargo ethane, this allows the operator to choose LNG as fuel in the future. "We work very closely with our sister companies and operators so that we can get a lot of comments from them on their operations and then we try to support and meet their different requirements. That's one of our advantages in the market," said Mr Zhu.

The competitive edge of this new type of 85K VLEC includes safety, efficiency, cost, environmental friendliness and operational flexibility.

Upbeat about the gas carrier market

Mr Zhu is optimistic about the market, saying, "Of course, today the market is not good, but I don't think it will always remain low. It's true that the American shale gas is facing very high pressure from the current low price of oil and gas. But we are focusing more on ethane, not on LNG. Today, ethane is not as popular a fuel in the international market. But more and more chemical companies are choosing ethane due to its much lower cost compared to today's raw materials in the chemical industry. All today's chartering orders come from the chemical side. That's why we think it still gives us an advantage if we have a better design catering to the market and charterer. We will benefit from our current investment in two years' time when we believe the oil and gas price will pick up.

"The market for LPG carriers is hot and we can still see potential. We would like to develop a new design, not only for ethane but also for LPG, as we have found a lot of opportunities in the market. More and more people like flexible solutions for transporting LPG from America to different areas. Based on today's design for the 85K VLEC, we are developing a new type of VLGC for the market and this will be ready?? very soon. We have already started, along with our partners, to calculate the size of?? tanks, etc. The new design will be a C-type tri-lobe tank with completely new construction materials," said Mr Zhu, introducing his next new product for the market.

When asked about his cooperation with DNV GL, he said that he appreciated the good relationship built up over the years, adding, "We've worked very closely with DNV GL on many projects. Both sides have just signed a strategic agreement and I look forward to further deepening and broadening our cooperation on gas carriers." ▮

Text: Yury.Ilchenko@dnvgl.com

GAS BUNKER VESSEL FOR LNG TRANSFER

Environmentally friendly ships trading in highly congested waters have become one of the key elements of coastal state environmental policies.

AGA (LNG bunker vessel)
Seagas, the first LNG bunker vessel in operation, is classed by DNV GL and supplies LNG to M/S Viking Grace, while she is berthing at Stockholm. Fiskerstrand Verft AS converted the former car ferry M/F 'Fjalir' (built in 1974) into an LNG bunkering vessel. The conversion was completed in March 2013 and the vessel, was named LNG/C Seagas.

Considering the international nature of shipping, the attempts to reduce emissions to sea by ships were formalized by the development of ECAs (Emission Control Areas), which was the main driver for the use of low-sulphur fuels at sea. Natural gas, used for decades, has been recognized as a good fuel alternative, allowing the tightest emission restrictions to be met. In addition, natural gas has been used as a fuel on board ocean-going LNG carriers propelled by boil-off from their cargo tanks almost since the first such vessel was built more than 50 years ago.

The technology for using methane in marine combustion engines is readily available and, considering the need for green shipping,

the growth of gas-fuelled sea vessels was expected be exponential, as was the growth in LNG fuel supplied to ships, in particular in SECAs.

The expected trend was somehow flattened by concerns being raised about "is the LNG transfer at sea and shore facilities safe enough?" which was translated into a proactive question: "how can we make it safe?"

DNV GL has participated actively in assessing and developing safe transfer procedures and provides integrated solutions for using LNG as fuel.

While the standards for shore liquefied-gas-transfer terminals were well developed, transfers at sea were the area where the standards had to be developed.

A new "Gas Bunker Vessel" DNV GL class notation was introduced in July 2015 and defined equipment and arrangements for a gas carrier equipped for gas bunker transfer at sea.

The notation did not introduce a new vessel type. A gas tanker of suitable size is a proven transport solution and may be a good and versatile platform for the gas bunker transfer. Newbuildings and existing small-scale LNG carriers initially intended to supply smaller LNG hubs may be easily converted into bunker vessels and effectively used, providing LNG bunker fuel where gas-fuelled ships need it.

The main work on developing these rules focused on evaluating hazards and measures that would constructively help to prevent emergency situations from occurring during the transfer and, if they did occur, to mitigate possible consequences.

Dry break-away coupling used to transfer small quantities of LNG was backed up with an emergency release system, allowing the operation to be terminated intentionally when the safety of the vessels is jeopardized.

An extended gas-detection system will help to find any leak at the connection at an early stage.

In the case of an accidental leak or spill, the cryogenic effect of the liquefied gas will be handled by hull protection that has been developed.

The static charge accumulation and galvanic currents are duly considered through the permanent installation of an insulating flange and, for special cases, a bonding system.

The nitrogen or inert gas supply system to the manifold area has been optimized for the inerting required due to the frequent connection and disconnection of the transfer hose.

The notation has optional qualifiers allowing operators to enhance the service capability of the gas bunker supply vessel, thus making operations easier and minimizing the workload for the crew.

We believe that the rules which have been developed for the notation will improve the safety of a vessel engaged in gas-bunkering operations and add confidence to the crew on board, operating company and operators of receiving vessels and, what is important – coastal state administration and port authorities.

And, not least important, this will also help to preserve the environment for future generations. ▮

YURY ILCHENKO

Graduated from St. Petersburg Higher Engineering Marine College in 1986, then sailed as a deck officer on gas carriers transporting ammonia, LPG and VCM cargoes. From 1995, he worked predominantly on ethylene carriers transporting LEG, ethane, butadiene and VCM cargoes as well as some dual-code chemicals. In 2006, when a captain, he decided to quit sailing and try a shore career, and started to work for a Norwegian ship owner operating a fleet of 20 ethylene vessels. In 2011, he joined Det Norske Veritas and currently works as a Principal Engineer in the LNG, Cargo Handling and Piping System Section at the DNV GL Approval Centre in Høvik.

Text: Jakub.Walenkiewicz@dnvgl.com

LNG – A VERY LIQUID CONCEPT

The LNG industry has been making headlines for a long time. The US shale gas revolution on one side of the globe, combined with a massive ramp-up of the Australian production on the other, contribute to a substantial growth in supply of natural gas availability in the market. If you look into the other side of the equation, there is a very optimistic prognosis for future gas demand.

Bearing in mind that most of the demand is expected to come from Asian countries, which are located remotely and separated by sea from the production regions, the only way to transport gas is by using LNG carriers. It all seems like a very solid business case.

Needless to say we didn't have to wait long to see new orders being placed in shipyards. Over the past four years there were on average 50 contracts signed annually. With 31 contracts signed in 2015 YTD, the contracting activity is likely to fall just short of the average. According to Clarkson Research, as of 10th of October the LNG order book contained 161 vessels of a total capacity of 25.4 mill. cbm. It represents 37% and 41% of the existing fleet respectively.

There are however a few problems. In the past few years, there has been almost no growth of LNG seaborne trade (0.6% per annum in 2011–2014 on average). Weak demand for tonnage coincided with a much faster development of the fleet. In 2013, the LNG fleet grew by 4% and in 2014 the growth accelerated to a whopping 8.8%! There have been 24 ships delivered YTD and a further 15 are scheduled to be delivered by the end of 2015, which means that the growth of tonnage will exceed 8% again. As a result, the freight rates have been falling constantly since mid-2012 from 140 000 $/day to an ultra-low $30 000/day, which in most cases is well below the breakeven level. There are already 30 LNG carriers laid up (source LLI).

It is obvious that without a substantial amount of new cargoes, rates are unlikely to recover. Some say "if the supply is there, the demand will come". The question however is, how much and when? The next year will definitely be crucial, as we will see first cargoes exported out of the US. Cheniere's Sabine Pass terminal will be the first player in the US, with initial cargo to be loaded already in December 2015. Some 64 million tons of new cargoes are expected to come from US Gulf annually, with Cheniere catering for almost half this volume.

In 2017, we should gradually start seeing increased volumes of gas coming out of Australia. Once the northern projects (Prelude, Ichthys, Weathstone and Gorgon) have been finished, total annual exports are expected to reach nearly 77 million tons by 2020. In addition, there are several other countries such as Canada, Iran, Tanzania and Mozambique are trying to get into the market as well.

If you summarise all of those projects, it is not unreasonable to believe that by 2020 we may easily observe at least 150 million tons of extra cargoes, suggesting a 10% growth per annum starting as early as 2016. It seems like various cargoes will be emerging in the market from now on, gradually soaking up the tonnage. Nevertheless the question remains: will there be enough demand to absorb the entire fleet? In the short term it is probably unlikely.

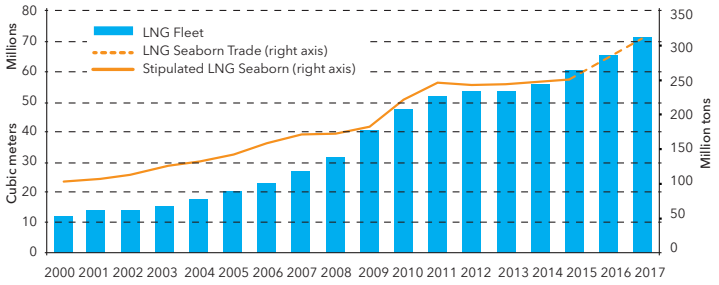
Even though a vast majority of LNG ships have been contracted against specific projects with secured charter, 20% of the current order book does not have contract coverage. Those ships may find it particularly difficult to enter this already crowded market.

Recent developments are not particularly encouraging either. The economic slowdown (particularly in China), re-starting of nuclear reactors in Japan are just some of the uncertainties adding pressure on gas producers, potentially reducing the amount of gas being traded in the coming years.

So there you have it. The future for LNG carriers seems to be rather bright. During the next decade we are likely to see seaborne LNG almost doubling, thus providing vast demand for new tonnage. In the short term future however, we may experience a period of low rates and a structural over-supply of ships, possibly resulting in an increased number of ships being laid-up. ▮

LNG CARRIERS

Fleet development vs. Seaborn trade. Source: Clarkson Research



JAKUB WALENKIEWICZ

Jakub Walenkiewicz is Principal Market Analyst in DNV GL in the Market and Sales Intelligence section. He has more than 14 years of research experience and writes articles, develops statistics and assesses influencing factors between shipping, international trade and energy markets. His analysis of commercially sensitive data is used to evaluate supply and demand trends and synergies between the maritime and offshore industries. Mr. Walenkiewicz holds a master's degree in Naval Architecture.

SAFER, SMARTER, GREENER

www.dnvgl.com