

GAS CARRIER UPDATE

No. 01 2016



Fuel gas technologies

Safety culture

New DNV GL rules

Digital twin

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Cover photo: CMM





Johan-Petter Tutturen
 DNV GL Business Director Gas Carriers
johan.petter.tutturen@dnvgl.com

DEAR READER,

This year's huge "gas event", LNG 18 in Perth, is now history. One thing we will definitely remember from this event is the unison message from several speakers at the various conferences encouraging the industry to innovate and work together with the overall aim to improve efficiency and cut costs. I couldn't have said it more clearly myself – this is precisely what we at DNV GL and other leading industry partners have been pursuing for more than two and a half years.

In 2014 we launched the award-winning LNGreen concept. Jointly with our partners we managed to improve energy efficiency by close to ten per cent while increasing cargo carrying capacity by five per cent compared to a standard HHI design. This will have a significant impact on charterers' bottom lines. Following up on this success, we recently launched LNGreen II and expectations for further improvements are running high among our partners. Our development work doesn't stop there: we have just launched LPGreen jointly with other notable partners in the industry, and there is plenty of optimism here as well. We are confident we will be able to present some initial results by the end of the year to help the industry become even more energy-efficient and improve its energy-to-mile ratio.

Apart from public demand for more efficient operations, the "gas industry" is facing other challenges: the shortage of skilled crews will be a headache for years to come. New trading routes, new gas suppliers/exporters, the opening of the new Panama Canal, a growing spot trade and unsustainable day rates seems to be our new everyday situation. Add the new, stricter environmental regulations and the cocktail is complete. During the development of our new DNV GL Rules, which have been released 1 January 2016, coping with future regulations and standards has been of biggest interest for us.

FSRU owners on the other hand are experiencing exciting times. New projects are being planned and explored, and new companies may soon enter this relatively small but distinguished group of operators.

In this issue of GAS CARRIER UPDATE you will meet people and companies willing to walk the extra mile to make the industry safer, smarter and greener, and find fascinating news about the market, innovative technologies, regulations and much more.

Enjoy the read!

GAS CARRIER UPDATE

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Additional authors:
 David Glass (DG), Arne Kjørsvik (AKJ),
 Andreas Kühner (AK), Nora Luttmmer (NL)

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TRADE UP, EARNINGS ... NOT

Expecting a steep increase in liquefied natural gas (LNG) demand, many owners have invested in new gas carriers, and new liquefaction plants have been built around the world. However, in a stagnant world economy, gas imports are not keeping up with supply. The result is dropping rates.

Various forecasts made at the beginning of this decade pointed to 2016 as a year of major change for the liquefied natural gas (LNG) market. This change should not be expected to occur in the form of a sudden increase of trade but as the emergence of new cargoes and new exporters. According to the International Gas Union (IGU), in 2015 the global liquefaction capacity grew by four per cent reaching 301.5 million tonnes/year (MTPA). New terminals in Australia, the US and Malaysia which will start commercial operation in 2016 will bring an additional 41.5 MTPA this year. We have already witnessed the first cargoes being shipped out of Cheniere Sabine Pass (US) and from Australia Pacific. Even though those cargoes do not change the overall volumes of gas shipped by sea, they mark an important milestone for the new trades.

The development of LNG trade will without doubt be predominantly shaped by North America and Australia. When finished, the Sabine Pass will consist of six trains, each with a capacity of 4.5 MTPA. Together with projects like Freeport LNG, Corpus Christi there is 62 MTPA of capacity under construction

in the US. Australian projects such as Gladstone, Australia Pacific, Gorgon, Wheatstone, Ichthys and Prelude will amount to 53.3 MTPA when finished. If we add all other projects worldwide, there is some 140 MTPA of liquefaction capacity currently under construction.

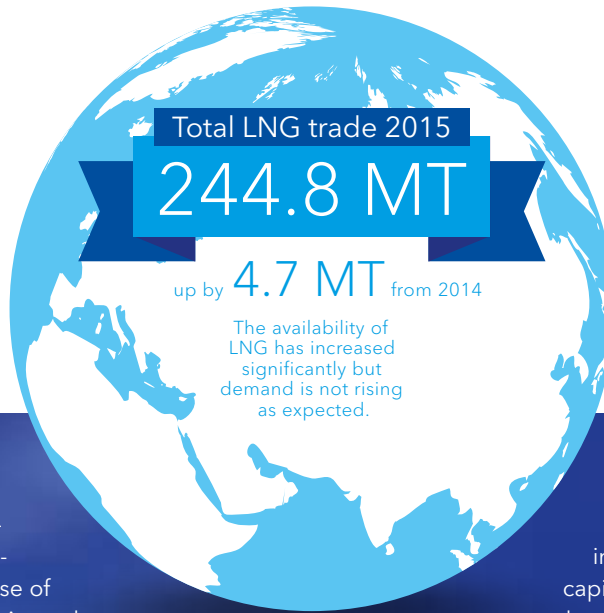
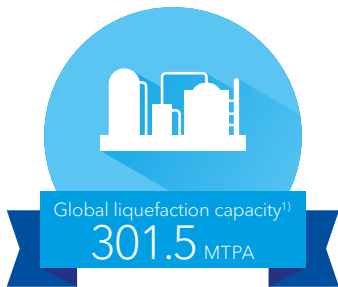
Plummeting earnings

Despite all the good news, trade volumes have not picked up substantially yet. While the LNG trade volume reached a record high of 249.5 million tonnes in 2015, this was only three million tonnes more than in 2011. Within the same time the fleet grew by an additional 60 ships, or five per cent per annum on average. It is no wonder earnings have plummeted nearly fourfold since 2012. According to Clarksons, the average one-year time charter (TC) rate for 160,000 m³ was 36,000 US dollar per day at the end of 2015. Currently we are seeing even lower rates (both spot and TC) of less than 30,000 US dollars per day.

Weak demand, particularly from major importers such as Japan, South Korea and China, influences the rate situation.

New liquefaction plants in Australia, the US and Malaysia will further increase the global capacity.





1) as of January 2016

Nevertheless, as the aggregated decline of imports by those three countries amounted to no more than 7.5 million tonnes, this shows that the real cause of the problem is the oversupply of ships. According to Lloyd's List Intelligence (LLI), the fleet is heavily underutilized, with as many as 40 ships remaining inactive. In addition, there are 139 ships on order, with the majority to be delivered before 2019. The average age of the fleet is 11.2 years, offering very limited potential for scrapping. We may only expect a few odd ships to be removed from the market annually, which will result in a net annual growth exceeding eight per cent in the coming years.

No immediate recovery in sight

It looks like a classic example of premature over-investment in ships. The underlying LNG trade fundamentals surely remain robust. Timing, however, is everything. Current freight rates are not sustainable, particularly for the new tonnage, which

requires break-even rates of at least 45,000 US dollars per day in order to cover operational and capital expenses. We do expect the trade to grow stronger in the coming years, however we need to bear in mind that the recent collapse of gas prices may have a negative impact on future investment decisions. From a short-term perspective, the outlook remains bleak. The recent shutdown of the Gorgon facility certainly does not help, although on the other hand, the restart of the terminal in Angola may remove a few ships from the spot market. Nevertheless, we may have to wait a bit longer for any substantial freight rate improvement. ■ JW



DNV GL Expert

Jakub Walenkiewicz (JW), Principal Market Analyst
Phone: +47 67 57 81 93
E-Mail: jakub.walenkiewicz@dnvgl.com



Photos: DNV GL, @photos - Fotolia

A PIONEER IN FUEL GAS TECHNOLOGIES

The German engineering contractor TGE Marine is a leading innovator in the dynamic gas carrier business. A pioneer in the development of LNG fuel gas storage and handling systems, TGE was among the first suppliers of advanced LNG fuel gas bunkering systems to meet the needs of the emerging low-emission ship fuel market.

"In the long term, LNG along with methanol will play the leading role as a fuel for marine applications," says Manfred Küver, CEO at TGE Marine. An engineering firm with more than 30 years' experience, the company is a main contractor for the growing cryogenic gas market specializing in cargo handling systems and tanks for LPG, LEG, ethane and LNG carriers. In autumn 2015 the Japanese industrial corporation Mitsui Engineering & Shipbuilding (MES) acquired a controlling stake in TGE Marine. "There will be synergies and we believe the two companies will be able to establish an excellent position in the global gas carrier market," Küver says. Together the two companies can offer turnkey solutions for two-stroke, dual-fuel main engines (under MAN ME-GI licence), including LNG fuel gas systems, as well as specific designs for small LNG carriers.

A promising future market Küver especially sees in small-scale LNG: tankers with up to 80,000 m³, LNG bunker vessels and floating storage and regasification units (FSRU). "In view of the environmental regulations more and more owners are looking at gas as a fuel." With the growing number of new vessel projects specifying dual-fuel engines, the long-anticipated market for small-scale LNG - including bunkering services as well as delivery in small-capacity vessels - is picking up speed.

In early 2016 TGE Marine was granted a European patent for a high-pressure LNG fuel gas system. The TGE engineering team had closely cooperated with Cologne University (TH Köln)



on the development of a control system capable of handling the high-speed load profiles imposed by two-stroke dual-fuel main engines running LNG as a primary fuel. The control system was thoroughly tested on board the world's largest Qmax LNG Carrier *Rasheeda* owned by Nakilat, a Qatari shipping company.

Healthy demand

The system has already been ordered for various newbuilds, among them two 26,500 dwt con-ro vessels contracted in the US by Crowley Maritime Corporation, which will be built by shipyard

VT Halter Marine. The vessels will operate in the Caribbean and are among the larger projects in the market. Each vessel will be equipped with three 770 m³ vacuum-insulated LNG storage tanks. TGE will also supply high-pressure/low-pressure pumps, BOG compressors, vaporizers, a utility and safety system as well as a control and alarm

"In view of the environmental regulations more and more owners are looking at gas as a fuel."

Dr Manfred Küver,
CEO at TGE Marine

board. Both vessels will be classified by DNV GL and are being built to DNV GL ship class rules as well as USCG regulations.

Many other contracts underline TGE Marine's leading market position. For example, the company was contracted by Jiangnan Shipyard to supply gas handling systems and cargo tanks for four 21,000 m³ liquefied ethylene gas (LEG) carriers for Petredec as well as four 22,000 m³ liquefied petroleum gas (LPG) carriers for Navigator Gas. All vessels are classified by DNV GL. >



An LNG fuel tank ready for installation on board the oil tanker *Bergen Viking* during the conversion of the vessel.

Photos: TGE Marine

> Another milestone was reached in early May 2016 when *AIDA Prima*, the world's first cruise ship to feature a dual-fuel engine capable of running on LNG when docked in port, successfully passed the LNG bunkering test in Hamburg.

TGE delivered the complete LNG fuel system for *Aida Prima*. A tank truck delivers the LNG to the vessel while in port. This is nothing new, says Küver. LNG-powered ferries and small offshore vessels have been bunkering using LNG trucks for some time, mainly in Norway. The difference is that the *AIDA Prima* is not "tanked" but the gas is continuously pumped on board all the time the vessel is in port. "Our system complies with all regulations and

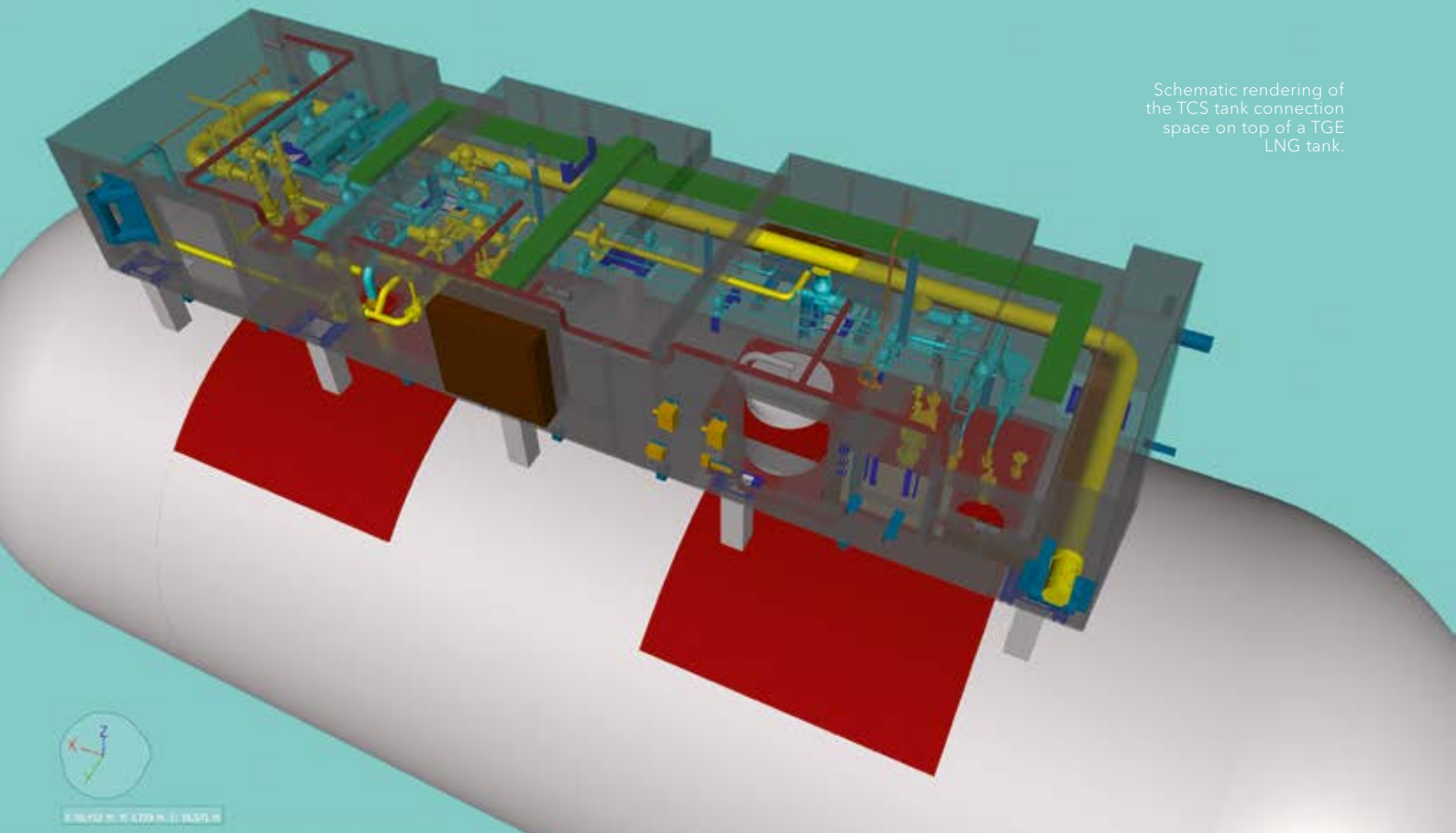
is extremely safe," says Küver. The challenge is the procedures and receiving port authority approvals as there are no standard guidelines yet. Separate agreements have to be made with each individual port. DNV GL also supported the owner to be able to carry out the LNG supply at different ports.

Ensuring safety

AIDA Prima was built by Mitsubishi Heavy Industries and is classified by DNV GL. The vessel is 300 metres long and 37.6 metres wide, has an eight-metre draught and a gross tonnage of 124,500 tonnes. She is fitted with three MaK 12V M43C main

"We presented a strong case for the inclusion of type C tanks as used in the GasPax designs in both codes. Type C tanks have acquired an excellent safety record in the gas tanker market over the years."

Dr Manfred Küver, CEO at TGE Marine



Schematic rendering of the TCS tank connection space on top of a TGE LNG tank.



A TGE tank ready for shipment to NACKS for a PCTC ordered by United European Car Carriers (above left). Installation of three TGE LNG tanks on board a newbuild at shipyard VT Halter Marine (left and right).

engines and one MaK M46DF dual-fuel marine engine. Key to realizing the Aida projects was TGE's participation in the GasPax research project between 2010 and 2013. The project partners, of which one was AIDA Cruises, set out to examine the technical challenges associated with the use of LNG in three types of passenger vessels: a Megayacht (Lürssen), a cruise ship (Meyer Werft) and a ro-pax ferry (FSG), and to come up with ready-for-market designs.

TGE designed the gas fuel systems for all of the GasPax project vessels. DNV GL was responsible for all class and safety aspects within these projects and issued approval-in-principle certificates for all designs. The project results directly influenced the development of international regulations as well as various ship design projects.

As an expert in gas handling systems, TGE has been actively involved in the development of the latest amendments to the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC), which will enter into force on 1 July 2016. The new amendments have also been adapted by the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF), which was adopted by IMO in June 2015. "We presented a strong case for the inclusion of type C tanks as used in the GasPax designs in both codes. Type C tanks have acquired an excellent safety record in the gas tanker market over the years," says Küver. Thanks to its fail-safe design criteria, Type C is the only tank technology for marine LNG applications

which does not require a secondary barrier to minimize the risk of LNG leakage. It thus complies with all applicable safety requirements and is significantly less expensive than vacuum-insulated double-walled tanks.

In terms of safety, Manfred Küver says, the requirements for "tank connection spaces" for type C tanks represent the most advanced development level yet. The fuel containment system shall be so designed that a leak does not endanger the ship, persons on board or the environment. The entire system is double-walled, and all tank connections, fittings, flanges and tank valves must be enclosed in gas-tight tank connection spaces unless the tank connections are located on open deck. The space shall be able to safely contain leakage from the tank in case of leakage from the tank connections. "Another crucial new feature of both codes is the goal-based approach," says Küver. "Earlier approaches were primarily of a prescriptive nature. The new, goal-based approach provides enough space for new concepts, innovation and improvements." ■ NL



DNV GL Expert

Gerd-Michael Würsig, Business Director
LNG-fuelled ships

Phone: +49 40 36149-6757

E-Mail: gerd.wuersig@dnvgl.com

SPREADING THE LNG NEWS

DNV GL - Maritime has taken another step towards digitalization, launching its new LNG intelligence portal called LNGi. It allows subscribers to determine the availability of LNG fuel along specific trade routes as well as for newbuilding projects.

As the pressure on the shipping industry to take action in response to tightening environmental regulations intensifies, liquefied natural gas (LNG) is clearly a favoured fuel option for emission control areas (ECAs). One of the biggest barriers to its rapid adoption by shipowners is uncertainty regarding LNG availability. Feedback received from stakeholders indicates that it is very difficult to keep track of developments in the LNG fuel industry: "The LNG industry has been growing rapidly over the past few years, so much so that it has become increasingly challenging to keep track of all the latest developments," explains Dr Gerd Michael Würsig, Business Director LNG-fuelled ships at DNV GL - Maritime. "This is especially true for shipowners who are considering using LNG in their vessels and want to make sure they have considered all the relevant factors."

Sharing market intelligence

To provide the industry with reliable market information to keep customers up to date on the latest developments regarding LNG and other alternative ship fuels, DNV GL has developed a new LNG intelligence portal called LNGi. The portal aims to bring stakeholders from across the LNG industry together to share market intelligence and contribute to the uptake of LNG as a ship fuel. DNV GL is collecting and assuring the quality of information regarding the development of infrastructure projects relevant to LNG bunkering for ships. The portal's interactive map provides information about LNG bunkering opportunities around the world and includes data on existing and planned infrastructure such as truck loading facilities, tank-to-ship bunkering options and LNG bunker vessels, as well as detailed information on various port and infrastructure projects.

Early subscribers of the LNGi portal include industry leaders such as Shell, ENGIE, GTT, MAN, Rolls-Royce, SGMF, Skangas, UASC, Wärtsilä and WinGD. Ole Skeltved, Head of Marine

Worldwide LNG distribution infrastructure overview

- in operation
- decided
- proposed

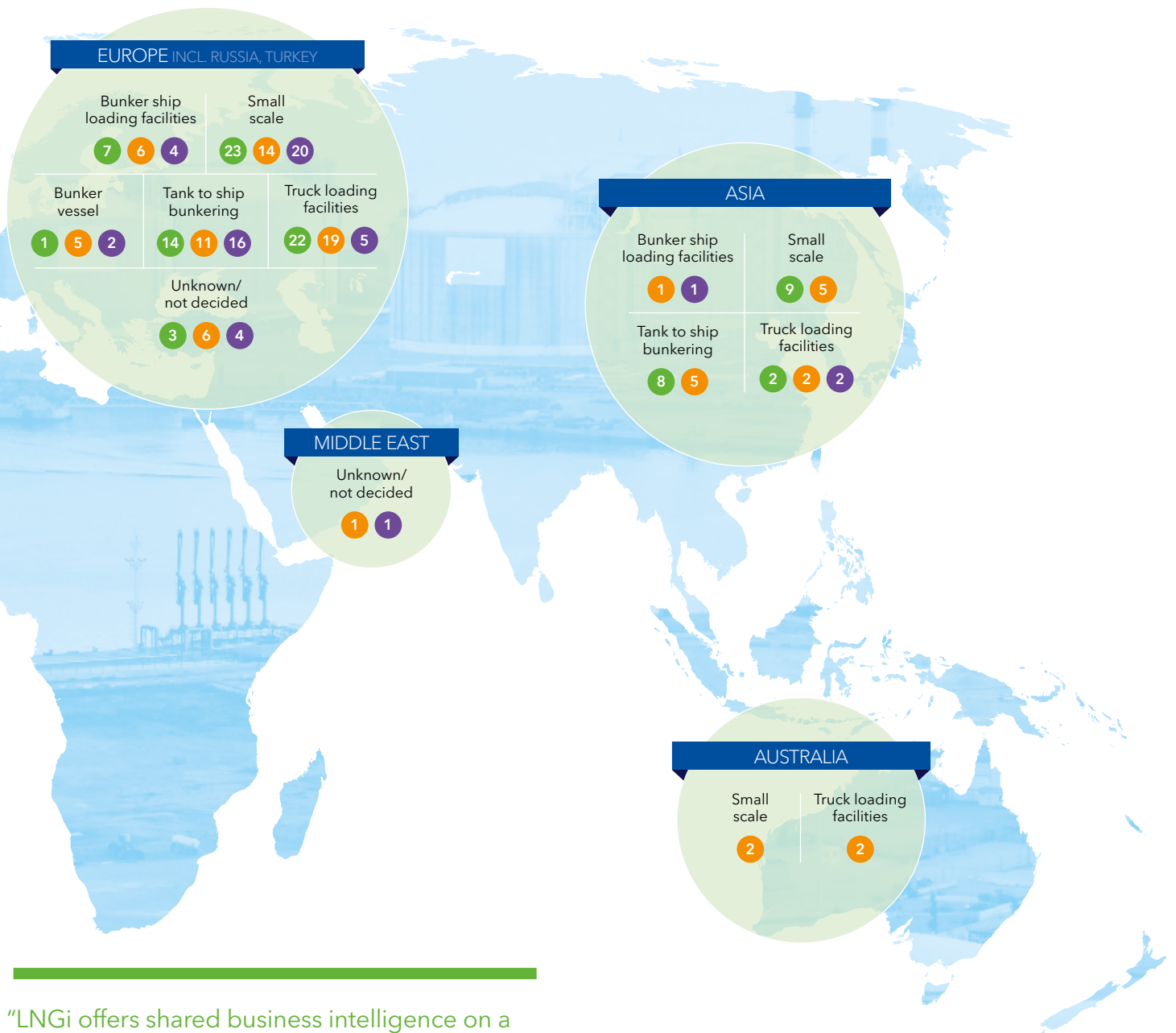


Installation Department at MAN Diesel & Turbo, praised the idea of creating an online portal for LNGi-dependent shipping: "Such a comprehensive overview would be difficult for any single company to obtain on its own. LNGi offers shared business intelligence on a much broader scale than previously available and helps give shipowners who are new to the LNG industry the confidence they need to move forward with their business plans in this field."

Information quality assurance

The Society for Gas as a Marine Fuel (SGMF) will support LNGi by reviewing the data published and providing information about LNG bunkering projects. "It is important that we all refer to a trusted data set as the industry develops. LNGi offers just that. Benchmark information is critical in a complex and sometimes confusing market and this data set will play an important role in accelerating developments in this field," says Mark Bell, General Manager at SGMF.

LNGi will be consistently developed to enhance the output and usability for subscribers. Future planned features for LNGi



“LNGi offers shared business intelligence on a much broader scale than previously available and helps give shipowners who are new to the LNG industry the confidence they need to move forward with their business plans in this field.”

Ole Skeltved, Head of Marine Installation Department at MAN Diesel & Turbo

include segment-specific studies, the option for shipowners to indicate their interest in LNG suppliers providing bunkering services at certain locations, and other details. Members will also have their say on which features they want to see developed.

What does the future hold?

By the end of 2016, an impressive fleet of 43 LNG-fuelled ships are scheduled for delivery/conversion. In parallel with these projects, infrastructure for LNG bunkering will be developed and, as

a result, opportunities for new LNG-fuelled ships will continue to emerge. This development will make LNG fuel more readily available in both Europe and North America.

Australia will also see the first LNG-fuelled ship on the water, demonstrating the technical and operational feasibility of LNG as fuel. In other words, in a matter of months the AIS plot will be far more diverse.

New subscribers can visit the LNGi website dnvgl.com/lngi for further information, to fill in the contact form and to simply contact their local office. ■ MCW



DNV GL Expert
 Martin Christian Wold (MCW),
 Senior Consultant Environment Advisory
 Phone: +47 452 75 212
 E-Mail: martin.wold@dnvgl.com

Photos: DNV GL, peresanz - Fotolia

SAFETY AS A CULTURE

At Consolidated Marine Management (CMM), the shipping arm of the Latsis Group, safety is more than a concept. It is a culture. Indeed Greece's largest commercial group comprises banking, oil refining, energy transport by sea, yachting and real estate companies.

Never let economic considerations compromise safety:
Kostas G. Vlachos,
COO of Consolidated Marine Management.

"In everything we do safety is paramount," says Chief Operating Officer (COO) Kostas G. Vlachos, who had joined CMM as Designated Person Ashore (DPA) in 1997, one of the first DPAs in Greek shipping. Vlachos explains: "The company was aware of the ISM Code and brought me in after I had spent 14 years in the Hellenic Coast Guard. During my final years there I had been head of the MARPOL Convention and ISM implementation departments. CMM was looking for a step-by-step approach to building up a safety management system, something I have always believed in."

Much has changed since those days, says Vlachos. Today there are two distinct safety categories: oil, gas and chemical carriers on the one hand, and all the other ship types on the other. "There are big differences, and tremendous steps towards improving safety have been taken in the oil and gas sectors, such as Sire inspections and TMSA, driven by the demands of the oil majors. Other ship types have made improvements to a lesser degree to meet statutory requirements as enforced by Port State Controls (PSCs) and Recognized Organizations (ROs) on behalf of flag administrations."

Never compromise on safety

In the field of process safety it is vital to take a systematic approach, with due attention to the all-important human element, Vlachos explains. "We are all looking to improve safety at CMM with the goal of ensuring all systems are fit for purpose and are fully implemented, but this is not easy. Owners and operators are making a major effort to change the mindset of people. There is a

"It is good for the customer and the shipping community in general to be able to assess a company on its safety standards."

Kostas G. Vlachos, COO of CMM

big difference between people ashore and those at sea. The former typically change more quickly, while crew often have to learn to change and adapt."

CMM seeks to ensure all stakeholders play their part in the safety culture. Various players are subject to different demands and have different views. The results will not be "fit for purpose" unless all aspects are properly accounted for.

Vlachos is emphatic about the safety of people on board being perceived as a common goal, a mission and not just dictated by regulations and prevailing market conditions. "It is good for the customer and the shipping community in general to be able to assess a company on its safety standards," says Vlachos.

CMM's COO believes the industry today makes a mistake by viewing fuel efficiency as the prime target alone. "By regulating the minimum power of the main engines with the aim of saving energy, ignoring completely the safety aspects in manoeuvring in adverse weather conditions, it might lead to a serious compromise of the safety of life at sea," says Vlachos. He agrees cost-cutting is necessary but insists that "the prudent owner will not cut safety", saying there are other areas where costs can be reduced, such as running through improved maintenance standards, avoiding damages, better inventory keeping and better control of lubricant consumption.

Fostering the right on-board culture

Since CMM was established in 1997 as the successor of Bilinder Marine, which had been operating and managing the fleet of John Latsis for many years, CMM has evolved steadily. A giant among tanker owners, John Latsis had owned one of the world's largest ULCCs, the *Hellas Fos* at 555,046 dwt, commissioned in France in 1979. When his son Spiros took the helm of the shipping company it was decided to operate clean product and gas carriers only and focus exclusively on clean energy transport.

Today the Latsis family's shipping interests are represented by Paris Kassidokostas Latsis, son of John Latsis' daughter Mariana. As Kassidokostas Latsis said at Posidonia 2014, the last two years have been exciting ones for CMM. Not only has the company been in expansion mode, but it has also rejuvenated its



Hellas Hercules. The tankers of Latsco Shipping operated by the subsidiary company CMM have been part of the Green Awards for a long time.

fleet. Today the average age is 3.4 years and it will soon be even younger as new ships are delivered. In 2011 CMM was operating five LPG carriers and four clean product carriers. By the end of 2016 a newbuilding programme carried out in South Korea will see the fleet standing at 23 vessels: nine LPG carriers, including seven VLGCs, nine MR and five LR2 product carriers, with four more MRs to join in 2017. Eight ships of the trading fleet are classed by DNV GL.

Growth has seen the Maltese/Greek-flagged company combining the marketplace for qualified staff with the right safety mindset and facing the challenge of maintaining their loyalty amid the current severe shortage of seafarers. On board there are usually

five to six Greek officers and a Filipino crew, though there are some Filipino officers as well.

In the drive to develop the right approach on board, each ship always has two cadets, often one Greek and one Filipino, says CMM's COO. "We want to develop both nationalities." In addition the company offers incentives to all crew members.

Discussing what lies ahead for CMM, Vlachos and his principals believe the opportunities and the order book will decide, especially in the VLGC sector. In 2015 the order book stood at eight per cent of the trading VLGCs. Today it is at 35 per cent, "a great increase at a time of a slowdown in the market," stresses Vlachos.

CMM is the technical management arm of the corporate company Latsco Shipping. Explaining the background of Latsco's expansion, Vlachos says: "The group came across a very opportune cycle regarding both sectors we are in – gas and clean products –, and this has been driving our expansion. We continue to be interested in expanding at a moderate pace when the timing is right and the opportunities the group is looking for present themselves." Today the entire fleet is on time charter to first-class oil majors.

Identifying effective ways to manage the human element is the big challenge, says Vlachos. "We all have to learn lessons from any failure that may occur as we don't want to fail because of our inability to learn from our mistakes and incidents."

Green shipping initiatives

In its ongoing effort to drive competitiveness, CMM works with DNV GL on a variety of projects. "Over the last two years we have collaborated with DNV GL R&D and Advisory Piraeus to assess and improve the performance of our cargo operations using COSS-MOS. In addition, we recently began developing our cybersecurity management system. We are also involved in the LPGreen joint industry project with DNV GL, HHI, Wärtsilä and MAN," reports Vlachos, adding: "While receiving value-adding services we also use these opportunities to increase the competence and motivation of our people in the company." The objective of the LPGreen project is to develop a more energy-efficient, environmentally friendly and safer vessel for transportation of LPG products taking into account existing and future trading patterns.

Further underlining its approach, CMM joined the Green Award Foundation to develop a programme for the LPG sector. On 1 April the company became the first LPG operator worldwide to be a Green Award LPG certificate holder, and on 17 May, CMM was the first company to have an LPG carrier certified.

"CMM's tankers have been part of the Green Awards for a long time and we have seen the advantages," explains Vlachos. "This will lead to an improvement in performance as the Green Award fosters positive ideas and has made a difference. It is not just a piece of paper, it adds value." ■ DG



DNV GL Expert

Nikolaos Kakalis, Manager R&D and Advisory, Region South East Europe and Middle East
Phone: +30 21 04 10 02 00
E-Mail: nikolaos.kakalis@dnvgl.com

A NEW, FUTURE-READY STANDARD FOR SHIPPING

The new rules, which represent the best of the combined expertise and experience of two leading classification societies, have been evaluated for critical issues and improvement potential by our most experienced technical experts. The rule set, consisting of more than 20,000 pages, has been scrutinized with respect to clarity, practical application and how it contributes to the overall safety of vessels and thus supports safe and reliable shipping. The process has involved more than 200 technical experts at DNV GL and the rule set has been improved by extensive input from more than 800 shipyards, designers, shipowners and managers. The review has resulted in the most modern rule set published by any class society. It is efficient, future-ready, consistent, transparent, modern and adaptable.

Harvesting operational experience

With around 13,000 ships classed, the experience DNV GL has gained through supporting customers in their day-to-day operations constitutes an unrivalled knowledge database.

In connection with the development of its new rules, DNV GL launched a research project to perform a thorough statistical review of the DNV GL-classed fleet. The aim was to identify possible areas where the rules could be further improved. More than 3,000 ships in service were closely monitored to identify any design-related defects. Typical failures and their frequency of occurrence were studied and the know-how gathered in the process was incorporated into the new rules.

A new and improved technical foundation

The incorporation of equivalent design waves (EDW) into the DNV GL rules marks a significant change in the way dynamic loads are calculated. The advanced load concept is a major step towards a more realistic and accurate representation of

environmental loads. Along with the state-of-the-art capacity models developed by DNV GL, this concept will improve the consistency of the safety level applied to the complete hull structure. In addition, this approach will help overcome challenges related to the development of innovative designs. It provides a basis for achieving an ideal distribution of structural strength, ensuring every tonne of steel is used efficiently.

With more precise load-related requirements and more advanced capacity formulations, the new DNV GL rules call for more extensive computational capabilities and are supported by powerful software tools ensuring an efficient design process.

New and enhanced notations

To enable owners to efficiently customize vessels to suit their needs, the new rules offer a variety of additional class notations. These are tailored towards ship types and additional features, and ensure that vessels are designed and equipped for their intended operational patterns. In addition, they are continuously developed to support the application of latest technology.

! Scrubber ready

As the development of regulations and technologies can be unpredictable and complex, DNV GL offers "Ready" notations to owners who want to prepare new vessels for the future installation of new technology. By obtaining such a notation, owners can postpone initial investment costs while ensuring that the necessary preparations are in place for a smooth and cost-efficient retrofit at a later stage. In addition, they may benefit from a higher degree of technology maturity (and possibly lower prices) by investing at a later time.

The SCRUBBER READY notation can be assigned to ships which have been planned and partially prepared for the

For more information and access to the new DNV GL rules, please visit: www.dnvgl.com/dnvglrules

Since DNV and GL joined forces, a huge effort has been made to consolidate our existing knowledge and further enhance our standards to serve as a reference for the maritime industry. The know-how and experience of both legacy companies have been incorporated into the new DNV GL rules which are now available to support state-of-the-art ship newbuilding and operation.

installation of an exhaust gas cleaning system (EGCS) for the removal of SO_x. This notation identifies the general type and category of scrubber system that can eventually be installed on the given vessel. It also details the level of scrubber readiness, with the lowest level attesting that the space available and installation arrangements meet the applicable class and statutory requirements. This can be expanded to include more extensive preparations. The highest level includes a complete review of the scrubber documentation according to main class rules, including the certification and installation of the piping and sub-systems.

! **TMON (closed-loop water) and TMON (open-loop water)**

The revised class notations for water-lubricated tail shafts are another example of the enhanced flexibility DNV GL now offers to shipowners. These two notations allow shipowners and operators potentially unlimited intervals between tail shaft withdrawal surveys of water-lubricated systems. With these two voluntary class notations, DNV GL is the first classification society to use a condition monitoring-based survey process that eliminates the requirement for tail shaft withdrawal surveys at predetermined intervals.

CALCULATION TOOLS - FREE OF CHARGE IN 2016!

Calculation tools are essential for developing modern ship designs. The new DNV GL rules for hull structures are supported by both the POSEIDON and Nauticus hull software applications, which already enjoy an excellent reputation among designers and yards. Both tools have undergone major updates recently to provide more efficient support for the design process and make it easier to apply the new rules. Please contact your local DNV GL Software representative for details.

The notations can be assigned to both newbuilds and ships in service. More details about these and the other 70 additional notations can be found in DNV GL Rules for Ships, Part 6.

Impact on design

New, state-of-the-art capacity models indicate that many existing designs have the potential to be optimized with respect to steel weight. In general, more accurate dynamic load patterns allow steel to be added where it is really needed, and reduced in less critical structural sections. The scope of application of direct assessments is unchanged, but alternative load application methods have been introduced.

The IGC Code became mandatory for all newbuilds with keels laid on or after 1 July 2016. This code has been fully incorporated into the new DNV GL rules.

The maritime industry welcomes the new rules

"All class societies have built their own tables comparing present and new mandatory rules (IGC Code). Since the new code is more goal-based and less prescriptive than the previous one, there will be more room for interpretation, hence more challenging for the designer," says Business Director for Gas Carriers, Johan Petter Tutteren. "What DNV GL has done is prepare a guideline on how to meet the new requirements, which is believed to be of huge value to the industry". ■ SS



DNV GL Expert

Stian Erik Sollied (SS), Business Development Manager and Rules Expert


Phone: +47 911 52 712

E-Mail: stian.erik.sollied@dnvgl.com



KEEPING PACE WITH ENVIRONMENTAL REGULATIONS

The environmental impact of the shipping industry remains a topic of keen interest for regulators, with agreed regulations entering into force in the near future and new regulations being developed around the world. Understanding the evolving regulatory landscape is of strategic significance when making business decisions.



Over the past decade, shipping has seen a surge of environmental regulations. Political pressure and an increasing focus from society at large have driven the International Maritime Organization (IMO), various countries and regions such as the EU to develop steadily more stringent regulations. The consequence is a patchwork regulatory system, where numerous overlaps create challenges for operators. There are unfortunately no indications that this will change. It is important for operators to both understand the existing regulatory framework and be aware of forthcoming developments, both at IMO and elsewhere, in order to make the right business decisions.

Ballast water management

Ballast water management has been a hot topic for a number of years. At present, the Ballast Water Management (BWM) Convention is only 0.21 per cent short of the gross tonnage ratification threshold. Several states have announced imminent ratification, and DNV GL believes the threshold is likely to be crossed sometime this year. The convention will then enter into force one year later, requiring all ships to comply within the following five years. The content and interpretation of the convention are still evolving. Presumably the IMO Marine Environment Protection Committee (MEPC) 70 will finalize the revision of the technical

Ballast water is among the top environmental issues addressed by new regulations.

> guidelines in October. There are presently 65 IMO-approved BWM systems on the market.

The national ballast water management regulations of the United States entered into force in 2013. New ships now have to comply upon delivery, while existing ships must comply by the first scheduled dry docking after 1 January 2014 or 2016, depending on ballast water capacity. US type approval is required for the ballast water treatment systems of affected ships; so far no such approvals have been granted. To address the obviously paradoxical situation of having to install approved systems when none have obtained type approval, the US Coast Guard (USCG) has issued more than 50 so-called Alternate Management System (AMS) approvals for systems accepted by IMO. These approvals are limited to a five-year validity period. To ease the transition further the US is also liberal in granting time-limited exemptions to individual ships. We believe that once US-approved systems become available the extension policy will become significantly more stringent.

For more information on different ballast water topics such as treatment systems and approval process please visit dnvgl.com/bwm.

SO_x regulations

Discussions at IMO are centred on the question of whether the global 0.5 per cent sulphur content requirement should enter into force in 2020 or 2025. A fuel availability study is in progress to provide a discussion basis for an IMO decision which may be made at MEPC 70 in October 2016. A complicating factor in the discussions is the EU Sulphur Directive, which stipulates a maximum 0.5 per cent sulphur content for all EU waters by 2020, irrespective of the IMO decision. If different dates are decided by IMO and the EU, shipping will for a period face a three-tier sulphur content regime. From an operational perspective, this will be challenging.

It should also be noted that the Water Framework Directive is putting constraints on the discharge of scrubber water in certain EU countries. Belgium and Germany have in essence prohibited the discharge of scrubber water in most areas, severely constraining the operation

of open-loop scrubbers. Other EU countries are following suit to a lesser or greater degree, with no common EU practice likely to be agreed. China has recently published regulations for SECA-like fuel requirements in certain coastal areas (see box next page).

More information and our updated Sulphur guideline are available at dnvgl.com/lowsulphur.

NO_x regulations

NO_x Tier III requirements have entered into force in the North American ECA for ships constructed on or after 1 January 2016. In essence, anyone constructing a ship today needs to consider potential operation of the vessel in the North American ECA, whether upon delivery or at some time in the future. If such an operation pattern is conceivable, NO_x control technology will be needed for that ship.

In contrast to the North American ECA the ECAs in the North Sea and the Baltic do not yet include a NO_x requirement. This has been on the table for a number of years and there are now robust signals that a joint North Sea/Baltic NECA application will be made to MEPC 70. Assuming agreement at IMO these Tier III requirements are expected to apply to ships constructed on or after 1 January 2021.

CO₂ and energy efficiency

Climate change remains the driving political force behind CO₂ and energy efficiency regulations. In the EU, regulations for Monitoring, Reporting and Verification (MRV) of CO₂ emissions have entered into force, requiring all ships above 5,000 GT sailing to or from European ports to comply. Ships must also report cargo data and average energy efficiency. The EU will make the data publicly available on an annual basis. Monitoring plans are to be submitted to verifiers by 31 August 2017, with 2018 being the first year of reporting. Data will be published by the EU in mid-2019. There is extensive work in progress to develop the practical framework and the EU is expected to publish practical details towards the end of 2016.

Part of the purpose behind the EU MRV regulations is to encourage IMO to work on a similar mechanism with global, not only regional, coverage. The EU

All technical and regulatory news can be found at dnvgl.com/tecreg

Commercial shipping in coastal waters subject to strict emission regulations.

CHINA IMPOSES SULPHUR LIMITS AND MIGHT ESTABLISH SECA ZONES

China has published regulations to establish SECA-like sea areas outside Hong Kong/Guangzhou (Pearl River Delta) and Shanghai and in the Bohai Sea. In a staged approach, the new regula-

tions impose an initial 0.5 per cent sulphur limit for fuel burnt in key ports within these areas, gradually expanding the coverage to finally encompass these sea areas entirely from 2019 onwards.

The sulphur limit might be lowered to 0.1 per cent as of 2020, and a formal ECA application may be submitted to IMO.



has stated that if this happens it will mothball its regulation. It is therefore of great significance that MEPC 69 did agree on a global mechanism for mandatory monitoring, reporting and verification of fuel consumption data for all ships above 5,000 GT. The scheme is expected to be adopted at MEPC 70, in which case 2019 will likely be the first year of operation. However, the scheme differs from the EU MRV in several important aspects, including confidentiality of data, calculation of efficiency metrics and requirements regarding the verification of data. While the European Commission sees the IMO work as an important step forward it seems unlikely to view the mechanism as robust enough to reverse its own course on the MRV scheme. DNV GL expects that the shipping sector will have to deal with two different but overlapping reporting regimes for at least some years.

IMO is also seeing a reinvigorated discussion on long-term CO₂ emission goals following the global climate change agreement reached in Paris last year. There is as yet no agreement

within IMO regarding the need to move beyond establishing a fuel data collection system, and it remains to be seen whether consensus can be reached. DNV GL sees a very real risk that unless significant progress is quickly made at IMO, other bodies outside the shipping industry may attempt to issue regulations. This would not be of benefit to anyone, least of all the shipping sector itself. ■ EN



DNV GL Expert

Eirik Nyhus (EN), Director Environment

Phone: +47 926 23 818

E-Mail: eirik.nyhus@dnvgl.com





With the market price at a record low and the global energy demand rising, natural gas is in high demand and favoured as a cleaner alternative to conventional energy sources such as oil or coal. Major reservoir discoveries in many countries have spread optimism regarding its long-term availability. However, pipelines are not available or feasible everywhere, and where they are, they often create undesirable political dependencies and are vulnerable to conflicts. Floating storage and regasification units (FSRUs) provide an alternative form of delivery, making liquefied natural gas (LNG) accessible for coastal areas with existing natural gas distribution networks or gas-burning power stations.

Rapid access to energy

Before LNG can be fed into a network, it has to be returned into its gaseous state by expanding its volume by a factor of 600. Regasification essentially means controlled warming of the liquefied gas from its cryogenic phase at -162°C to ambient temperature using seawater or another heat source. Traditionally this has been done by land-based regasification plants located near LNG carrier terminals in ports. In 2015 more than 90 per cent of global LNG gasification occurred in onshore plants. However, inland structures usually require many years of planning and are subject

to complex permitting procedures involving safety, environmental and other considerations. Once installed, they are there to stay regardless of changing energy needs.

Moving regasification offshore offers various advantages. Fixed or floating offshore gasification plants are unaffected by the long planning cycles of onshore plants, require no space on land and can be placed away from people, shipping lanes and port traffic. Floating gasification units can be moved to a new location when the demand situation changes. They require lower CAPEX than onshore plants, are flexible and cost-effective and are increasingly used to supply natural gas to smaller markets or as temporary solutions while permanent onshore plants are under construction.

On the other hand, land-based gasification plants offer a more permanent, lower-risk solution with long-term supply security and greater gas storage capacity. They can be combined with industrial processes requiring cold energy, thereby reducing the overall energy consumption.

Floating regasification units require a stationary offshore terminal with risers and pipelines or a dockside terminal to feed the natural gas into the onshore storage and distribution network. FSRUs are typically moored or anchored in place for extended

The FSRU *Höegh Gallant* has been in operation in Ain Sokhna, Egypt since 2015. The FSRU *BW Singapore* is operating at same location. Both have DNV GL class.



Photos: DNV GL, Höegh LNG

periods of time, storing the LNG received from LNG carriers directly on board. About 15 per cent of FSRUs in operation today are converted conventional LNG carriers with additional regasification plants installed on board; as demand increases more FSRUs are purpose-designed and built. The construction cost of an FSRU is much lower than that of an onshore plant of similar capacity, and charter contracts run much longer than for conventional LNG carriers, generating reliable long-term cash flow. This makes FSRUs attractive to investors.

With the interest in FSRUs increasing, a variety of new design concepts have been proposed. For example, the actual regasification plant can be designed as a topside placed on top of a jacket or jetty. In shallow coastal waters, a caisson can be used as a supporting structure, with the storage vessel mooring on one side and the LNG delivery carriers on the other. Placing the gasification unit on a floating barge allows it to be towed to wherever it is needed, independent of the storage vessel or with limited storage capacity on board. Some FSRUs can double as standard LNG carriers when not under stationary contract, or stay at a terminal only for the time it takes to regasify their cargo. All these approaches aim to optimize flexibility, CAPEX and OPEX while accommodating various technical requirements and local installation situations.

A promising market

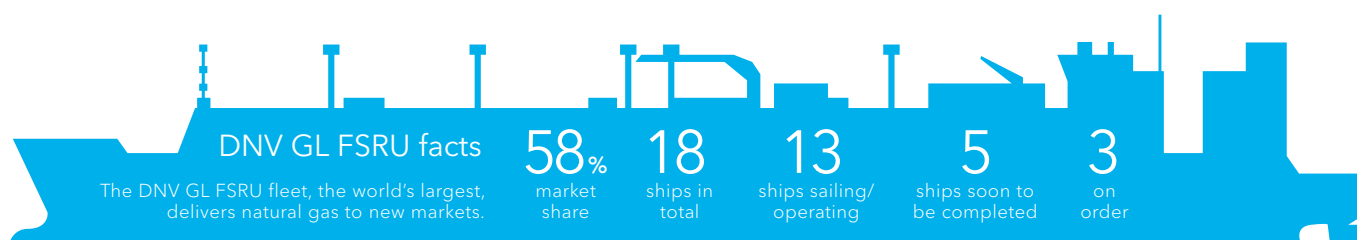
DNV GL has been supporting the emerging FSRUs technology from the beginning. The very first FSRU, the DNV GL-classed converted LNG carrier *Golar Spirit*, began operating in Brazil in January 2009. Several conversions with DNV GL-class have been commissioned by the owners Golar LNG and Höegh LNG since, and in 2014 Golar took delivery of their first purpose-built FSRU, the *Golar Igloo*. The DNV GL portfolio currently counts 18 FSRUs of various sizes, including five under construction, one undergoing conversion, and three on order. As of January 2016 the global FSRU fleet has comprised 30 operational units.

The current market situation is characterized by strong demand and rising charter rates. Egypt, Jordan and Pakistan became LNG-importing countries through the use of FSRUs in 2015. The number of LNG importing nations using FSRUs has increased significantly since 2009 while the number of onshore-only importers has remained stable over the past three years. The demand for FSRUs is expected to continue, driven by additional emerging markets just entering the natural gas market. A number of projects are under development or planned. Five of seven countries with LNG import projects expected to be launched in 2016 or 2017 will use FSRUs at least initially. ■ AK



DNV GL Expert

Pål Einar Spilleth, Ship Type Expert Gas
Phone: +47 934 25 714
E-Mail: pal.einar.spilleth@dnvgl.com



Advanced virtualization technology will soon allow entire ships and their operation to be simulated by computers.

THE DIGITAL TWIN

In a challenging economic environment, shipping companies are looking for innovative technology to drive efficiency and reduce operational costs while managing operational risks effectively and maintaining safety. The digital twin of a ship is a key concept in the ecosystem of asset-centric engineering applications offered by DNV GL.

A digital twin is a digital copy of a real ship which synthesizes the information available about the ship in the digital world, virtualizing all of its systems. A digital twin allows any aspect of an asset to be explored through a digital interface, including its layout, design specifications, simulation models, data analytics, and so on. It is easy to see that there are countless uses for a vessel's digital twin throughout its life cycle.

During the design phase the digital twin is used as a virtual test bench to improve system performance. It also serves as an information management system supporting the workflow while reducing development costs and time. In the third-party verification stage it facilitates a more automated, systematic approach to safety assurance. As digital technologies continue to evolve, cloud-based information management and multimodel simulation

platforms will support the design of ship systems and their digital twins, allowing various stakeholders to populate the digital twin of an asset with modules and evaluate in advance how the system will operate as a whole.

Once a ship is in service, its digital twin offers various possibilities for evaluating performance and criticalities in near real time and suggesting corrective action, especially when coupled with operational data from sensor-instrumented equipment. Over time, increasingly detailed virtual models will be continuously populated with information collected on board, accelerating the development of industrial big data and smart analytics platforms.

The concept of digital modelling has already been implemented successfully in the DNV GL COSSMOS tool, which can simulate and optimize complex and integrated ship machinery systems, a



“Instead of being connected to the actual equipment on the vessel, the control system is connected to a digital twin (HIL simulator), with sophisticated models of the vessel and its equipment.”

Arne Kjørsvik, Manager Digital Services, Marine Cybernetics services, Offshore Class, DNV GL

platform leading the way toward a “digital twin” for ship machinery. “In essence, we use COSSMOS to build virtual engine rooms, digital twins of the vessel machinery either to be built or operated. The virtual engine room is then coupled with the entire operational profile of the ship together with cost data to perform advanced techno-economic analyses of practical use,” Nikolaos Kakalis, Manager R&D, Region East Med, Black & Caspian Seas at DNV GL states.

Pathway to a new era of shipping

Another example illustrating practical use of digital twins is the DNV GL application Nauticus Twinity, which is based on Marine Cybernetic's Hardware-In-the-Loop (HIL) testing technology. “HIL testing is an efficient black-box method for testing and verification of control system software. HIL has been proven for more than 150 offshore vessels and units. Instead of being connected to the actual equipment on the vessel, the control system is connected to a digital twin (HIL simulator), with sophisticated models of the vessel and its equipment,” describes Arne Kjørsvik, Manager Digital Services, Marine Cybernetics services, Offshore Class, DNV GL. This technology can be easily adapted for gas carriers and other ship types. The experience gained during the tests conducted so

far is continuously analysed and utilized to further enhance the test technology for all ship types.

Virtual ship platforms will lead to several new ways of operating and maintaining ships and fleets. Indeed, the digital approach may eventually be the preferred method for stakeholders in the shipping industry. For the time being, however, it is still in its infancy, and smart ways of organizing and making accessible the vast amount of information need to be explored. New technologies leveraging ontology-based reasoning, functional modelling, multiphysics simulation, machine learning, and big data are currently being investigated by both the industry and academia; by 2025, the results of these investigations should provide the basis for new standards and best practices for ship and operational management in the new digital-industrial age of shipping. ■ AKJ



DNV GL Expert

Odd Charles Hestnes
Group Leader Sales & Products
Phone: +47 901 01 24
E-Mail: odd.charles.hestnes@dnvgl.com

Regional Maritime offices

Americas

1400 Ravello Dr.
Katy, TX 77494
USA
Phone: +1 2813961000
houston.maritime@dnvgl.com

Greater China

1591 Hong Qiao Road
House No. 9
200336 Shanghai, China
Phone: +86 21 3208 4518
marketing.rgc@dnvgl.com

North Europe

Johan Berentsens vei 109-111
Postbox 7400
5020 Bergen, Norway
Phone: +47 55943600
bergen.maritime@dnvgl.com

South East Europe & Middle East

5, Aitolikou Street
18545 Piraeus, Greece
Phone: +30 210 41 00 200
piraeus@dnvgl.com

Germany

Brooktorkai 18
20457 Hamburg, Germany
Phone: +49 40 36149-8786
region-germany.maritime
@dnvgl.com

Korea & Japan

18F Kyobo Bldg.
Jong-ro 1, Jongno-gu
110714 Seoul, South Korea
Phone: +82 2 734 7326/7
region.korea@dnvgl.com

South East Asia & India

16 Science Park Drive
118227 Singapore
Singapore
Phone: +65 65 0 837 50
sng.fis@dnvgl.com

West Europe & Africa

3 Cathedral Street
Palace House
London, SE1 9DE
United Kingdom
Phone: +44 207 357 6080
london.maritime@dnvgl.com

DNV GL AS

NO-1322 Høvik, Norway
Tel: +47 67 57 99 00
www.dnvgl.com

DNV GL - Maritime

Brooktorkai 18
20457 Hamburg, Germany
Tel: +49 40 36149-0
www.dnvgl.com/maritime

About DNV GL

Driven by its purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. Operating in more than 100 countries, our 15,000 professionals are dedicated to helping our customers in the maritime, oil & gas, energy and other industries to make the world safer, smarter and greener.

DNV GL is the world's leading classification society and a recognized advisor for the maritime industry. We enhance safety, quality, energy efficiency and environmental performance of the global shipping industry - across all vessel types and offshore structures. We invest heavily in research and development to find solutions, together with the industry, that address strategic, operational or regulatory challenges.

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