DNV·GL

GAS CARRIER UPDATE

2018

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Digitalization

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Cover photo: BW LNG

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DEAR READER,

The digital revolution has undoubtedly arrived in our industry, and your classification society is working hard to bring its benefits to you, saving you money and many bureaucratic headaches. For example, DNV GL offers you a personalized online portal to give you secure access to important services and supporting resources. Machine learning has been integrated into many online services to minimize administrative burden. Smart survey booking finds the best time window for periodical surveys, helping you do as many inspections and audits in one appointment as possible. Another major innovation is electronic ship certificates, accessible anytime from anywhere.

As the world increasingly looks to natural gas as a low-pollution source of energy, the entire LNG value chain stands to benefit. Technologies closing the gap between LNG carriers and the on-shore distribution infrastructure are burgeoning. In this issue you will learn about an ingenious ship-to-shore LNG transfer platform that simplifies the delivery of liquefied natural gas in smaller ports. FSRUs, crucial for returning LNG to its gaseous state, are in great demand around the world as an inexpensive alternative to land-based gasification stations. Our new FSRU class rules, based on feedback from customers, offer owners and operators more flexibility, more options, and more convenience, for example through extended dry-docking periods enabled by underwater inspection.

Our market outlook draws an optimistic picture, with a few cautionary notes, of course. We at DNV GL are doing everything we can to support positive developments and give well-founded advice. Facilitating communication between project partners is of utmost importance as technologies and regulations get more complex. BW LNG, for example, was able to bring the best ideas to the table by cultivating an open dialogue between its partners in several newbuilding projects, and the LNGreen project achieved the best combination of current technology by taking a new approach to knowledge-sharing.

Imparting knowledge you can profit from is also the concept behind DNV GL's advisory services, which cover every aspect of the asset lifecycle and make it easier for you to handle complexity. In fact, our summary of current and future environmental regulations in this issue gets you up and running on this very important topic. You know that whatever question you have, DNV GL as your competent partner will help you make smart decisions.

Enjoy reading!

GAS CARRIER UPDATE

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ICE-COLD CARGO MAKES RED-HOT HEADLINES

After years of anticipation, growing worldwide liquefaction capacities and new LNG tonnage entering the market are beginning to align. With global demand on the rise, new trade patterns emerging, and transport activities intensifying, the LNG segment is quickly becoming one of the most interesting markets to watch.

Over the past few years, we were nothing but optimistic about the future of the LNG segment. Considerable additions of liquefaction capacity combined with the rapidly growing appetite for LNG has surely painted promising prospects for this industry. On the flip side, however, low LNG tanker earnings seemed to be the only missing element of that exciting story. Ever since 2015, we have been witnessing new LNG cargoes entering the market, yet due to excessive deliveries of new tonnage, rates remained stubbornly below the break-even levels.

Not anymore! In the fourth quarter of the last year, spot earnings increased almost twofold and have remained on that level, flirting with the mark of 80,000 US dollars (USD) per day. It didn't take long for the sentiment to change. New headlines emerged very quickly, warning about the possible scarcity of new tonnage, which may hit the sector as early as 2020! From oversupply to undersupply in less than three months. It remains to be seen whether this story holds true in the future. Ten new contracts for LNG tankers placed in just two months of 2018 certainly calls for some reflections. However, it would be unwise to draw long-term conclusions based upon just that one whiff of optimism. Let's have a closer look at the current fundamentals.

516 ships

The world LNG fleet currently stands at 75.9 million m³ capacity.

Rapidly growing seaborne trade

Double-digit growth has been awaited for a long time. In 2017 it was finally achieved when 26 million tonnes of cargo was added to the trade, representing a growth of ten per cent. Looking ahead, in 2018, we expect another 36 million tonnes of "new LNG", which will result in twelve per cent of annual growth.

When you look at the trade patterns, the situation looks even better. The tonne-mile effect grew by twelve per cent in 2017 and is expected to accelerate to 14 per cent in 2018. It comes as no surprise that the increasing distances are caused mainly by the US cargoes. However, on 8 December 2017 *Christophe de Margerie* loaded the first cargo from Yamal bound for the UK, opening a new trade pattern. In 2020 (with three trains running), it will add another 17.5 million tonnes per annum (MTPA) of LNG into the gas trade.

In 2017, 24.9 MTPA of liquefaction capacity came online. The vast majority (18.7 MTPA) came from Australia, with two Gorgon trains, Ichthys T1 and Wheatstone T1. In addition, Cheniere's Sabine Pass opened the third train (4.5 MTPA). Another 1.2 MTPA was added by Petronas' *PFLNG Satu*, and 0.5 MTPA came from Sengkang LNG. This year's expected additions are even larger. Cameron LNG

T1, Cove Point T1, Sabine Pass T4 and Elba Island LNG will collectively add 17 MTPA from the US. On the Australian side, Ichthys T2, Wheatstone T2 and *Prelude FLNG* will bring 12.3 MTPA. In addition, Yamal T1 will produce 5.5 MTPA, and Golar's project in Cameroon (GoFLNG) is expected to produce two MTPA. Altogether, the world liquefaction capacity will have grown by 36.8 MTPA by the end of the year. The good news is that the growth doesn't stop there, as another 33.3 and 25.2 MTPA will come online in 2019 and 2020 respectively. When we accumulate all additions between 2017 and 2020, we are looking at a whopping 120.2 MTPA representing 35 per cent growth in just four years. No other shipping segment can enjoy such a robust trade development.

One of Australia's LNG projects – Wheatstone LNG commenced operations at the end of 2017.

24.9 MTPA of liquefaction capacity came online in 2017 – with 18.7 MTPA coming from Australia.

Changes to the list of top importers

Although Japan still remains the leader, last year China overtook South Korea, claiming second place. To add even more flavour, during the first two months of the current year, Chinese imports reached 63 per cent of the Japanese level, which only underlines the strength of their demand. Elsewhere, back in 2015, India pushed Taiwan down the list and currently takes fourth position after South Korea. It is just a matter of time before it advances to the top three LNG importers. A large increase in imports is also observed in Pakistan, Jordan and France.

There is a growing number of countries which join the "FSRU team". In 2017, there were 26 floating terminals operating worldwide, and another 14 were planned. Most of the terminals are located in Latin America, the Middle East and Indian peninsula. The major incentive behind the FSRU projects is a significantly lower capital cost. An onshore terminal would typically have capex in a range of USD 330/tonne, whereas an FSRU will cost three times less. Not only does it offer much lower construction cost, but it also provides a great deal of flexibility, as it can be moved from one country to another or also be used as a conventional LNG tanker.

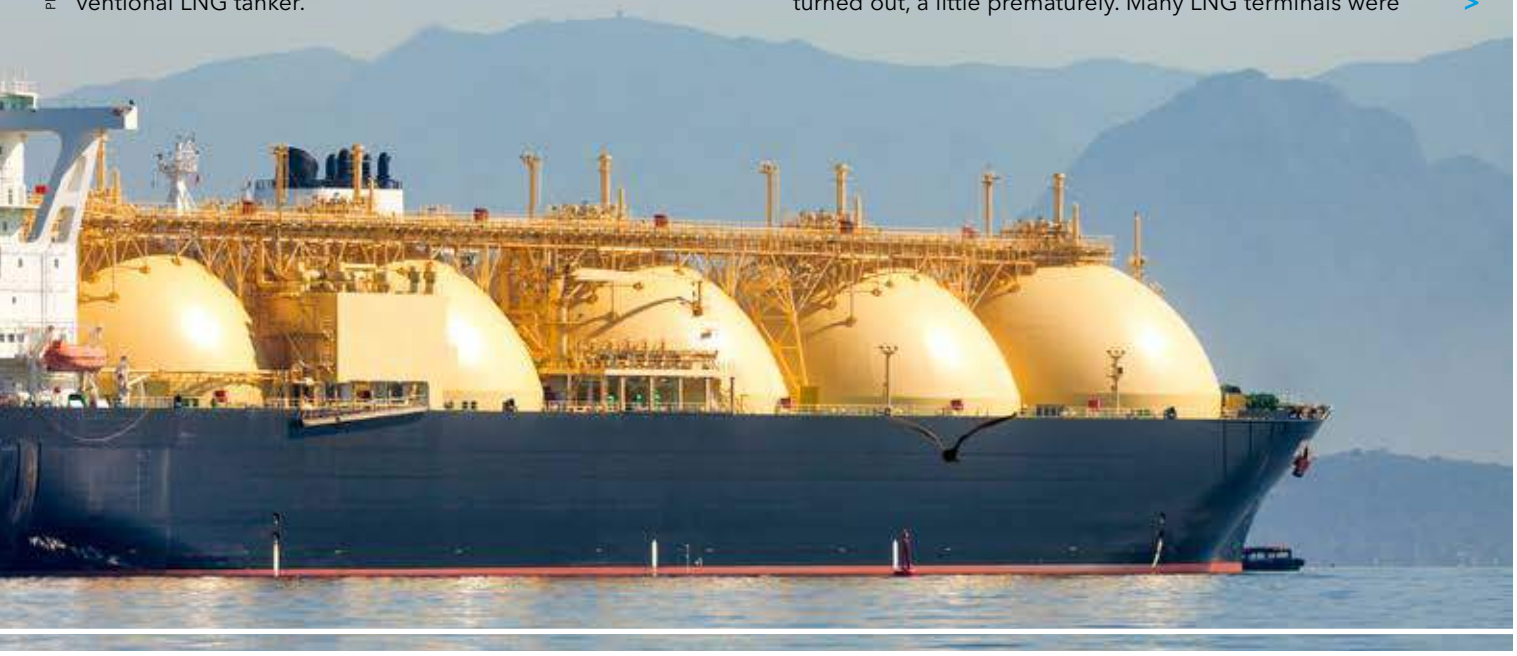
So, whether onshore or floating regasification unit, developments are substantial. It does look like it is currently a supply-driven market, where every cubic metre of LNG gets sold. The only question is, how long will it last?

Finally how big is the fleet?

The rapid fleet development has been a source of concern for quite a few years. In the end, oversupply was the reason behind the disappointing earnings. Five years ago, the world LNG tanker fleet stood at 372 ships, corresponding to 53.4 million cubic metres (cbm). Since then, 153 ships have been delivered. With very little scrapping activity, the fleet passed the 500 mark in November 2017, and it currently stands at 516 ships and 75.9 million cbm, which represents over 40 per cent growth.

As it usually happens in shipping, as soon as there is a whiff of optimism, new ships get built come hell or high waters. This time around, a flurry of new contracts was driven mainly by liquefaction projects in Australia and shale gas developments in the US. Ships started to hit the water one after another, but as it turned out, a little prematurely. Many LNG terminals were >

Photos: Chevron, luoman – iStockphoto



Japan continues to be the world's number one natural gas importer, followed by China, South Korea and India.

> delayed, which is why we hadn't observed any substantial growth of seaborne trade until 2016.

Ever since, however, the demand for tonnage has been increasing steadily. Owners have gained a bit of breathing space, although earnings hadn't really improved much until the last quarter of 2017. One may say that in the past five years, only the last two quarters have brought some good returns.

Will there be a shortage of ships?

Recently, there has been a lot of discussion about a possible shortage of tankers in the near future. A typical supply/demand desktop exercise may prove such theory correct. For example, if all projects come online on schedule; if all liquefaction plants run with full-capacity utilization; if imports of LNG continue to soar undisturbed; if gas is traded on the longest distances; if prices allow a decent arbitrage etc., etc. A careful reader would count five "ifs" in the previous sentence, and they certainly do not exhaust the list of possible concerns. Without disproving the undeniable success of the LNG industry, a few possible problems should be addressed.

First of all, at the time of writing this article, there are 105 LNG carriers on order, representing 20 per cent of the existing fleet. The list of deliveries, particularly in 2018, is rather overwhelming. According to schedule, 63 ships are supposed to be handed over to owners this year. The 36.8 million tonnes of this year's expected cargo growth will generate a need for 40 to 45 ships only. What to do with the remaining 20 ships? Luckily, we will most likely not see all ships delivered in time anyway. A high non-delivery factor suggests that at least one third of deliveries will slip until 2019 when we already expect 34 tanker deliveries. It looks like we may kick that delayed-deliveries "tin can" down the road for quite a few years before we start to see any shortage of ships.

105 ships are currently on order, representing 20 per cent of the existing fleet.

Secondly, we need to look at the distances. Although Australian exports will most likely maintain their usual trade patterns (in terms of average distance), US exports will be more diversified. In case of Australian exports, we need around 1.1 ships per million tonnes of cargo. US exports may increase that factor up to 1.7 ships, assuming that gas is shipped to the Far East. In the US, however, LNG is sold in much more flexible terms. Lack of fixed destinations is one of the advantages, which allows LNG buyers to resell the cargo as they wish. It means that some of the LNG that was meant to go to the Far East may end up in Europe, thus indeed reducing the voyage distances and demand for ships.

Cross-regional arbitrage should also be monitored. Although American gas appears to be very cheap, in most cases it needs to be shipped over long distances. Until recently, low freight rates certainly helped to achieve higher competitiveness for US projects. In the wake of better ships' earnings, we need to factor them into the overall equation as they naturally reduce the price arbitrage.

The issues we have just listed are fairly obvious and in some cases even predictable. What about the black swans? A typical example seems to be painting itself before our eyes. US President Donald Trump's proposal of introducing import taxes for steel and aluminium was not welcomed warmly at all. Many countries have warned that they will retaliate with similar measures. One of those countries was China, which pledged to introduce similar taxes on US-originated LNG. If it becomes a reality, it will severely damage the price arbitrage, subsequently reducing the amount of cargo on that trading pattern.

To summarize

The LNG industry seems to have a bright future ahead, and shipping will benefit a lot from it. Trade keeps growing rapidly, and the freight rates have picked up momentum. One may say that LNG tankers are doomed to success, and it is probably true. We may not, however, forget that it doesn't take long to destroy even a well-functioning market. The ordering of new tonnage is certainly tempting these days. Newbuilding prices are as low as they can possibly be. A couple of years back, a brand-new 175,000 cbm tanker would set you back nearly USD 210 million. Today it is only USD 180 million. If you order against an existing project, by all means, go ahead. Otherwise, just look over your shoulder and see how long it took for rates to recover. ■ **JW**

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KEEPING PACE WITH A CHANGING INDUSTRY

The comprehensive overhaul of DNV GL's class rules includes a completely rewritten regasification section. Since the first FSRUs were introduced a decade ago, the classification society has accumulated plenty of technical and market knowledge that now benefits the industry.

The updated class rules offer more flexibility, more options and more convenience.

Floating storage and regasification units (FSRUs) are a relatively young and highly dynamic industry segment with a steep learning curve. As a classification society DNV GL has been at the forefront of the technological development, ensuring safety and guiding the industry along the way.

When redrafting its regasification rules DNV GL was not only able to draw on its extensive in-house knowledge and many years of experience but also on feedback from key users, designers, shipyards and shipowners. Naturally the IGC Code forms the basis of the safety requirements, but the updated DNV GL class rules go much further, incorporating criteria derived from practical experience. True to DNV GL's policy of offering shipowners more flexibility, they follow a two-track approach, says Johan Petter Tutturen, DNV GL Business Director Gas Carriers. The basic REGAS rules comprise all requirements to ensure safe operation, and a line-up of optional class notations further enhance safety levels on board for those owners and operators who want to go the extra mile. "What is more," says Mónica Paola Alvarez Cardozo, Senior Engineer, LNG, Cargo Handling & Piping Systems, "our clearly-defined set of basic rules and the add-on Enhanced Safety (ES) qualifier make it easier for shipyards to build to our class." The response from designers, yards and owners has been positive, says Alvarez Cardozo. "In particular, major Korean yards who were instrumental in the rule development process and were given the opportunity to comment on the draft rules at a very early stage have been very supportive."

Saving costs

Accommodating specific needs and new trends and providing flexibility for exceptional situations is part of the DNV GL classification philosophy. For example by opening up the possibility of fitting regasification plants on board non-LNG carriers ship types on a case-by-case basis. Furthermore, the updated regasification rules now reflect DNV GL's established practice with earlier regasification vessels, e.g. regarding the strength of the regasification module skid or the use of high-integrity pressure protection systems (HIPPS).

One of the most popular changes relates to FSRU dry-docking. "Ships are normally required to dry-dock every five years," explains Alvarez Cardozo. "Our new class notation UWILD (Underwater Inspection in Lieu of Dry-docking) allows an FSRU to remain at a stationary location for as long as desired, subject to flag state approval. We will do all required inspections as before but carry them out differently, using underwater techniques where applicable." This inspection model, which can save owners and operators significant costs, has been accepted by several flag states, who will approve its application on a case-by-case basis. Arrangements to accelerate this approval process may be made in future, Tutturen adds.

Rule development work at DNV GL continues. "We are simplifying our mooring rules, leaving behind some of the complexities of the POSMOOR notation which was originally designed for offshore structures in the North Sea. Our new approach will account for more benign waters." DNV GL is also working on an option to waive the requirement to enter into the tanks every five years, a time-consuming and costly process. "Our partnership approach means we are willing to do what we can to make our customers' lives easier without compromising safety," Tutturen stresses. ■ **AK**

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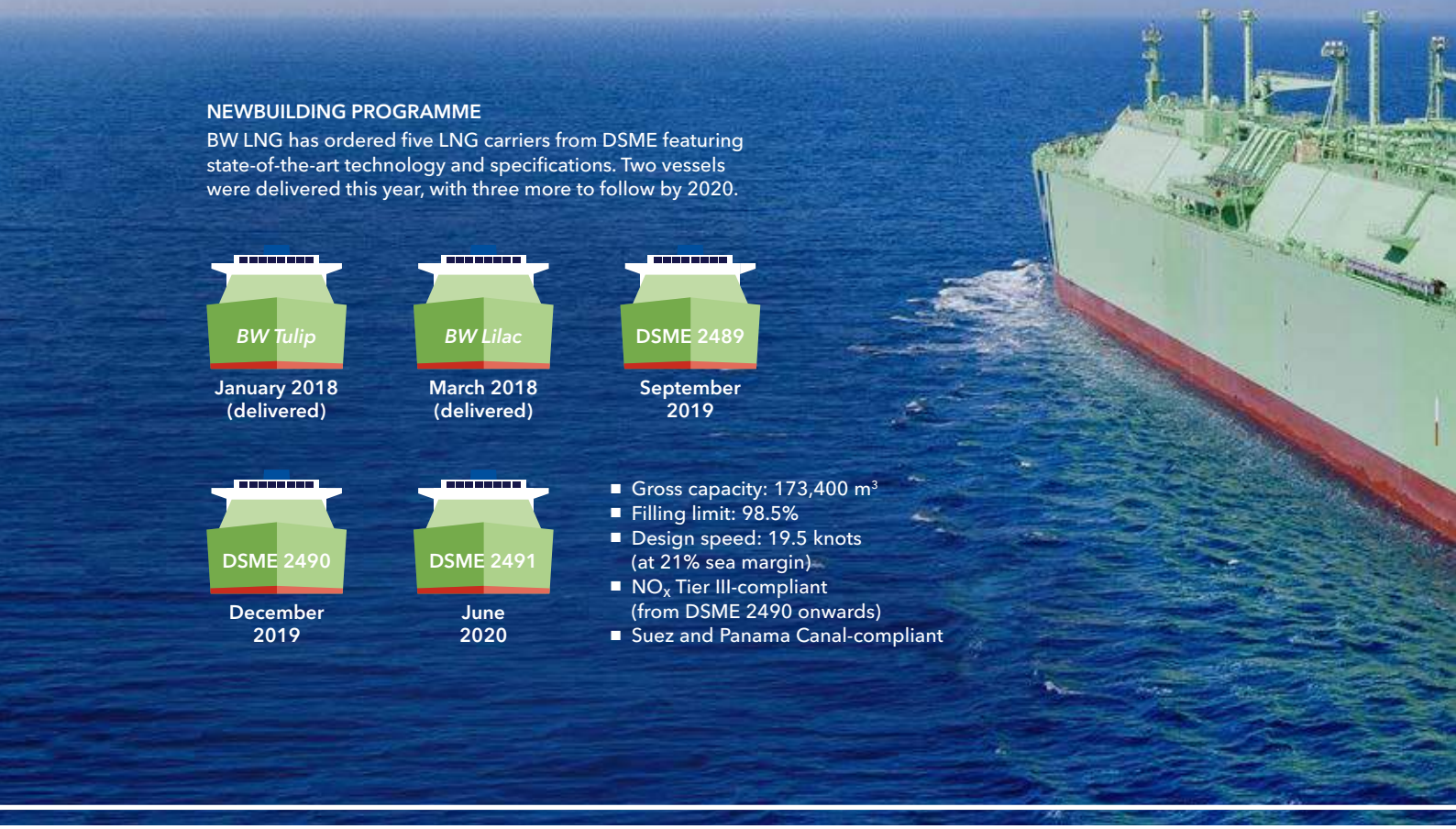
FLEXIBILITY FOR CHANGING MARKETS

With its latest orders for next-generation LNG carriers and FSRUs, the BW Group has again demonstrated its flexibility in adapting to a changing market environment. The newbuilding orders reflect a continuous search for efficiency gains whilst maintaining full focus on safety and operational excellence. Supported by in-house newbuilding and technical management teams, BW's recent growth initiatives have already paid off in attractive charter contracts.

At BW, the commercial team and a dedicated group of technical experts from their in-house newbuilding department keep a close eye on market requirements and seek solutions to address an increasingly dynamic market environment in LNG shipping and infrastructure. In developing projects, BW utilizes the long-standing technical experience gathered from numerous newbuilding projects since the company was established, alongside operational experience from managing one of the largest fleets of LNG and LPG carriers in the world. Each new project benefits from a growing and deepening pool of knowledge where new designs are continuously optimized for safety, efficiency, maintenance and the environment.

BW's growth initiatives are set against a backdrop of an LNG industry constantly seeking efficiency gains, and BW's strategy is to be at the forefront of this development. To adapt to the changing market environment, BW has recently ordered five next-generation LNG carriers as well as three FSRUs, all classed by DNV GL.

"All our ships are built for maximum efficiency, safety and reliability," says Petter Larssøn, Vice President, Gas Solutions and LNG Shipping, BW LNG. He emphasizes, "Our aim is to be at the forefront of efficiency developments not only for today, but also in the development of lasting solutions which will be competitive over time". With this in mind, the in-house newbuilding team makes numerous modifications to the original design. "We have many



NEWBUILDING PROGRAMME

BW LNG has ordered five LNG carriers from DSME featuring state-of-the-art technology and specifications. Two vessels were delivered this year, with three more to follow by 2020.

- Gross capacity: 173,400 m^3
- Filling limit: 98.5%
- Design speed: 19.5 knots (at 21% sea margin)
- NO_x Tier III-compliant (from DSME 2490 onwards)
- Suez and Panama Canal-compliant

preferences when tailoring newbuilding designs and may apply as many as 800 to 1,000 changes to a yard design, from small to large, in order to include lessons learnt, ensure operational flexibility, and include new technological developments," Kasper Winroth, LNG Manager at BW LNG, explains.

Open dialogue in design development

The technical preferences range from careful selection of equipment makers to improving redundancy and efficiency through to enhancing the design to ensure the crew can fulfil their tasks. "We believe these efforts yield results, through optimizing the design we ensure that operations and maintenance will be much more efficient, which provides the best economics for us and for the customer," Larssøn underlines. Having an in-house newbuilding team and a large gas carrier fleet facilitates sharing experiences and solutions with key yards and suppliers across all disciplines involved in ship design. The newbuilding team is in constant dialogue with shipyards and equipment makers to evaluate new developments, improvements or products. This includes close cooperation with partners such as DNV GL.

"Having an open dialogue on what goes on in the industry and continuously working on optimizing the designs is very important for us," Larssøn comments. "We have a longstanding relationship with DNV GL and they understand our business and our constant push to evolve and change in line with the dynamic industry environment. DNV GL has been involved in many processes during the newbuilding phase, looking at equipment, instrumentation, automation, digitalization and more, and supporting us in the constant pursuit of operational excellence and operating best-in-class vessels. Moving into future concepts like digitalization and automation will get increased focus going forward. We are looking at alternatives for operations and maintenance, which could involve innovations such as the use of drones for tank inspection, which will save costs and improve safety," he adds. >

> "All our ships are built for maximum efficiency, safety and reliability."
>
> **Petter Larssøn,** Vice President, Gas Solutions and LNG Shipping, BW LNG

Photo: BW LNG

Optimizing flexibility and lowering the unit freight costs while preserving safety and reliability and complying with all environmental restrictions: experts must cooperate closely to tackle this complex task.

BW's first FSRU *BW Singapore* has been chartered for the EGAS project in Egypt.

> The recent LNGC and FSRU newbuilding orders were placed before firm charters were lined up amid changing market requirements. "We have taken some newbuilding positions ahead of charters/contracts to time deliveries and benefit from attractive yard pricing. This allows us to meet the expected market requirements," Larssøn explains. "This is especially important in the FSRU segment, where the lead time of projects is often very short and you cannot offer a solution to the client without an available asset", he adds.

So far, these decisions have paid off: BW's first FSRU, the *BW Singapore*, was chartered immediately following delivery for the EGAS project in Egypt, with a world-record five-month implementation time after contract signing. The second FSRU, the *BW Integrity*, was chartered out on a 15-year contract in Pakistan shortly after delivery. Similarly, the two MEGI LNG carrier newbuilds delivered in Q1 2018, *BW Tulip* and *BW Lilac*, are both committed to charters. Furthermore, FSRUs offer an interesting risk mitigation option by doubling as fully tradable LNG carriers. "In case of time gaps between delivery and start-up of an FSRU project, the vessels can sail as LNG carriers with competitive features such as large size and relatively efficient fuel consumption," Winroth points out.

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>
> **Kasper Winroth,** LNG Manager at BW LNG

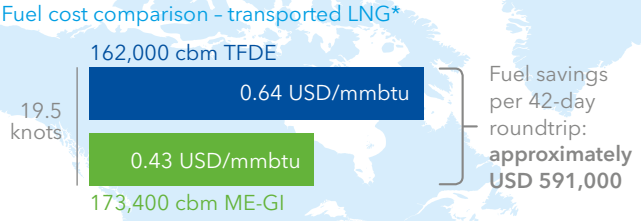
Flexible and capable FSRU newbuilds

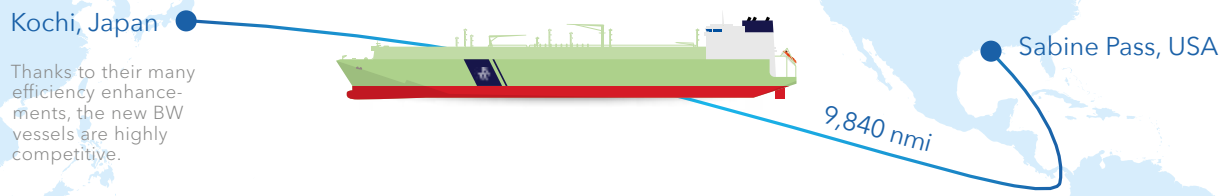
When BW LNG launched the FSRU projects, the newbuilding team first optimized the designs so the vessels would be competitive for most projects worldwide. One of the key parameters is regasification reliability and efficiency, especially when these vessels are deployed in connection with large infrastructure projects. "One of the major developments in FSRU technology is increased regasification efficiency and capacity compared to five or ten years ago. The size of FSRUs has also increased to provide more storage space and accommodate cargo from all types of incoming LNG vessels," Larssøn explains. With a capacity of about 170,000 cubic metres, these FSRUs are big enough for LNGCs of nearly any size whilst ensuring highly efficient operation and fast send-out. "We aim to design FSRUs that fit most projects worldwide, focusing on safe, reliable, efficient operation and flexible capacity," Winroth explains. All of BW's FSRUs are based on seawater heating, either direct or via a glycol intermediate loop,

US - JAPAN ROUNDTRIP VOYAGE COMPARISON

Gas consumption comparison

Gas consumption	162,000 cbm TFDE (mt LNG/day)	173,400 cbm ME-GI (mt LNG/day)	Variance
Ballast @19.5 knots	111.2	80.6	+38%
Laden @19.5 knots	116.9	82.7	+41%





*Gas price assumed USD 9.15/mmbtu
Pilot fuel is included as LNG equivalent units

to regasify the LNG in the most energy-efficient way. The capacity of the regas plant is tailored to location-specific conditions. Equipped with efficient four-Stroke DF engines from Wärtsilä and MAN, the BW ships offer regasification with a minimum of environmental footprint.

LNG vessels for the future

Another project the BW LNG newbuilding team has been working on is the development of next-generation LNG carriers that will attract clients in an ever-changing market with increased demand for flexibility and efficiency.

For the series of five vessels ordered from DSME, the newbuilding team and its partners again utilized their extensive LNG-specific operational experience to achieve significant improvements over existing vessels.

"The big driver in LNG shipping is reduction of the unit freight cost," Larssøn points out. "You can reduce the unit freight cost by building larger vessels with lower fuel consumption and boil-off rate." 174,000 cubic metres is the size BW LNG prefers as it is highly flexible; 180,000 cbm ships may also be considered in future.

The fuel consumption of the new LNG carriers is some 30 to 40 per cent lower than that of DFDE/TFDE, and even better when compared with steam propulsion, thanks to the slow-speed two-stroke dual-fuel engines. The ME-GI engine offers reduced specific consumption, improved propulsive efficiency and increased fuel flexibility. Allowing almost any mix of gas and liquid fuel, the engines give the charterer a wide range of options. Apart from the larger size and lower fuel consumption of BW's next-generation LNG carriers, the third big efficiency improvement is the significant reduction of the boil-off-rate (BOR), achieved by combining a low-BOR containment system with a reliquefaction system working in tandem with the ME-GI fuel gas supply system. This ensures the best reliquification efficiency in the market, compared to independent reliquefaction systems. BW also places great emphasis on minimizing the environmental footprint of its ships. Lowering emissions to air and sea is a continuous effort at BW. Of course the vessels will comply with the relevant emission regulations. This can in part be achieved by reducing fuel consumption; in addition, the latest newbuilds have an EGR system on the main engine to reduce NO_x emissions to Tier III levels while reducing the amount of waste water that is discharged to sea, compared to an SCR system.

To comply with the Ballast Water Management Convention, BW LNG has opted for a combined electrolysis and filter system that comes with both IMO and USCG approval.

Zero harm is paramount

BW has a zero-harm policy and continuously works towards the ambitious goal of eliminating safety incidents entirely. The company believes that one aspect is to design vessels to reduce risks; a second one is to educate the crew, the yards and the suppliers to eliminate hazards and safety incidents, both during construction and during operation. BW has its own yard teams who supervise construction and work together with the suppliers and partners executing its projects. Experts from DNV GL are also present on site to support the supervision and make sure the work is performed in a safe manner. Cooperating closely with customers as well as partners such as DNV GL, BW constantly strives to live up to its zero-harm goal. "This is about changing behaviour, processes, procedures, training, communication, management, leadership, on-shore and offshore operations, and practising a safety culture that ultimately pays off by keeping people safe," Winroth points out. ■ JS

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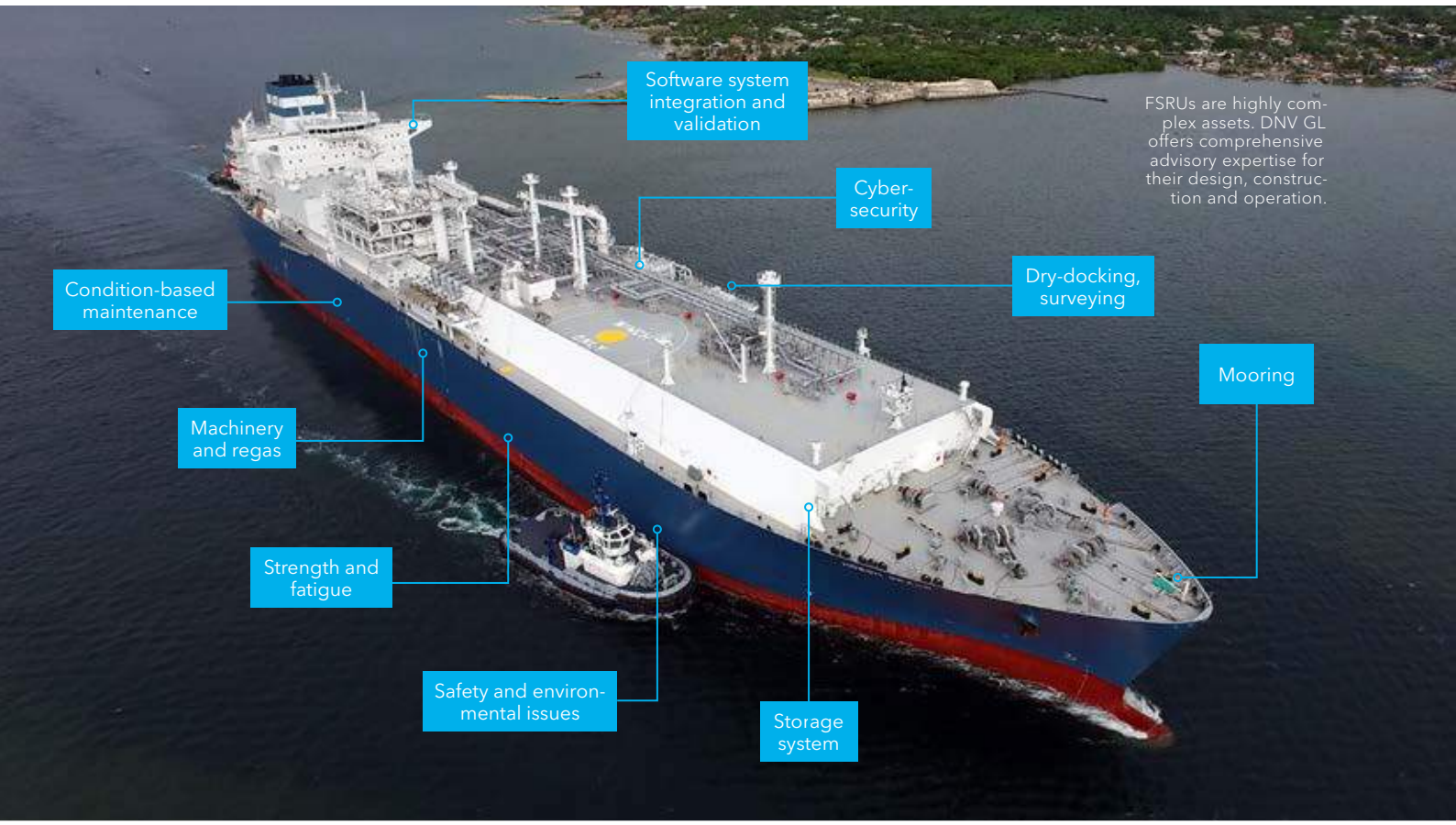
Photos: BW LNG, DNV GL



FSRUs are highly complex assets. DNV GL offers comprehensive advisory expertise for their design, construction and operation.

ASK THE FSRU EXPERTS

Over the past ten years LNG has become a popular form of transporting energy over large distances. DNV GL's advisory services help owners and charterers of floating regasification units assure the safety, functional integrity and economic value of these complex units.

The availability of liquefied natural gas (LNG) in large quantities in the world market is providing many coastal nations with access to a new, low-pollution energy source. Forming the interface between LNG carriers and the local gas supply infrastructure, floating storage and regasification units (FSRUs) play a key role in the LNG value chain, and not surprisingly demand for these units remains strong. Compared to land-based regasification plants they offer numerous advantages, including faster planning, construction and deployment, flexible redeployment, independence from space availability on land and the associated permitting procedures, and significantly lower cost. In addition, FSRUs promise independence from international pipelines and are less likely to meet with popular opposition or be subject to bureaucratic delays.

By providing three separate LNG-related functions – transport, storage and regasification – FSRUs offer exceptional versatility and convenience. However, to allow owners and their customers to reap the full benefits of this potential, FSRUs must be designed with enough flexibility in mind so they can be used in a variety of situations throughout their operating life. Furthermore, the physical properties of LNG require highly specialized handling and storage equipment which is subject to stringent quality and safety standards. Today's owners and operators know that understanding the complexities and system interdependencies on board a regasification unit is a gigantic task. From the planning and design stage through to the asset's end of life there are countless questions to be answered that require very specialized knowledge. Working with a competent partner is a must.

Going the extra mile

Based on its many years of experience and its pioneering role in the FSRU segment, DNV GL is in a unique position to help planners, designers, builders, owners and operators of FSRUs ensure efficient construction and operation while adhering to the highest safety standards. Having been involved in the development of FSRUs from the very beginning, DNV GL offers a comprehensive

range of class-independent advisory services for FSRU projects, supporting owners in defining the boundary conditions for FSRU designs, ensuring fast approval of modifications when customizing existing vessels, and providing decision support and requirement-based evaluations that go beyond the ship itself and can include items such as tendering, cybersecurity, shore facilities, and project due diligence as well.

Services based on real-life experience

Conversion of existing LNG carriers is a common way of making FSRUs available to the market relatively quickly. In such a case a thorough assessment of the vessel before conversion is essential for the success of the project. In particular, the LNG cargo tank system must be examined for its remaining operable life, and all processing equipment, pipelines and connection points on board must be scrutinized for fatigue and crack propagation to determine how long the ship can serve its new purpose safely and to find out if and where steel repairs or renewals are required. For conversion projects it might be beneficial to increase the maximum tank vapour pressure beyond the 0.25 bar normal for LNGCs. Experience indicates that such vessels may sustain pressures up to 0.4 bar or even above when operated in calm waters.

As for newbuilding projects, there are many questions that must be answered by the different stakeholders before a new FSRU can be ordered and built, from feasibility and risk assessments to specification reviews, the unit capability definition and the design review, through to support in charterer negotiations and contracting. Since the world's first-ever FSRU was commissioned about ten years ago, DNV GL has assisted in numerous projects. Backed by this practical experience and its profound knowledge of applicable rules and regulations, DNV GL is able to provide guidance before, during and after conversion or newbuilding.

For example, a major FSRU operator needed to map and assess the complex energy flows on board these units to identify the best new technology options for next-generation designs. DNV GL used its COSSMOS modelling service to examine the integrated power generation and processing plant design, simulate operation, and define operational profiles and the required metrics to provide decision support for the future operator. In the process, the intricate interaction patterns between the subsystems were studied, and critical areas for process improvement were identified. DNV GL developed, proposed and evaluated various alternative system configurations so the customer could select the best-performing variant.

In another project, an existing Moss-type LNG vessel was to be converted into an offshore FSRU, and DNV GL was asked to assess the feasibility of extending the operating life of the cargo tank system for this purpose. In particular, the owner needed a thorough fatigue and crack propagation analysis. Based on its long experience with Moss-type LNG tanks and knowledge of the relevant rules and regulations, DNV GL scrutinized the tanks, in particular the critical tower-to-tank shell connections, which are prone to fatigue. The remaining fatigue life and crack propagation rates were calculated to establish leak-before-failure criteria, and the customer received a comprehensive assessment and well-founded advice as a basis for its decision-making process.

Full lifecycle support

When a shipping company serving the oil and gas industry asked DNV GL for help developing a well-structured energy management approach that would support the company's cost containment strategy, DNV GL formulated an energy strategy, defined appropriate organizational roles and processes interfacing with the company's existing processes, and prepared a reporting and monitoring concept. The DNV GL experts also performed quantitative analyses of operational profiles and fleet performance along with a cost–benefit assessment, and defined implementation-ready on-board energy-saving measures.

As these examples show, DNV GL's advisory services cover a wide range of LNG and FSRU competence and service areas, providing valuable decision support, helping avoid management mistakes, and improving safety, energy efficiency and ultimately, financial performance and corporate value. ■ **AK**

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COMPREHENSIVE SOLUTIONS FROM DNV GL'S MARITIME ADVISORY

DNV GL's advisory services cover every aspect of a regasification unit's lifecycle.

STRATEGY AND FEASIBILITY

- Techno-economical project evaluation
- Site selection
- Selection of FSRU concept
- Qualification of technology
- Tender process assistance
- Yard assessment
- Regulatory support

NEWBUILDING

- Risk studies
- Strength and fatigue
- Sloshing
- Machinery and regas system optimization
- Software system integration and validation
- Mooring analysis
- Construction monitoring

SERVICE IN OPERATION

- Dry-docking optimization
- Condition-based maintenance
- Energy management
- Cybersecurity
- Safety culture
- Emergency planning & accident investigation
- Navigational risk assessment
- Remote monitoring and control

A thorough assessment of the cargo tanks prior to conversion is essential.

SHIPS FOR THE LONG HAUL

With the global LNG distribution network rapidly expanding and energy prices on the rise again, LNG carriers must meet entirely new requirements with regards to both design and operational efficiency. DNV GL offers unique capabilities in comprehensive performance optimization.

"We will be ready to offer our fourth-generation LNGC V2.0 design to our clients in the coming months – thanks to the great work done by DNV GL."

Song Wei, Head of the R&D department at Hudong-Zhonghua Shipbuilding

The worldwide LNG trade patterns are changing. Today liquefied natural gas is routinely transported across very long distances – typically from the USA or western Africa to the Far East. What is more, ship fuel prices, after years of decline, are on the rise again, while the pressure increases to keep the CO_2 footprint in check. All this means that fuel efficiency plays a greater role than ever in keeping transport costs down and the ships attractive to charterers.

With this in mind, the Chinese shipbuilding company Hudong-Zhonghua wanted to get the best out of the design when planning its next generation of 174,000-cubic-metre LNG carriers. To leverage the latest expertise and technology, H&Z approached DNV GL for a joint development project. "DNV GL has rich experience and expertise in both the LNG industry and modern CFD technology for vessel performance analyses. We are very happy to work with this international leading class," said Song Wei, Head of the R&D department at Hudong-Zhonghua. The operational profile for the ships was developed based on real-life AIS sailing data, which suggested a typical 60 per cent of sailing time spent in laden condition and 40 per cent in ballast, with speeds ranging between 15 and 19.5 knots.

In a first phase Hudong presented two design proposals: a slender, longer hull shape with a B1 beam (less than 46 m wide), and an alternative design with a wider, B2 beam (more than 46 m wide) at reduced length. To identify the most fuel-efficient concept, DNV GL undertook simulations with a standardized CFD setup in full scale. This procedure does not require application of traditional model test extrapolation methods since the fluid-dynamic properties are considered for the actual operating conditions. Both designs showed well-balanced performance between laden and ballast draught. For the anticipated operating profile, however, the B1 design exhibited a power demand that was approximately five per cent lower than that of the wider B2 variant, a penalty that could not be compensated by the benefit of higher displacement. Having achieved this much, the project partners were convinced that further hull design improvements would allow them to tweak efficiency by an additional three to four per cent.

Project phase two involved a dedicated, formal hull lines optimization to exploit the full potential of the B1 design. DNV GL's ECO Lines service, which combines a fully parametric geometry model with computational fluid dynamics (CFD) and dedicated genetic optimization techniques, was the method of choice. The process began with a mutual definition of optimization targets and applicable design constraints. Then a dedicated parametric model was developed which served as a basis for generating hull shape variations. The process ensures that the ship forms derived are buildable while meeting the design constraints.

In this case constraints were applied to keep the displacement in ballast and laden conditions as well as the centre of buoyancy within tight limits. In addition a minimum propeller clearance was

Changing trading patterns call for a new generation of efficient, long-distance 174,000 m³ LNG carriers.

defined, and various hard points were added to allow installation of the LNG tanks.

Now the basic design was ready for computer-based optimization using DNV GL's high-performance cluster of more than 7,000 CPUs. The geometry was generated for each design variant, and hydrostatic properties were analysed to check for intake and stability requirements. Design variants that met the requirements then underwent a performance analysis by means of computational fluid dynamics. More than 120,000 hull shape variations were looked at in the course of this project.

An item of special importance was the alignment of the propeller shaft lines. While many twin skeg designs feature inclined shaft lines to adapt to the local flow conditions, Hudong preferred parallel shaft lines to obtain a more compact machinery space. To investigate the detailed effects of the rotating propellers in the wake of the skegs, DNV GL utilized a dedicated software tool which uses fully viscous calculations to optimize the propulsion system, accounting for the rotational components of the propeller. Finally a configuration was identified that accommodated a parallel shaft line arrangement and showed the desired level of performance.

Energy efficiency optimization

Because of the complex nature of LNG carrier operation, the machinery and systems must be flexible and operate efficiently across the entire operational profile. Operational and demand profile models were developed using COSSMOS, a DNV GL simulation software tool. Hudong and DNV GL set the speed range parameters for laden and ballast condition ten to 20 knots. In addition, the engineer considered various non-sailing modes, including anchored unloaded, cargo loading, anchored loaded, and cargo unloading condition. Based on the operational profile, various re-liquefaction technology variants, fuel gas handling system configurations, and auxiliary engine economizers were subjected to techno-economic assessments using DNV GL's COSSMOS tool. The results showed that AE economizer systems may bring better important overall efficiency improvement technology.

"We were very excited to see the final report, which showed that the expected improvement potential could be fully realized by this JDP," said Song Wei, when the results had been reviewed. "We subsequently conducted model tests. We will be ready to offer our fourth-generation LNGC V2.0 design to our clients in the coming months – thanks to the great work done by DNV GL." ■ **AK**

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Photos: DNV GL, Hudong-Zhonghua

TOWARDS ZERO EMISSIONS: ENVIRONMENTAL OUTLOOK

While the world is struggling to live up to its commitment to limit climate emissions, new data indicate that climate change may be more severe and occur more rapidly than anticipated earlier. The IMO is looking for ways to make shipping climate-neutral over the next decades. DNV GL gives an overview of the status of the discussion and potential future measures.

When the Paris Agreement was adopted in 2015 in response to the increasing signs of global climate change, shipping and aviation were not included. Instead, the IMO and ICAO were asked to come up with greenhouse gas (GHG) emission reduction schemes of their own. At MEPC 72 the IMO has now adopted a strategy to reduce emissions from shipping. This aims to reduce total emissions from shipping by at least 50 per cent by 2050, and to reduce the average carbon intensity by at least 40 per cent by 2030 while aiming for 70 per cent in 2050, all figures compared to 2008. The ultimate vision of the IMO is to phase out greenhouse gas emissions entirely at the earliest time possible within this century. This initial strategy will be reviewed in 2023 based on information gathered from the IMO Data Collection System (DCS) as well as a fourth IMO GHG study to be undertaken in 2019.

As it must be assumed that the global shipping activity will continue to grow towards 2050, the 50 per cent emission reduction target is quite ambitious and will most likely require widespread uptake of zero-carbon fuels in addition to other energy efficiency measures. However, there are no zero-carbon fuels available today. A concerted research and development effort is needed not only to develop such fuels but also to make them available in the required volumes.

To implement its ambitious strategy the IMO must develop new policy measures and regulations. The strategy contains a long list of options, such as

The IMO is looking for strategies to eliminate greenhouse gas emissions from ships by 2100.

strengthening the EEDI, applying operational indicators, reducing speeds, rolling out market-based measures, or developing zero-carbon fuels. Work on an action plan to kick-start the development of appropriate measures will start this fall.

While limited immediate impact on ships is to be expected, the efforts required to reach the long-term goals will have to build over the coming years, with a real impact starting to materialize in the 2020s. In a long-term perspective, DNV GL expects this strategy to fundamentally change the way ships are designed and operated.

More information on low-carbon shipping and alternative fuels is available at **www.dnvgl.com/low-carbon-shipping** and **www.dnvgl.com/alternative-fuel**

The EU's CO_2 monitoring, reporting and verification (MRV) scheme is in effect as of 2018.

CO_2 data collection in the EU and at the IMO

In the EU, regulations for monitoring, reporting and verification (MRV) of CO_2 emissions have entered into force, requiring all ships above 5,000 GT sailing to or from European ports to report CO_2 emissions, cargo data and average energy efficiency. 2018 is the first year of reporting, with data being published annually by the EU as of mid-2019.

One purpose behind the EU MRV regulations was to encourage the IMO to work on a similar mechanism with global coverage. The EU regulation itself contains a provision for a review aimed at alignment with a future international system, if in place. It is therefore significant that the IMO has adopted a global mechanism for mandatory monitoring, reporting and verification of fuel consumption data for all ships 5,000 GT and above. The scheme, known as the IMO Data Collection System (DCS) on fuel consumption, will have 2019 as its first year of operation.

The IMO DCS differs from the EU MRV in several important aspects, including the confidentiality of data, the calculation of efficiency metrics, and the requirements for data verification. While these are all issues where the EU has a strong preference for the requirements of its own system, the European Commission has nevertheless initiated a formal review process aimed at aligning the EU MRV with the IMO DCS. There are encouraging signs of a legislative proposal to be published in May 2018, though it is expected to be challenging and likely time-consuming for the commission, the parliament and the council to come to an agreement. DNV GL believes that full alignment is unlikely, and that the industry may have to cater to both reporting regimes for the foreseeable future (see article on page 24).

More information on EU MRV and IMO DCS is available at **www.dnvgl.com/mrv** and **www.dnvgl.com/dcs**

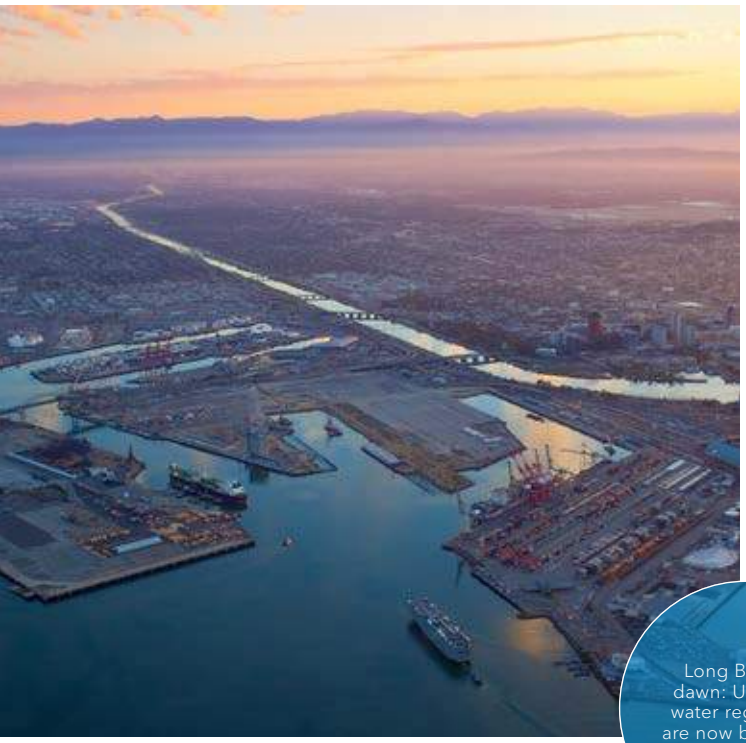
SO_x regulations

IMO has agreed that the 0.5% global sulphur cap will be implemented from 1 January 2020. The decision is final and will not be subject to renegotiation, which gives certainty to the maritime and bunker industries. There were intense discussions on both the practicalities of implementation and on how to ensure robust enforcement and a level playing field. IMO is continuing to discuss implementation and supporting measures on a priority basis and is holding an intersessional meeting dedicated to the topic in July. The meeting is expected to provide robust guidelines for industry and authorities; these will be finalized at MEPC 73 in October and then circulated.

Ship operators will have to choose their preferred compliance strategy, a decision with far-reaching operational and financial implications. There is no one-size-fits-all solution on the table; scrubbers, LNG, and "hybrid" fuels are all realistic options, but most vessels are expected to default to using 0.5% marine gas oil (MGO) and blends, at least initially. Local availability issues and price volatility are expected to result from the dramatic change of the fuel demand situation as of 1 January 2020, and the number of non-compliance cases, especially because of insufficient tank cleaning at bunker facilities and on board ships, is likely to be rather high during a transitional period.

Enforcement remains a critical concern, especially on the high seas. Contrary to emission control areas (ECAs), where enforcement is up to the respective port state, monitoring of operations on the high seas is the responsibility of the flag state. Legitimate questions are being asked about the readiness of all flag states to provide uniform and robust enforcement to ensure a level playing field around the globe. To alleviate the enforcement issue to some extent, the IMO at MEPC 72 agreed to establish a ban on carriage of non-compliant fuels for all ships without scrubbers. This ban is likely to be adopted at MEPC 73 and will then take effect in March 2020. Ships without scrubbers will still be allowed to carry non-compliant fuel as cargo.

Moving to regional and domestic matters, it should be noted that in the EU the Water Framework Directive is imposing restrictions on the discharge of scrubber water. Belgium and >



Long Beach at dawn: US ballast water regulations are now being fully enforced.

> Germany have prohibited the discharge of scrubber water in most areas, thereby limiting the operability of open-loop scrubbers. Similar restrictions apply in some US coastal waters, e.g. off Connecticut.

In Asia China's regulations for domestic SECA-like requirements are being rolled out in the sea areas outside Hong Kong/Guangzhou and Shanghai as well as in the Bohai Sea. China is taking a staged approach, initially requiring a 0.5% maximum sulphur content in fuel burned in key ports in these areas, gradually expanding the coverage to finally apply fully to all fuels used in these sea areas from 2019 onwards. Conceivably the allowable sulphur content will be tightened to 0.1% by 2020, and China may eventually submit a formal ECA application to the IMO. In our view there is a real possibility of these zones being extended to include further Chinese sea areas.

More information is available at **dnvgl.com/maritime/publications/global-sulphur-cap-2020.html**

NO_x regulations

The NO_x tier III requirements have entered into force in the North American ECAs for ships constructed on or after 1 January 2016. Anyone constructing a ship today needs to consider whether operation in the North American ECAs will be part of the operational pattern, whether upon delivery or at any time in the future. If so, NO_x control technology will be required on board. When choosing an NO_x control technology operators should consider how they intend to ensure compliance with the 2020 sulphur cap to avoid system integration issues.

With respect to upcoming regulations, IMO has agreed to apply NO_x Tier III requirements to ships constructed on or after 1 January 2021 when operating in the North Sea and Baltic Sea ECAs. There are presently no indications of plans for additional NO_x Tier III areas.

Ballast water management

The Ballast Water Management (BWM) Convention entered into force on 8 September 2017, more than 27 years after the start of negotiations, and 13 years after its adoption in 2004. The implementation schedules was revised at MEPC 71 in July 2017. Briefly put, every ship in international trade will be obliged to comply at some point between 8 September 2017 and 8 September 2024. For ships from 400 GT upwards, the compliance date is linked to the renewal of the International Oil Pollution Prevention certificate, while ships below 400 GT must comply by 8 September 2024. By that date the entire world fleet must be in compliance.

In the US, the domestic ballast water management regulations entered into force in 2013. New ships must 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. USCG type approval is required for ballast water treatment systems; six such approvals have been granted so far, with eleven more in the approval pipeline. The USCG's previously liberal extension policy granting deferred installation dates to more than 12,500 ships due to the unavailability of approved systems has changed since the first type approvals were issued. Presently the USCG is very restrictive on granting extensions and this policy is likely to tighten further. In practical terms, operators should now plan their installation dates based on the compliance dates in the regulation and not gamble on receiving an extension.

For more information on ballast water-related topics please visit **dnvgl.com/bwm**

Emerging issues

There are a number of new environmental regulations under consideration at the IMO as well as in various countries. They cover a broad range of topics, such as plastic pollution from ships, the impact of noise on cetaceans, particle emissions, hull biofouling, and a ban on heavy fuel oil in the Arctic. The discussions are at various stages; New Zealand, for example, has introduced biofouling regulations in May this year. The noise issue is primarily a concern of a few isolated stakeholders, while plastics and an Arctic HFO ban are under consideration at the IMO. Nevertheless, most if not all of these topics are likely to be the subject of further domestic or international regulations sooner or later during the next decade. ■ **EN**

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Photos: DNV GL, Courtesy of the Port of Long Beach

THE PATH TO DIGITAL CLASSIFICATION

After a fast start, DNV GL continues to pick up the pace in the digital transformation of its classification services.

"We started looking into machine learning as a tool for modernizing classification in 2016," says Morten Østby, Senior Principal Consultant at DNV GL. "When the team realized how important this could be, it was implemented in April 2017. By the autumn it was in production."

Such a fast-track realization is fairly typical of the digital transformation sweeping DNV GL's classification business. "The aim is to move the customers over to a digital interface," says Østby, "where clients and vessels can stay up to date, receive notifications, and take advantage of digital storage capabilities – and that's just the beginning." Østby's ally in the push to modernize class, Senior Principal Engineer Arun Sethumadhavan, emphasizes the main focus of the digital initiative: "Ease of access and comprehension are important for customers. Today that means mobile access and expanded functionality." The jumping-off point for the journey through DNV GL's modern class universe is a personalized online portal that provides customized and secure access to all digital services and support resources. As of November 2017 they are embedded in DNV GL's Veracity platform.

Simply efficient

"Smart survey booking is a major move in streamlining a previously tedious and often inefficient manual task," says Østby. Smart Survey Booking is a DNV GL service enabling clients to keep their vessels in operational condition in the most efficient manner possible. The service minimizes the on-board impact from surveys and audits and reduces on-shore and on-board administration work, among other advantages.

The smart survey booking solution automatically finds the optimal window for a ship's periodical surveys, allowing >

Reflecting updates instantly, electronic certificates are accessible around the world.

Photos: DNV GL, ©Saklakova – stock.adobe.com

> for as many survey and audit requirements and requests as possible to be covered in one survey, to avoid multiple inspections.

"Based on this time window and a list of possible ports entered by the operator, the system also looks for the closest geographical location, accounting for the scope and duration of the survey and surveyor availability, and issues a recommendation," says Østby. "This minimizes both the time involved in booking the survey and the inconvenience for the vessel, while keeping the costs down by helping reduce surveyor travel times."

An enhanced version of the application is expected to be available before 2019, Østby informs: "When the customer requests a survey, the system will estimate port call options based on the Veracity ETA Predictor, and benchmark these ports to help identify where full scope can be completed where also travel and overtime cost is favourable." A link to all DNV GL-approved service suppliers in the respective country has also been added to the benchmarking feature with the aim of improving efficiency and keeping survey costs down.

Learning application

Many improvements are made possible by introducing machine learning, or ML, into the survey booking process. "ML is used to calculate the time required for each survey," says Østby. "When the scope and other parameters are set, the system outputs a time estimate based on historical data."

DNV GL has also incorporated ML into its DATE (Direct Access to Technical Experts) service where a customer's problem description transmitted by e-mail can make it challenging to assign the case to the correct category and expert or section for fast processing. "A discrepancy between the description and interpretation may cause the inquiry to be routed to the wrong expert," says Sethumadhavan. "Now DATE uses ML to vet cases based on historical data and quickly directs them to the proper expert. This cuts down on manual vetting and reduces time wasted on re-routing and finding another expert. We are already seeing that ML-assisted vetting is more than 80 per cent accurate, and it gets better every day." Each ML-vetted routing receives a confidence rating before being enacted. Any inquiry that has not received a very high confidence rating is returned for manual vetting. "ML is chosen for category assignment only when the confidence level is very high," explains Sethumadhavan. "By using continuous learning logic, the ML system is constantly refining its selection criteria and improving its hit rates quickly."

But there are other human factors that complicate the advisory process. "While we all use English only, there are different language patterns and rules in different parts of the world," Østby

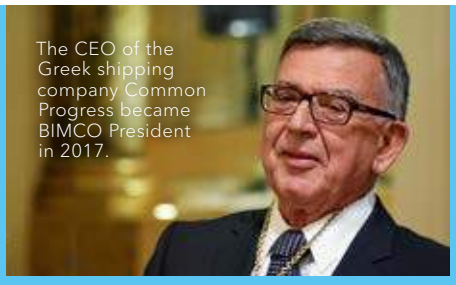
DIGITAL SERVICES – THE GAINS, THE CHALLENGES, THE POTENTIAL

Anastasios Papagiannopoulos, President of the Baltic and International Maritime Council BIMCO, shares some thoughts about the importance of digitalization in shipping.

What needs and challenges shipowners are facing can be fulfilled or overcome by adopting digital services?
Papagiannopoulos: Digital services can bring efficiencies in operation and reduce administrative burden on board as well as on shore. At BIMCO we have been engaged in projects to reap benefits from structured and automatic exchange of information between ships and ports to facilitate port formalities. We see great potential in this area and work is now underway to facilitate agreement on the data elements for such communication.

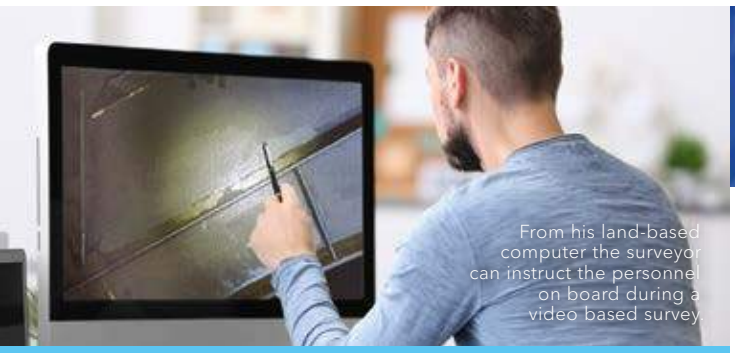
What should shipowners consider now to realize the full potential of digital services for their fleets?
Digital services can be deployed to ships today. They do however require effective communication channels to the Internet. Careful consideration of the connectivity for ships is an important parameter. At the same time, careful consideration of the security of on-board cybersystems is equally important. While harvesting the upsides of a digital transformation, covering the downsides is a necessity. The industry guidelines for cybersecurity on board ships are an important reference.

What has been the most valuable digital trend launched in the maritime sector recently and why?
Remember how we looked at the Internet back in the early 90s. It had some potential, but most of us had no idea about the revolution it would bring about. What I am trying to say is that cheap connectivity is an enabler in itself. We have yet to see what we can make out of it in terms of common platforms and services across the fleet.



The CEO of the Greek shipping company Common Progress became BIMCO President in 2017.

What future services that have not been launched yet would have big potential to succeed?
For many years we have been talking about the concept of a "maritime single window" for exchanging port formalities. So far it is merely a vision. We at BIMCO are confident about the potential of the concept and are working actively to facilitate its implementation. Thousands of man-hours are spent every year on tedious repetitive tasks to satisfy the individual requirements of each and every port in the world. We look forward to allowing our crews on board to do more meaningful work instead.



From his land-based computer the surveyor can instruct the personnel on board during a video based survey.

REMOTE INSPECTION: EYES ANYWHERE

Ship inspection often poses a conundrum: The object may be a fairly straightforward structure or piece of equipment on board, but human eyes are still required to verify its state. Traditionally that means the human doing the verification has to be on board. But that is not necessarily true anymore.

Remote technology is enabling eyes to see the object of inspection from virtually anywhere in the world. Equipped with something as simple as a smartphone app, personnel on board can connect to the surveyor on land, and the survey is underway.

"The surveyor steers the input and evaluates the quality of the data," says DNV GL's Senior Principal Consultant Morten Østby. In other words, the 'cameraman' on board takes instructions from the surveyor on land who acts as the 'director'. One key prerequisite: the surveyor must have actual on-board experience.

"You have to have been there to be able to know what you are seeing," Østby confirms. "But the customer must be willing to cooperate," he adds. "Proof of repair or remediation must be provided." For the time being the technology will be used on occasional surveys, not for certification, and possibly for selected follow-up items when the surveyor has left the ship.

Remote inspection could also be used for certification of materials and components. "The first steps have been taken. Many more will follow," Østby assures.

Photos: ©Africa Studio - stock.adobe.com, BIMCO, DNV GL

says. "We have had to teach the machines to accept compound words and different spellings. We can even teach them to vet incorrect language."

E-certificates in demand

DNV GL has been running pilots on electronic certificates for several years, achieving IMO compliance and winning the endorsement of many flag states, 53 as of 1 April 2018.

"This shows just how fast the technology can be taken into use once it has proved viable," says Østby. "Within seven months after the rollout in mid-October 2017, more than 100,000 electronic certificates have been issued on more than 9,800 vessels in operation, including many class entries and newbuilds, and the number is growing rapidly every day." Customers benefit significantly, says Østby, by being able to share certificates globally immediately upon issue. "Ports, vetting organizations, flag states, charterers, buyers, insurers – everyone wants to see the certificates," he says. "Before, owners and captains had to keep track of the original while sending multiple copies to land. Manual updates were an overwhelming task, and the system was by no means secure. Now the digitally signed original is secure but easily accessible in the Cloud."

Using an e-mail subscription function, each update of an e-certificate or issuance of a new one triggers a notification to all involved parties, with the verified document attached. Documents are accessible through the DNV GL interface, i.e. the fleet status portal. In addition, provisions to carry out authentication/validation checks and access can also be granted via a secure public website, Trust.dnvgl.com, using a unique tracking number (UTN) on the certificate or by sharing temporary access codes generated from the fleet status portal. "All transactions are in keeping with IMO guidelines," says Østby.

The overall response from Flag States to the electronic certificate regime has been positive. "So far more than 85 per cent of the DNV GL fleet is covered by flag acceptance for issuance of statutory certificates on their behalf," Østby confirms. Embracing the new digital reality involves a behavioural change for the stakeholders, he notes, and DNV GL is willing to help those unfamiliar or uncomfortable with digital transactions to familiarize themselves with new methods and learn to trust the system.

Many owners have requested e-certification for all their ships as soon as possible. "Owners see the benefits. Endorsements are verified and completed automatically, complex processes such as frequent certificate updates are automated, and there is no human handling of documents," Østby sums up. "That reduces the quality assurance work to verify certificates, and once they are in the system, they can never be lost."

DNV GL is proud to be leading the fast march toward modernizing classification, bringing efficiency, accuracy, and security to certification and survey booking processes that had remained virtually unchanged for decades, if not centuries. ■ **KG**

Find out more:

on electronic certificates: dnvgl.com/EC

on smart survey booking: dnvgl.com/SSB

on Veracity: veracity.com

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The first-ever deployment of the universal transfer system (UTS) to transfer LNG in Norway on 7 October 2017.

THE LINK THAT IS NO LONGER MISSING

The natural gas industry is looking at a new era in LNG distribution: the Madrid-based global energy company Gas Natural Fenosa and the Norwegian engineering firm Connect LNG have jointly made the world's first floating ship-to-shore LNG transfer system a reality.

LNG is rapidly conquering coastal countries around the world, making clean energy available to ports large and small. A new floating system developed jointly by Gas Natural Fenosa and Connect LNG now offers a convenient, safe and uncomplicated means to transfer LNG from ships to onshore terminals.

During the successful sea launch of the first full-scale and market-ready universal transfer system (UTS) on 7 October 2017, Gas Natural Fenosa and Connect LNG carried out a complete LNG transfer operation from Skangas' LNG carrier *Coral Energy* to the onshore LNG terminal at Herøya, located in one of the largest industrial parks in Norway.

The time from finalization of the detailed design to successful hook-up of the terminal was less than six months. The solution was installed at the Herøya terminal the day after its arrival from the dockyard, and in full operation the next day, exemplifying the rapid deployment capability of the solution.

The patented UTS is a floating solution that replaces the need for cost-intensive and environmentally challenging shoreside and jetty structures. Promising to be a true game-changer, it could rapidly expand the LNG value chain at locations where LNG transfer was previously not possible due to environmental and economic constraints. The UTS is a plug-and-play solution requiring no modifications to LNG carriers.

Safety first with the UTS solution

The UTS seamlessly integrates with safety systems on both the LNG carrier and the onshore terminal. Whether the port is building new capacity or seeking to expand its existing infrastructure, the UTS will work with all cargo handling and safety systems as well as operating philosophies. The platform supports safety systems, including ESD valves, monitoring equipment, ERS, and control systems of any kind, enabling safe connection, transfer and disconnection. In an emergency the UTS can be disconnected and separated immediately without compromising the integrity of any system components.

Separation between the terminal and the LNG carrier reduces collision risks and increases the safety distance from other activities. The system is designed to comply with all relevant rules and regulations and has undergone full offshore classification by DNV GL.

The UTS is a platform-based floating LNG transfer solution that can connect to any LNG carrier. It transfers LNG safely and efficiently from the vessel to the onshore terminal using flexible, floating tubes.

"With their UTS, Gas Natural Fenosa and Connect LNG have launched a system on the market that provides cheaper access to a low-emission energy source," states Johan-Petter Tutturen, DNV GL Business Director Gas Carriers. The UTS is the direct link that will help meet the rapidly increasing global demand for natural gas, especially for power generation in emerging markets.

"We started an innovation journey and here we are today with a game-changing solution that is revolutionary for the LNG industry," says the spokesperson for Gas Natural Fenosa. "From now on there is a market-ready system available that opens a world of possibilities in the small-scale LNG business."

"With Connect LNG's disruptive technology and agile company culture, combined with Gas Natural Fenosa's long track record in the energy market, there was an obvious foundation for collaboration. Leveraging both companies' strengths, the UTS provides access to natural gas where it has not been economically viable in the past," declares Morten Angset Christophersen, Managing Director at Connect LNG. ■

Photos: DNV GL, Gas Natural Fenosa

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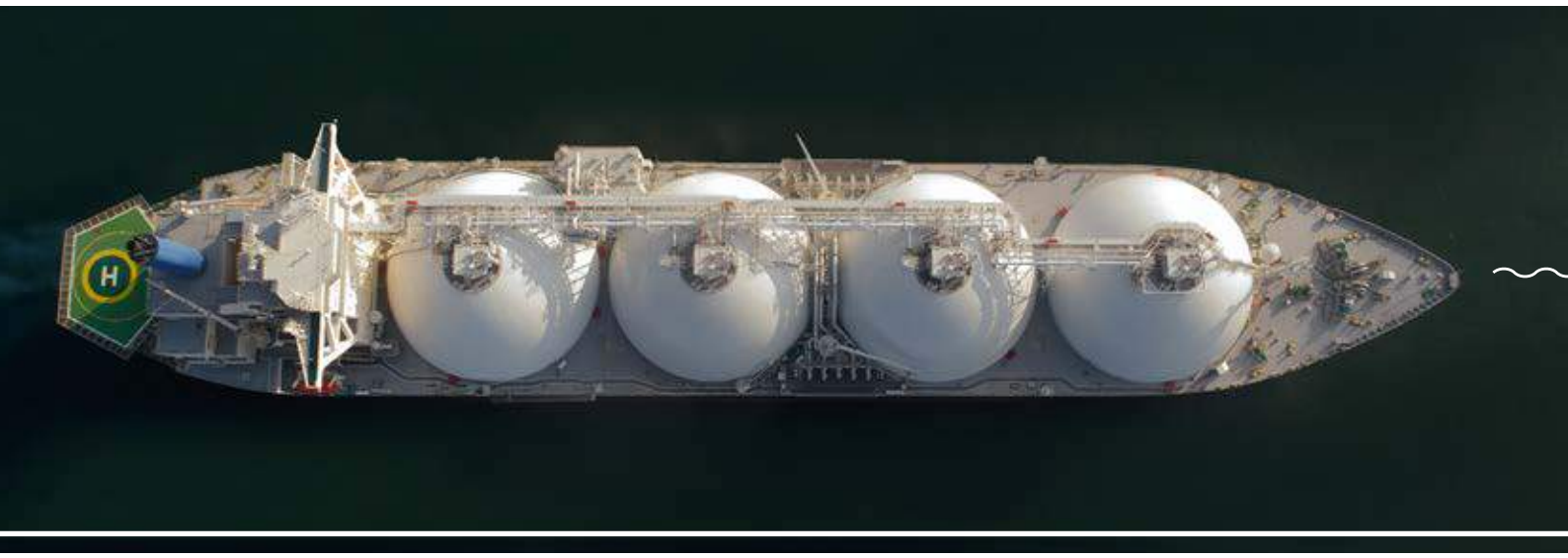
GAS NATURAL FENOSA AND CONNECT LNG

As a pioneer in gas and electricity integration, Gas Natural Fenosa is a multinational group providing energy to nearly 22 million customers in more than 30 countries. The company's operations cover the entire natural gas value chain, from pipelines and liquefaction to storage and regasification through to a fleet of LNG carriers of its own. Backed by this comprehensive expertise, the company is well positioned to play a leading role in addressing the world's future energy needs.

Connect LNG was established on the belief that cleaner and cheaper energy should be accessible worldwide. Based on decades of Norwegian experience with LNG and maritime technology, Connect LNG develops solutions to make this mission a reality.

gasnaturalfenosa.com
connect-lng.no



MRV AND DCS: ON TRACK FOR GREENER SHIPPING

Monitoring fuel consumption and CO_2 emissions is the first step towards significantly reducing greenhouse gas emissions from ships. DNV GL helps shipowners and operators comply with new EU and IMO requirements for energy efficiency management.

Just a few days before the landmark International Maritime Organization (IMO) London conference, the chances of an agreement to control shipping's greenhouse gas (GHG) emissions looked unlikely. But then, ironically on Friday 13 April, the members of the Maritime Environment Protection Committee (MEPC) reached a consensus: by 2050 shipping would cut its GHG emissions by at least 50 per cent from 2008 levels. This was the first time emission targets were set for global ocean shipping.

Commercial shipping is getting greener. Both the EU and the IMO are committed to reducing noxious maritime emissions. However, to get a reliable data basis about climate-affecting exhaust gases, a legally binding framework must be established to collect and evaluate relevant information. To that end the EU, and shortly thereafter the IMO, implemented two similar albeit separate regimes: the EU's Monitoring, Reporting and Verification (MRV) of CO_2 Emissions regulation ((EU) 2015/757), and the IMO's Data collecting system on fuel consumption of ships (DCS).

Streamlined reporting service

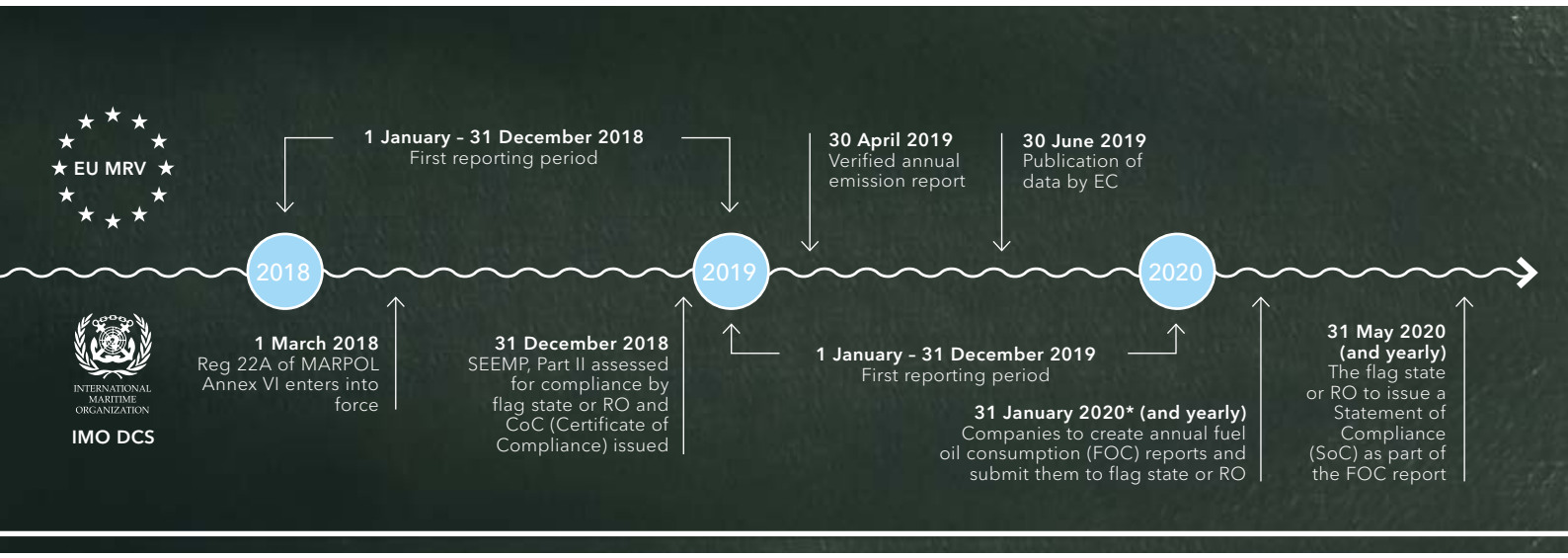
The primary goal of both regulatory frameworks is to monitor maritime fuel consumption and CO_2 emissions. The aggregated information may eventually be used to cut emissions through a fee scheme, such as emission certificate trading. The EU MRV focuses on ships entering or leaving European ports, whereas the IMO system covers emissions from global shipping.

Implementing these regulations is technically complex. DNV GL stands ready to support owners and operators as a reliable and competent partner in both roles: as an accredited verifier for the EU MRV system or as a Recognized Organization (RO) authorized to verify compliance with the IMO DCS on behalf of several flag states. As Sven Dudszus, Head of Section EU Product Certification at DNV GL – Maritime, points out, "DNV GL offers its verification

DNV GL SUPPORTS ITS CUSTOMERS BY:

- **Combining verification** of MRV and DCS – same verifier makes sense
- **Digital reporting** to minimize efforts for the ship operator
- Providing **online tools to:**
  - generate the SEEMP, Part II
  - continuosly verify the completeness of reported data
- **A dedicated interface manager** to support implementation of effective reporting
- Providing **reporting formats** to cover the necessary information for verification
- **Minimizing the need for site visits** and requests for more information
- **Offering a flexible and cost-efficient solution** to ensure compliance with IMO DCS at all times – or EU MRV if applicable (depends on trading patterns; but DCS always applies)

Find out more at: www.dnvgl.com/maritime/imo-dcs



service independently from a ship's classification society to make the process as smooth as possible. For practical purposes we recommend using the same verifier for EU MRV and IMO DCS. If a customer uses another class society for statutory certificates, the flag must accept that another RO is used for DCS."

In effect since 31 August of last year, the MRV regulation requires shipowners to submit a Monitoring Plan, a complete and transparent description of the method used to determine the CO_2 emissions of each vessel from 5,000 GT upwards, similar to the IMO scheme. "All in all some 10,000 ships with continuous EU trades are subject to the EU MRV," says Dudszus. DNV GL has prepared roughly 50 per cent of these documents to date. "This is a great mark of confidence on the part of our customers who benefit from the fact that we are the only verifier in the market to offer the plan review and the emission report for a specified time period as a single-package solution."

Ensuring data integrity

The first MRV reporting period started at the beginning of this year. The aggregated ship emission and efficiency data will be published by the EC every year, starting on 30 June 2019. The IMO DCS process will be launched in January 2019. By that time every ship must present proof of the applied method; the IMO stipulates an updated SEEMP, Part II. The RO or flag state will issue annual DCS statements of compliance to shipowners by 31 May.

DNV GL will provide an electronic reporting form through the My Services customer portal in Veracity. Customers can then submit the completed form to DNV GL for approval of SEEMP Part II. To minimize the effort involved in the reporting process for shipowners and operators, DNV GL covers both the EU MRV and the IMO DCS processes in one tool. Single-source data verification for both annual emission reports is the most common-sense approach, especially for vessels operating on both European and non-European global trades, or changing their region of deployment. Ships can use existing infrastructure on board to capture some of the required information, such as fuel consumption data which is routinely collected anyway.

Data plausibility is checked in a fully digitalized process, making sure the content and reporting parameters comply with the EU and IMO rules and requirements. Data integrity is of the essence. Since many performance and status data points cannot be read electronically but must be logged manually, errors can occur. DNV GL provides specialized tools to help customers check the information prior to transmission.

Defining an interface is all that needs to be done to enable transfer of the data. "We have appointed an Interface Manager who will assist customers in implementing an effective reporting system upon request," says Dudszus. The choice is between automated system-to-system data uploads or manual transmission of fuel consumption data. DNV GL customers subscribing to the ECO Insight service are already covered for their MRV and DCS reporting duties.

DNV GL recommends customers to report their data throughout the year instead of filing a cumulative report at year's end. This will allow DNV GL to perform continuous data quality checks so that by the end of the year all data have been screened for completeness and plausibility.

Operators can upload the annual emission report to the EMSA THETIS database stipulated by the EU, which will be verified by DNV GL. The DCS data will be uploaded to the IMO database either by DNV GL as a designated RO or by the flag state.

DNV GL verifies the data received, whether overall fuel consumption data, log abstracts or fuel balance details (e.g. bunker delivery notes), in an automated process, avoiding time-consuming visits at the ship manager's office for verification or physical documentation. "Our processes will be optimized continuously. Working closely with our customers we will provide the smartest solution in the market," says Dudszus. ■ **PL**

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Achieving the best performance for the future with today's technology was the objective of the LNGreen project.

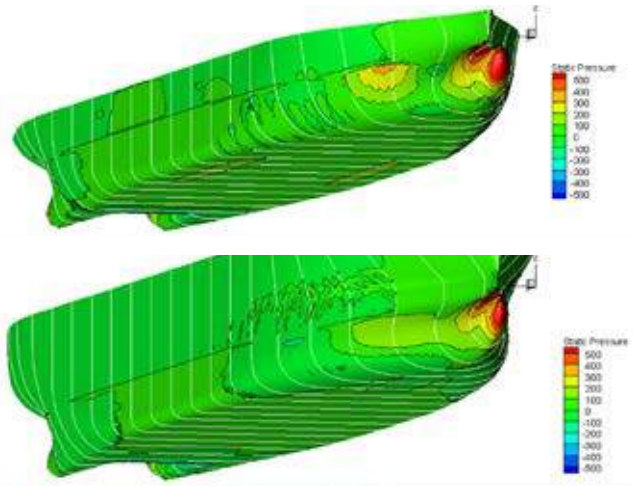
LNGREEN: SHARING THE WAY

Established to develop tomorrow's LNG carrier through innovative use of today's technology, the LNGreen joint development project is now drawing to a close.

Project partners DNV GL, Hyundai Heavy Industries (HHI), Gaztransport & Technigaz (GTT) and shipowner GasLog achieved significant improvements in LNG carrier design and efficiency in Phase I, focusing on hull hydrodynamics, cargo volume, reduced boil-off, and overall machinery and system efficiency. Compared to the base case, studies proved that an overall energy consumption improvement of approximately eight per cent depending on operating condition could be achieved.

Phase II was dedicated to further enhancing optimization potential and verifying results, including an increase of 25 per cent in operational efficiency from partial re-liquefaction, and a validation of the findings from LNGreen I for technologies such as dual-fuel auxiliary engines with economizers.

"Joint development projects (JDPs) are where we try out new ideas," says Phase II Project Manager Daniel Nordås, Hydrodynamic Engineer at DNV GL Maritime Advisory. "Phase I delivered a lot of innovation, and we used Phase II to validate and refine these concepts, but also to encourage further investigation of potential uncovered in LNGreen."



Before-and-after graphics showing the results of a hull pressure distribution optimization study performed by DNV GL.

Open to improvement

The project focus was to combine accessible technology and existing knowledge in new ways, and that in itself required an innovative approach to sharing. "This particular way of working together required a different mindset," says Nordås. "Compared to a typical JDP, there was more open discussion and sharing of knowledge. Each potential innovation was discussed freely."

One notable example was the sharing of data and methodology. "Partners typically do not want to disclose the specifics of how they work, as this is their competitive advantage," Nordås says. But in LNGreen, GasLog sent operational data to HHI and engaged with the yard in the design process, and DNV GL cooperated with HHI on advanced analyses such as added resistance in waves, in order to provide a more robust platform for design discussions and innovations.

"DNV GL's primary role was to assure smooth cooperation between the partners, with a focus on finding new ways to use

existing technology," Nordås relates. "We provided design verification services and acted as a sparring partner, discussing both practical and technical matters, and potential class and regulatory issues."

Representing tank design and manufacturing in the project, GTT has their own takeaway: "It is always a plus to have cooperated closely with leading industry partners, but in LNGreen we also gained valuable insight into shipowners' requirements and priorities," says GTT CEO Philippe Berterottière. "This further strengthens our credibility in future dealings with both yards and owners."

GasLog's motivation for participating in LNGreen was to discover and explore improved and innovative design solutions for the future LNG vessels, says a GasLog representative. "HHI was very accommodating in exploring new options to satisfy the project's needs. HHI and GTT worked very closely together, and DNV GL contributed by validating technology and assuring compliance with class rules. All these efforts helped move the discussion forward."

Sharing the benefits

Hyundai Heavy Industries also confirms their satisfaction with the overall results: "HHI is pleased with the good cooperation established between all partners in the LNGreen project. The partners have shared knowledge in new ways and achieved innovation that will benefit LNG shipbuilding and transport for many years to come," says Project Manager Bumwoo Han from HHI.

Johan Petter Tutturen, DNV GL Business Director Gas Carriers, sums up: "LNGreen provided innovative insight into gas carrier design and operations, but the project also laid the foundation for increased trust and sharing between the partners. Now we look forward to sharing the benefits of all our efforts with the gas carrier industry." **KG**

Photos: DNV GL

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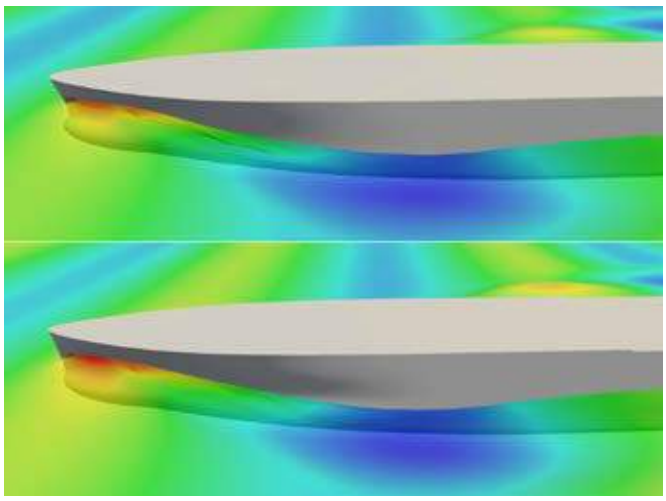
LNGREEN RESULTS

MAXIMIZE HYDRODYNAMIC PERFORMANCE
- 2.5 per cent hull resistance improvement
- Hull form optimized for reduction of added resistance in design waves
- Twisted rudder, rudder bulb, positive indication of efficiency improvement with high-efficiency propeller

MAXIMIZE CARGO VOLUME AND MINIMIZE BOIL-OFF
- 5 per cent increase in cargo volume (182,800 m^3 vs 174,000 m^3)
- Boil-off rate reduced to 0.085 per cent per day without change of insulation type (vs 0.09 per cent/day)

INCREASE OVERALL MACHINERY AND SYSTEM EFFICIENCY
- 6 per cent increase in efficiency compared to DFDE base case
- Validation of the two-stroke option as most efficient
- Consideration of mechanical energy saving devices (ME and AE economizers, shaft generators, dual-fuelled auxiliary engines)
- Application of reliquefication unit



Hydrodynamic analysis demonstrating hull behaviour in short waves. These investigations are essential for hull efficiency improvements.

SAFER, SMARTER, GREENER

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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.