THE NAVAL ARCHITECT

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Editor: Richard Halfhide
Editorial Assistant: Sophie Collingwood
Production Manager: Nicola Stuart
Advertisement Production Manager: Stephen Bell
Subscriptions & Publications Manager: Tasharna Francis
Publisher: Dmitriy Ponkratov

Advertising Sales: J P Media Services
Email advertising: jpayten@jpmediaservices.com
Telephone: +44 (0)1737 852135

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The Royal Institution of Naval Architects
Editorial Office:
8-9 Northumberland Street
London, WC2N 5DA, UK
Telephone: +44 (0) 20 7235 4622
Telefax: +44 (0) 20 7245 6959
E-mail editorial: editorial@rina.org.uk
E-mail production: production@rina.org.uk
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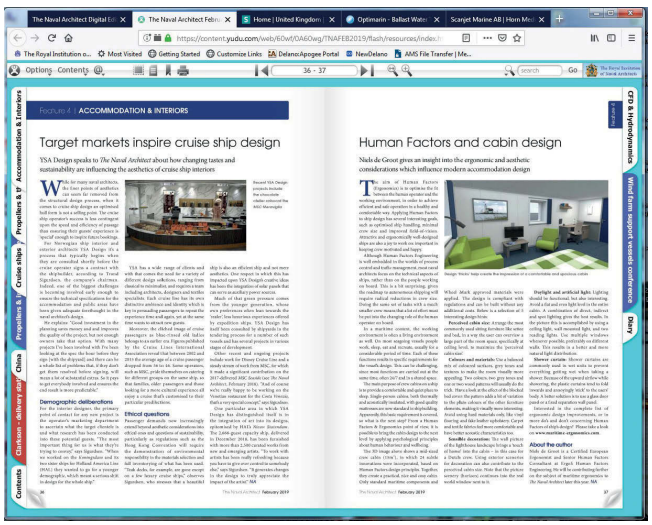
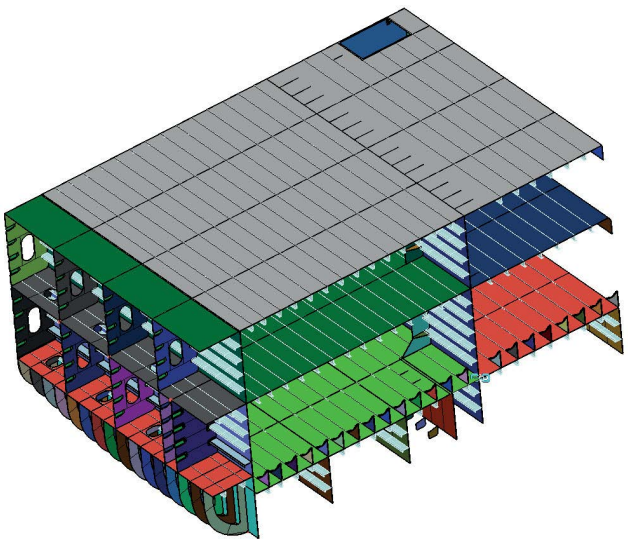




Disruption, with a capital 'D'

Could cargo drones, such as the Sabrewing concept, fly in on the disruptive slipstream of Covid-19?

What a difference a month makes. It doesn't seem so long ago I was making plans for a visit to Tokyo to attend the Sea Japan trade show, only for that event to be cancelled. Then, a trip I was scheduled to attend from London to Oslo, onboard Hurtigruten's latest expedition ship *Fridtjof Nansen* bit the dust, as did a number of other press briefings here and in Europe that *The Naval Architect* team were due to attend. Barely two weeks ago, with the streets of central London looking increasingly empty, the decision was taken to close the RINA offices indefinitely and adopt a 'work from home approach'.

So this edition of *The Naval Architect* is somewhat unique (at least until next month) as it's been produced almost entirely remotely and in something of an improvisational spirit. While these may be (as we're constantly reminded) unprecedented times, one of the most striking things I've noticed is how quickly we learn to adapt to changed circumstances, particularly with the enhanced communication tools at our disposal nowadays.

Webinars, I can tell you, have quickly become very popular with maritime PR companies, perhaps realising that it's actually easier to persuade a bored, self-isolating journalist to listen in online than attending yet another awkward social function at a London hotel or conference centre.

But, more than that, it perhaps serves as a salutary reminder that we could live our lives in a way that puts far less strain on the Earth's resources. Like me, many of you have probably seen pictures or read stories of how greatly reduced energy consumption and air pollution have been over the past few weeks. Admittedly with that has come a massive decline in business – not to mention restriction of our liberties – that we will be feeling the consequences of for many years to come, but if some part of that could become assimilated into our daily lives it could only help in limiting climate change.

Reluctantly, I suspect we will have to accept that efforts to contain global warming will take a backseat to kick-starting the world economy in the aftermath of Covid-19. As a publication that focuses upon ship design and maritime technology, it would be remiss of us not to remain focused on the ongoing efforts to improve efficiency and the development of greener alternatives.

At the same time, it will be interesting to watch whether some of the more idealistic future technologies can continue to compete with more pragmatic options in a straitened financial climate. In that context, something like CE Delft's study for pro-gas lobbyists SEA/LNG on the scalability and availability of bio- and synthetic LNG (p21) comes across as very shrewd rhetoric; zero-carbon methane might be possible, if there is sufficient investment in infrastructure and enough renewable electricity to go around, but at least you'll still have the safety net of fossil methane.

A somewhat more radical vision of the post-virus world was presented by Paul Cuatrecasas, the founder and CEO of London-based technology acquisition advisors Aquaa Partners, who believes the transportation and logistics sector could be on the cusp of massive disruption in the form of autonomous cargo drones (p17). I found Cuatrecasas's argument undermined somewhat by his limited appreciation of the full scope of international merchant shipping; while it may be possible for autonomous air freight to claim some share containerised shipping, it's clearly never going to be viable (or desirable) to transport dry or wet cargo in this manner.

What was more interesting, especially in terms of how Covid-19 may influence the argument for more localised manufacturing and production versus global trade, was the future role of 3D printing and how that might influence the types of materials being transported in the future. He also made some illuminating comments about how other sectors have tried to assimilate new technologies, particularly the role reversal that occured with General Motors' acquisition of autonomous car specialists, Cruise.

Some readers may feel that, as subject matter goes, it's a little 'off topic' for this magazine, but the argument that shipping is different to other industries can also seem like recalcitrance. I've argued before that the traditional pre-eminence of the shipyards could, perhaps should, be challenged by the marine technologists. Maybe this is something that will change as and when Chinese shipbuilding becomes less dependent upon European equipment providers (p12).

In closing I'd like to wish readers and their families the best of health during this troubling time. Our plan is for publication to continue as usual over the next few months and hopefully normality will be restored sooner rather than later. I would also like to take this opportunity to remind you we always welcome your comments, suggestions and contributions about what you would like to see covered in the magazine. *NA*

Wind power

ABB tech aboard Japanese wind turbine vessel

Japan's first self-evaluating super-size wind turbine installation vessel (WTIV), which will support the country's offshore wind sector, will be supplied with ABB's advanced power and control technologies.

ABB's technology uses a closed ring configuration for the ship's dynamic positioning operations, which it says enables safe and predictable performance in the event of a power plant fault.

The company adds that its solution, on either newbuilds or existing ships, provides the vessel with increased resilience to network disturbances as well as protection against power loss.

As part of ABB's supply package, it will oversee the delivery and system integration of generators, a high voltage switchboard system, variable speed drives and motors for main propulsion and bow thrusters, and its Power and Energy Management System (PEMS).

The WTIV will also have access to ABB's Ability Remote Diagnostic Services for Marine, a network that predicts maintenance and plans interventions based on remote equipment monitoring and data analytics. The system also provides remote technical assistance, supported by seven shore-based ABB Marine & Ports' Collaborative Operations Centers. The company states this is part of its 'Electric. Digital. Connected.' vision to equip the marine industry with electric, digital and connected solutions for more efficient and sustainable ship operations.

Due for delivery in 2022, the 28,000gt WTIV will be built by Japan Marine United (JMU) for engineering company Shimizu Corporation. The ship is capable of transporting and installing seven 8MW wind turbines per voyage and will operate in water depths between 10-65m.

ABB says that the 142m newbuild's lifting and carrying capacity will be the greatest available on a WTIV to date, which at maximum strength is capable of lifting to 158m using a 2,500tonne crane.

Shimizu Corp.'s wind turbine installation vessel

LPG

LPG reformed gas fuelled carrier given AiP

Daihatsu Diesel has received an Approval in Principle (AiP) from classification society ClassNK for its concept design of an LPG reformed gas-fuelled, coastal LPG carrier.

ClassNK has based the approval on its Rule Part N, which adopts the International Gas Carrier (IGC) Code and the society's own Guidelines for Ships Using Low-Flashpoint Fuels, outlining the safety requirements for viable alternative fuel groups such as ethanol (ethyl), methanol (methyl) and LPG.

According to Daihatsu Diesel's design, the vessel is equipped with its dual fuel engine as well as an LPG reformer, which is a joint development by Daihatsu Diesel and Osaka Gas. The product's other contributors, including Iino Gas Transport, Izumi Steel Works and Miura Shipbuilding, assisted with both development and safety assessments. Shigeki Kinoshita, President of Daihatsu Diesel says: "We have developed dual-fuel engines from the viewpoint of global warming prevention, and this LPG reformer will provide more options for customers."

LPG is difficult to use in both lean burn and duel fuel engines as it is primarily made of propane and butane and is liable to abnormal combustion (knocking). The LPG reformer in Daihatsu Diesel's design converts LPG into a synthetic methane gas, equivalent to the kind found in LNG. As this conversion process will take place prior to fuelling the engine, ClassNK believes that the risk of knocking is reduced, and it expects that the LPG design will perform as well as an engine operating on LNG fuel.

"We have cautiously confirmed the design's safety and are proud to be involved with this project. LPG is starting to become an option in the maritime industry, and we have high expectations for the possible benefits that its use may bring in terms of environmental safety and efficiency," says Toshiyuki Shigemi, senior executive vice president at ClassNK.

Sea traffic management

Maritime consortium takes on STM ecosystem

Industry consortium Navelink, a non-profit group founded in December 2019 by Kongsberg, Saab and Wärtsilä, will oversee the Sea Traffic Management (STM) ecosystem.

During a STM conference last year, plans were announced to implement a global STM infrastructure, which has since been developed through a series of STM

projects. Navelink's contract will run until the end of the pre-existing STM projects, which at minimum will last until July 2021.

According to Kongsberg, the aim of the consortium is to reach a new global standard, enabling scalable maritime information exchange. During the next 18 months, Navelink has plans to allow the first three projects to use its system to authenticate users and identify operational services.

All three projects, EfficientFlow, RealTimeFerries and STM Balt Safe, are EU-backed and Navelink has appointed the Swedish Maritime Administration (SMA) to provide the projects' infrastructure solutions. The cooperation between these projects and the industrialised, open ecosystem infrastructure is the first of its kind.

Technical consultancy company Combitech, which will deliver the infrastructure and operations for Navelink, states that although the potential of a globally standardised digital infrastructure is huge, it relies on incremental advancements and successful partnerships. "In order to succeed, we need to be humble and develop this step by step in close cooperation with relevant authorities, partners and other actors," says Anders Wendel, head of Navelink at Combitech.

Cyber security

Lloyd's Register issues cyber certificates

Greek shipping company, Almi Tankers, has received ISO 27001 certification by Lloyd's Register (LR) for its Information Security Management System (ISMS). According to Almi Tankers, receiving the ISO 27001 certification is an important step in establishing its ISMS, which also abides by EU General Data Protection Regulation (GDPR) guidelines.

It is one of the first Greek maritime companies to receive the ISO 27001 standard, which LR states is a certification of best practise for ISMS. "An organisation that is certified has been through a rigorous independent audit process and demonstrated its ability to meet the stringent requirements of this standard," says Phillipa Charlton, marketing director at LR. The classification society adds that Almi Tankers continues to improve its services and processes and has previously been awarded ISO 9001, ISO 14001 and ISO 45001 certificates for its products.

Wärtsilä has received system-level cyber security certification from the classification society for its integrated main and auxiliary machinery's network architecture. The technology company has also been awarded LR's ShipRight SAFE AL2 certificate for its Data Collection Unit (WDCU), as well as Approval in Principle (AiP) for Wärtsilä's entire integrated system network, which is one of the first of its kind globally.

"This certification validates Wärtsilä's work in mitigating cyber security risks with the appropriate controls in the integrated system, when collecting and sharing operational data. The knowledge that these systems are cyber secure provides customers with the assurance that they are safe to use," says Jonas Blomqvist, general manager, cyber security, marine business at Wärtsilä.

Lloyd's register certification validates Wärtsilä cyber security measures

Efficiency

Consortium investigates future of EEDI

A consortium of classification society ABS, Vessel Performance Solutions (VPS) and Arcsilea has received EU funding for its study into the future of the Ship Energy Efficiency Design Index (EEDI).

Titled 'Decarbonisation of Shipping: Technical Study on the future of the Ship Energy Efficiency Design Index', the study will investigate the EEDI's ability to deliver improved designs and its relationship with a range of technologies.

With aims to retrieve preliminary results before October 2020 and full investigations to go ahead in early 2021, the study also intends to propose updated targets, accelerate the deployment of low carbon solutions, and advise on how to integrate new technologies.

Georgios Plevrakis, director of global sustainability at ABS, says: "The consortium members collectively bring a wealth of knowledge and experience on regulatory design construction, operations and safety." According to Arcsilea, the company will provide its experience in ship design and implementation of EEDI for RoRo, RoPax and cruise ship sectors. Whereas Denmark-based VPS says its contribution is long-standing knowledge of the relationship between design and operational performance of vessels. *NA*

Correction

In March's edition of *TNA*, in the article entitled 'Stena calls out 'ageist' tanker market' we wrongly stated that BP Shipping has an upper age limit of 400 years for LNG carriers that it charters. This was, of course, a typing error and the correct age limit is in fact 40 years. The editorial team regrets any confusion caused.

Covid-19 continues to disrupt shipping across all areas

Malcolm Latarche follows up on the continuing effects that the global Covid-19 pandemic is inflicting on the shipping industry throughout every sector

When last issue this column looked at some of the early ramifications of Covid-19, including the plight of the *Diamond Princess* and the effect on installing scrubbers and ballast water systems, the situation that has developed a month later could hardly have been imagined. Today, most of the world is in some form of lockdown or another and normal life has been put on hold everywhere in Europe, Asia, the US and Oceania.

Ships are still operating where there is cargo to carry, but the slowdown of economic activity and a price war on oil means that the cost of crude has collapsed to levels below those experienced in 2015/16. This has seen tankers again being used for floating storage – providing work for the ships themselves despite there being precious little movement of cargo.

The falling oil price has also seen the differential between HFO and VLSFO bunkers fall to as low as US$50 per tonne, which has at least benefitted those owners unable to get their scrubbers installed.

However, this was not of much use to *MSC Joanna*, a 2006-built 9,178teu box ship, as the ship's owner was planning to fit a scrubber but work was delayed due to lack of yard space. In anticipation of having a scrubber, the owner had left some HFO onboard but sealed the tank due to the IMO ban on carriage of non-compliant fuel that came into effect in March. Maybe that was a mistake, as when calling at the Jebel Ali Port, UAE, the ship was boarded by the authorities and promptly banned from operating in UAE waters and ports for the duration of one year. The master has also been banned from working on any ship calling at UAE waters or ports and may have legal action taken against him.

After the problems with *Diamond Princess* and several others, cruising has been suspended in all but a few areas following several outbreaks of the virus onboard and hostile receptions for ships calling at some ports. Panama has even banned the transit of ships with cases of the disease onboard. Bulk cargoes have been little affected so far, but container lines have blanked sailings and volumes are down. Specialist ships such as car carriers are also affected with one owner, Wallenius Wilhelmsen, having laid up ships and announced some demolitions.

Ships' crews have been particularly hard hit in reaction to the virus as they are mostly denied shore leave and crew changes have been made extremely difficult to arrange due to quarantine restrictions and lack of flights generally. While no major problem has been made public there are anecdotal reports of difficulties in obtaining supplies at some ports.

The three leading PSC authorities – Paris MoU, Tokyo MoU and the USCG have issued advice and allowed some dispensations in troubled times and classification societies have been increasing remote survey activity. DNV-GL reported in late March that it had completed 15,000 remote surveys since introducing them in October 2018.

Other impacts on shipping have seen several major events, including Sea Japan and Seatrade Cruise Global, cancelled and Posidonia and CMA postponed until later in the year. On the regulatory front, the IMO has been obliged to postpone several committee and sub-committee meetings including MEPC 75 and MSC 102 and has effectively shut its headquarters as staff join many in shipping companies around the world working from home.

Postponed IMO meetings and the immediate problems in dealing with a real emergency seem to have combined to push events around decarbonisation and greenhouse gases out of the headlines and perhaps off the agenda of shipping bodies. Certainly the amount of financial support being given by Western governments to all industries and citizens will have a very long term effect on the economies of countries and recovery from that will inevitably take priority.

The US support package alone is calculated at over US$2 trillion and more may yet be needed. Some experts have calculated that the effect on the world economy will make the 2008 economic crash look small by comparison. The cost to the greater society and other industries may make shipping's loss seem quite small by comparison but it is a fair bet that for several years from now, rebuilding the world economy will be the focus of attention of governments around the globe.

Some analysts have speculated that the concept of globalisation could itself be threatened and say that governments will be keen to see less reliance on imports and more local production, especially of essential goods and equipment. Whether that will happen or not remains to be seen, although the general public does seem to be calling for countries to have the ability to respond to emergencies better than they have to this. *NA*

Sat Comms

i4sea joins Inmarsat's certified application providers

Satellite communications provider Inmarsat has signed up Brazil-based company i4sea to become a dedicated application provider for its IoT Fleet Data service.

i4sea will supply Inmarsat's Fleet Data with Atm Ocean, an application that calculates ocean and weather hyperlocal forecasts up to seven days in advance. The company's application offers six integrated tools, which also provides dynamic draft prediction, terminal efficiency analytics, and prediction and analysis of siltation or erosion dynamics of the seabed.

"As a certified application provider, we will be constantly developing new features to generate increasingly powerful tools for the maritime market. This is the first smart system that integrates, in a single platform, all the essential tools to support decision making regarding vessel manoeuvres and port terminals' operations," says Bruno Balbi, CEO at i4sea.

Inmarsat's Fleet Data extracts and pre-processes information from sensors onboard vessels, then uploads onto a centralised cloud-based database. The platform is equipped with a dashboard and an Application Programming Interface (API), which the company says can easily navigate the service's collated data and provides easy customisation and analysis for customers. Inmarsat claims that its Fleet Data can improve operational efficiency and increase performance and benchmark data across a single vessel or fleet.

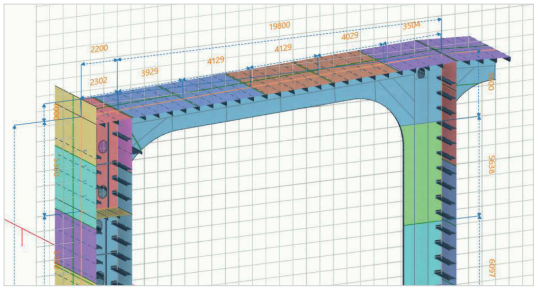
The collaboration between Inmarsat and i4sea is one of 20 start-up and maritime market leader partnerships brought together by the Bluetech Accelerator program. Created by the Portuguese Ministry of the Sea in 2019, Bluetech Accelator aims to create an ecosystem of maritime innovation and business acceleration, and i4sea is the only Latin American start-up selected.

CAD/CAM

3D model-based approval proves feasible

A feasibility study of a 3D model-based plan approval (3D MBA) completed by Napa, ClassNK and Japan Marine United Corp (JMU), concludes that information needed for class approval can be successfully confirmed using a 3D CAD model.

The joint project was established to evaluate the technical improvements needed at each stage of plan approval in order to realise practical use of the 3D MBA. Classification society ClassNK ran the trial evaluation of a hull structure design, based on a 300,000dwt ore carrier modelled in 3D CAD. JMU designed the model using Napa Designer to view it digitally, a 3D CAD software application created by data analytics company Napa that can view and evaluate 3D ship designs. In addition, Napa's electronic examination system, NK-PASS, was used for plan submission, storage and notifications of the test's results.



Trial of 3D model-based approval using Napa designer

ClassNK notes that the results of the survey will be the foundations for further technical studies and will eventually realise 3D model-based plan approval. According to Napa, this approval comes during a gradual transition period from using 2D drawings to models created in 3D CAD software. The company believes that this approval could lead to faster, easier approvals and, in the future, commercial digital twin applications.

"3D model-based approval is an essential part of naval architecture's future. By continuing to rely on 2D drawings the sector wastes hundreds of thousands of manhours each year, as well as increasing the likelihood of avoidable errors in their designs," says Tapio Hulkkonen, design solutions director, product management, Napa.

Ballast water management

Bawat BWMS receives USCG type approval

The United States Coast Guard (USCG) has given type approval to Denmark-based technology company, Bawat, for its ballast water management system (BWMS).

Bawat's technology kills aquatic organisms found in ballast water through heat pasteurisation, a process unlike other treatment systems as it functions without the use of chemicals, filters, ultraviolet light or electrolysis systems.

According to Bawat, its product is the only BWMS that works with only one pass of the ballast water through its system. The company adds that this is both time saving and cost effective as it eliminates the need to treat water during loading and discharging, which shortens the vessel's time in dock.

Moreover, the pasteurisation process utilises the ship's waste heat, instead of relying on additional electricity created onboard. "So, the Bawat system is not only truly green but also offers almost zero operating costs. All other systems require vessels to generate additional power, thus having high operational costs," adds Marcus Hummer, chief executive at Bawat.

Bawat's BWMS has also received type approval according to updated standards set by IMO in late 2019. As one of the few BWMS's with both type approvals, Hummer claims that the technology will give customers more flexibility in the future.

"Most shipowners seek cost effective systems that have both the IMO type approval and the more stringent USCG type approval to gain the reassurance that the technology works, and their vessels can remain compliant of both international as well as local rules. A vessel without USCG type approval, even if not operating in US waters immediately, would certainly lack future flexibility to do so," adds Hummer.

Engines

MAN Energy Solutions wins Finnish order

German manufacturer MAN Energy Solutions will supply its engines for the Tallink Group shuttle ferry, *MyStar*, which will be built by Rauma Marine Constructions (RMC) in Finland.

Scheduled for delivery in early 2022, MAN energy solutions' diesel-electric plant comprises five MAN 51/60DF duel-fuel main engines, which will primarily run on LNG. The MAN engine converts liquid fuel (diesel) or natural gas into electrical power, which the company claims can be used in different applications with a range of fuels while fully loaded. Additionally, MAN states that the engine can switch between gas to liquid fuel without any output and speed fluctuations.

Upon its completion, *MyStar* will be RMC's largest build to date, 212m long with a gross tonnage of 50,000dwt and capable of accommodating 2,800 passengers. The newbuild will operate in the Tallinn – Helsinki route and is the second order for MAN's 51/60DF engines for vessels operating in the Baltic within the last year.

"With this new order, we are really putting the 51/60DF – and MAN engines in general – in the shop window at a time when the Finnish market has many interesting projects underway," says Lex Nijsen, head of four-stroke marine sales at MAN energy solutions.

MAN will also supply German shipping company TT-Line's 230m long Ro-Pax ferry with 51/60DF engines, which will be built by Jinling Shipyard in China and is also due for delivery in 2022.

LNG

Wärtsilä supplies LNG propulsion system for BC ferries

Canada-based shipowner BC Ferries has contracted Wärtsilä to supply an integrated propulsion system for its newest Salish Class vessel, which will be built by Remontowa Shipbuilding (RSB) in Gdansk, Poland. The 107m long ferry is designed to carry 600 passengers and crew, as well as up to 138 vehicles, and will operate between Vancouver city and ports on Vancouver Island.

Wärtsilä's technology comprises an LNG plant, duel-fuel engines and an electrical propulsion system. The equipment, scheduled for delivery in Q3 2020, includes three LNG-operated Wärtsilä 20DF dual-fuel engines and a Wärtsilä LNGPac fuel storage, supply and control system, as well as its power distribution system, Low Loss Concept (LLC). According to Wärtsilä, its LLC technology provides higher efficiency, less weight and volume, and high system redundancy.

The company have previously supplied propulsion systems for another three LNG-fuelled Salish Class BC Ferries, also built by RSB, and received this latest order in January 2020. Additionally, in 2018, Wärtsilä upgraded two BC Ferries' Spirit Class vessels to operate with LNG fuel.

"The decision by BC Ferries to again select RSB as the yard, and to opt for Wärtsilä's proven and well-established LNG propulsion technology, provides clear confirmation of the efficiency of Wärtsilä's integrated solution concept," states Wilco van der Linden, director of business development, ferry industry at Wärtsilä. *NA*

BC Ferries' Salish Class vessels featuring Wärtsilä's integrated propulsion system

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Chinese shipyards' uncertainty over post-Covid19 schedules

China's shipbuilding industry is returning to work following the Covid-19 outbreak, but what measures have been taken by the country's major shipyards?

China's shipyards believe it's possible to catch up and remedy the month's backlog, providing that it can rely on its staff working overtime. However, shipbuilding is a global industry dependent on multiple stakeholders and, with the pandemic wreaking havoc worldwide, Chinese shipyards are faced with many uncertainties.

On 7 March, an offshore FPSO built by Waigaoqiao Shipbuilding, affiliated to CSSC, was successfully undocked

Return to work intensifies

Aside from Hubei province, most of China's shipyards resumed production on 10 February. At that time, China's Covid-19 situation remained uncertain and despite each shipyard resuming work, the initial rate of workers returning was generally less than 50%.

Take, for example, Shanghai's three large-scale shipbuilding companies: Jiangnan Shipbuilding Group, Hudong Zhonghua Shipbuilding and Shanghai Waigaoqiao Shipbuilding. The total number of employees for all three shipyards combined exceeds 6,000 workers, and each company still experienced a workforce shortage in which a large number of employees remained abroad, and upon their return to Shanghai were obliged to self-isolate at home for 14 days before returning to work. Moreover, the shipyards have spent a lot of manpower and material resources on staff placement.

Fortunately, due to the efforts of all sectors of society, shipping companies and employees, China's shipyards have not reported an emergence of Covid-19 in returning employees. Shipbuilding companies in Hubei province, including those in Wuhan, are gradually loosening their working restrictions and the majority of shipyards across China are entering into a 'production acceleration period'.

A production and operations supervisor at Jiangnan Shipbuilding commented that, in order to recover lost time, the company organised production and distribution departments to carry out detailed sorting in February. Products under construction were divided into three ranks; key, important and general. According to a company representative, Jiangnan Shipbuilding is taking part of its second rank's production capacity and feeding it into the production of the key products under construction.

"This epidemic has had a huge impact. We should first ensure that business will not collapse in the first half of the year, and then seize the overall progress through policy incentives, management organisation and other ways in the second half of the year," the representative added.

It has been reported that in the first half of the year, Jiangnan Shipbuilding has plans to deliver an 84,000m³ VLCC and a 28,000m³ LNG-FRU. At present, both vessels are in their critical phase and the VLCC will set off for its sea trials on 21 March.

When faced with the vessel delivery, the specific choices of each Chinese shipbuilder are different. From the outside world looking in, Waigaoqiao Shipbuilding has a seemingly bold approach. On 11 February, China's second day following official work resumption, the company trialled two 210,000tonne bulk carriers. Despite the company undertaking detailed personnel screenings and emergency plans, it faced great social pressure when it announced its trial plans. However, on 12 March, the two vessels were delivered to their respective owners in South Korea and Greece on the same day.

Since Waigaoqiao Shipbuilding resumed work, it has completed the construction of a 114,000tonne Aframax oil product tanker, a 210,000tonne Newcastlemax bulk carrier, and a 180,000tonne Capesize bulker. The company also completed the sea trial for another 180,000tonne Capesize, delivered a JU2000E offshore jack-up drilling platform, and signed the completion of a PSV and the construction contract for two 156,000tonne Suezmax tankers. Taking their lead from Waigaoqiao, Chinese shipyards are attempting to show global shipowners that the impact of the pandemic on China's shipyards' production is controllable.

Matching issues

But the country's shipyards have less control when confronted with supporting enterprises and service providers. Urging the timely supply of domestic supporting

facilities is dependent on knowledge and unity, and whether foreign supporting facilities will be able to keep up with the demand is uncertain.

A representative of the China Shipbuilding Industry Economic and Market Research Centre's has said that over the next two to three months, the industry's supporting companies in Hubei will be directly affected by the pandemic, and it will take five to six months to digest the impact of the virus after returning to work. In the wake of Hubei companies resuming production, closing the gap left by Covid-19 is only a matter of time. However, outside of Hubei province, there is a severe shortage of supporting companies for shipping.

In early March, an employee responsible for supporting facilities at Jiangnan Shipbuilding expressed their concerns for the continuous supply of outfitting parts. The company's outfitting parts mainly come from businesses located in the Jiangsu and Zhejiang provinces. However, at that time, these supporting companies experienced problems due to difficulties reinstating foreign employees, a lagging supply of equipment and a low return rate of personnel. All of which directly affected the production flow of the company's general assembly plant.

It is reported that Jiangnan Shipbuilding is coordinating the production plans of its various suppliers and encouraging companies with a high rate of returning workforce to share the production tasks of some partner companies, to support key products which have limited resources.

However, the greatest uncertainty faced by Chinese shipyards is the return of foreign suppliers.

Ships built in China will still be equipped with many imported products, most of which are key equipment onboard the vessel. Many shipyards have reported that they are faced with situations where business with foreign shipowners, foreign service providers and even ships awaiting crew, are unable to take place. Although the shipyards have used remote video to take steps such as installation, guidance, debugging and approval, some works involving confidential business, or that require specialised work, still need onsite presence from foreign service providers.

In the face of the pandemic, the cultural differences among shipbuilders across the world has also emerged. A shipyard worker in charge of safety control commented that, at the time when China experienced its Covid-19 outbreak, a foreign employee based in China planned to return home as soon as possible. "On one hand, they were not used to self-isolation lifestyle. On the other, they believe that they are safest in their motherland. But I told them that, right now, China is the safest place to be." *NA*

Shipping's grand challenge: the transition to low-carbon

IMO's GHG targets pose an unprecedented challenge to an industry still adapting to the sulphur cap. Kirsi Tikka believes greater collaboration, and learning from previous mandates, should guide thinking

A new decade has started with calls for action to reduce greenhouse gas emissions from shipping. This will be an era of transition and it is difficult to predict all of the changes that will take place, but we can be sure the industry will face many challenges to meet its carbon reduction targets in the next 10 years. Uncertainty about future regulations and available technology has clouded the industry's future outlook for some time, and the global coronavirus outbreak has introduced a new level of uncertainty and difficulty that nobody was able to foresee a few months ago.

The societal pressure for action by governments and industries is building and the international shipping industry is not immune to this pressure. For shipping, this can be both a challenge and an opportunity, given its global commercial nature and international regulatory framework provided by the IMO and its member states. How the industry responds to this challenge will shape its future.

This year started with a new global sulphur limit for marine fuels. The switch over from heavy fuel oil to low sulphur fuel was anticipated with anxiety about fuel availability, quality, compatibility, and price. The reports on the issue have ranged from a smooth transition, to a lack of bunker barge capacity, to a legal storm of contractual disputes. Shipowners who installed scrubbers took advantage of the early price gap between high and low sulphur fuels, but that gap has quickly narrowed, while events leading to the reduced oil and fuel costs, as well as delays at Chinese shipyards, have overshadowed last year's price assumptions. Investment in retrofits, whether scrubbers or new technology, has risks that are difficult to quantify.

Although the IMO global sulphur limit has a significant impact on shipping, its significance pales in comparison to the IMO targets for shipping decarbonisation, and the current decade will be critical for achieving the preliminary emission reduction targets set for 2030 and 2050. There is a common agreement the targets cannot be met without alternative fuels and these alternatives must be available by 2030.

Kirsi Tikka

Industry initiatives

The industry has currently a number of initiatives to work towards low and zero carbon solutions. The Getting to Zero Coalition, committed to getting commercially viable zero emission vessels operating along deep sea trade routes by 2030, and the Poseidon Principles, providing a framework for integrating climate considerations into lending decisions, are examples of industry-led initiatives to facilitate the transition to low carbon shipping.

Alongside these, the regulatory process will be key to successfully achieving the carbon targets. IMO's authority as the regulator of international shipping will be tested not only by its capability to develop the final strategy and pathway to decarbonisation, but also by the successful implementation and enforcement of the sulphur cap by its member states.

The industry, the IMO, and its member states have critical years ahead. However, at the moment there does not seem to be a clear pathway to decarbonisation. There is no obvious choice for an alternative fuel that would satisfy all emission requirements and be globally available given the current technology and infrastructure.

LNG is considered as a transition fuel but not as an ultimate solution since it provides a limited reduction of CO_2 emissions. There are a number of pilots testing several alternatives and a number of initiatives bringing the various stakeholders together. However, it is unclear how the industry will respond to the financial and regulatory challenges of today as well as prepare for the next decade.

In the short-term, action is needed to maintain the reductions already achieved and improve towards the 2030 target. The CO_2 emissions relative to the IMO benchmark year 2008 have dropped as a result of slow steaming in weak market conditions and due to energy efficiency improvements, both in new buildings and existing vessels. Some of these gains are at risk if market conditions improve and, if the improvement is sustained, the benefits of slow steaming may be lost. Ideally, better market conditions should accelerate the technology development needed to eventually achieve the 2050 target of reducing total GHG emissions by 50%.

The current submissions for short-term measures at IMO are built on goal-based technical and operational measures. These submissions were scheduled to be discussed at the Intersessional Working Group on Reduction of GHG Emissions from Ships at the end of March but, unfortunately due to the coronavirus pandemic, both this and the MEPC 75 meetings have been postponed indefinitely.

These postponements add to the challenge and we need a pragmatic approach, without sacrificing safety and technical integrity, to implement short term measures as soon as

possible. The measures could be implemented in stages, allowing time for development of a more sophisticated framework taking advantage of digital advances and other developments in the industry.

Learning from the past

Even with the urgency of the issues, it is critical that the process results in good regulations which promote the right behaviour and safety. New regulations and technologies often have unintended consequences. It is critical that alternative fuel and new technology development and regulations prioritise safety. It is also important that the regulations have a solid technical basis. We should learn from past regulatory challenges.

Let's consider the multiple fuel types ships have to carry today and the operational challenges associated with them. If, in 2005, the global sulphur limit had been set at 0.5% rather than 3.5%, would we still need Emission Control Areas, and would the transition to a single fuel, possibly with a phased approach, have been better than providing an equivalency option of scrubbers?

The Intersessional Working Group on Reduction of GHG Emissions had been scheduled to meet in March to discuss short-term measures

Goal based regulations are intended to provide compliance options and incentives for technology development, but they need to be carefully formulated to promote correct behaviour and desired outcomes, and to avoid unnecessary complexity and bureaucracy in their implementation and enforcement.

The double-hull requirement for tankers was another regulation with a major impact on the industry. At the time of their regulatory development a number of alternative solutions were proposed to address accidental oil pollution from tankers, but regulation

remained prescriptive requiring a double hull, and modern tankers have fairly standard structural designs with minor modifications. It is possible the markets would have led to a standard solution anyway, but after a period of prototype testing.

The industry should consider the role of standardisation in the future to eliminate inefficiencies, to lower the cost of building ships, and to reduce the cost of developing a global infrastructure for multiple fuel alternatives. We should not discourage innovation or simplify a complicated technological issue to come up with a quick prescriptive requirement. Complex analysis and testing should be done before and during the regulatory process, and the resulting regulation should be clear and feasible to implement and enforce.

Considering regulatory lessons learned, the Ballast Water Management Convention provides a cautionary example. It is an example of a regulation that was not clear and could not be implemented in its initial form. As a result, its compliance and enforcement has been fraught with uncertainty. It serves as a reminder that regulating technology that does not yet exist is difficult.

While double-hull requirement was well within the capabilities of the industry to regulate, implement, and enforce, the ballast water regulation introduced science and technology that was new and unfamiliar to the shipping community. The sulphur regulation required the refinery and bunker supply industry to provide the new fuels. But decarbonisation will be at a different scale and cannot be accomplished by shipping alone. Major investment, of both financial and intellectual resources, is needed for developing new fuels and building new infrastructure.

Encouraging collaboration

The development of zero-carbon fuels and technology cannot wait for the regulatory process to complete its course. Global technology collaboration to review alternatives and innovate new solutions is required. Ultimately, regulations are needed to provide the foundation for a level playing field, and regulatory certainty is needed to encourage, not penalise, early adopters.

We should study how others facing grand challenges have achieved their goals. A good example is the building of, and discoveries from, the CERN Particle Accelerator, which has been truly an international collaborative effort involving thousands of scientists, engineers, and technicians. Due to the financial and intellectual resource requirements, the CERN discoveries could not have been achieved by a small group of scientists and engineers alone.

In the same way, the stakeholders in maritime trade and transportation need to accelerate the research and development work with collaboration on a grand scale, utilising global private and public R&D resources. Addressing this grand challenge with an international collaboration does not eliminate the competition and the need for commercial entities to develop their own commercially viable and safe solutions.

The transition to low-carbon shipping will require a large financial investment. The cost to reduce CO_2 emissions by 50% by 2050 has been quoted at US$1 trillion, based on a recent study by University Maritime Advisory Services (UMAS) and the Energy Transition Commission. Most of the spending, over 80%, would go to the development of the infrastructure and production facilities needed to supply alternative fuels. The figure is based on an academic study using possible scenarios and the reality may be different, but we can be sure that the costs will be high.

Carbon taxing

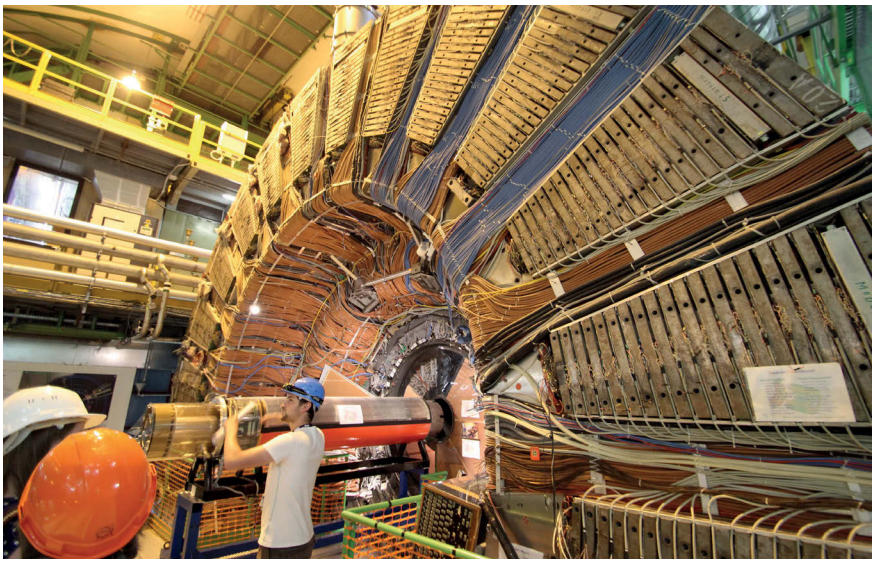
It is difficult to see the source of the needed investment without assigning a cost to CO_2. This will be a difficult conversation all stakeholders will need to have and the debate has already started. A tariff of US$2 per tonne of fuel has been proposed by shipowner associations with the proceeds used to fund R&D. As a cost, it would be small and it could be absorbed by the industry, but it will not change behaviour, and it will limit the incentive to develop new technology to only those who have access to the raised funds. However, we can argue that it is a small step in the right direction.

Ultimately, the costs should be translated to business opportunities and low carbon technology should provide a competitive advantage. This would require a cost for carbon that would make investments in low carbon fuels and technology good business.

If we consider the fast pace of technology development today, we must remain optimistic that technical solutions will be available to provide both environmental and financial sustainability for shipping, as soon as the regulatory certainty and financial incentives are in place. At the same time, the challenge is grand. It requires bright scientists and engineers, investment, and a lot of hard work.

It will be an exciting decade and we have no time to waste. *NA*

The Large Hadron Collider should serve as an example to shipping



About the author

Dr. Kirsi Tikka MRINA was formerly executive vice president and senior maritime advisor at the American Bureau of Shipping (ABS). She currently serves as an independent non-executive director for Pacific Basin Shipping and for Ardmore Shipping Corp.

Coronavirus: a catalyst for change?

Disruption in the transport and logistics sector could be accelerated dramatically by the coronavirus pandemic, according to one tech specialist

"We've heard the word disruption over the last few years in the context of new technology companies and how they've disrupted traditional businesses, but Covid-19 has just slapped everybody in the face," says Paul Cuatrecasas, a former investment banker turned tech entrepreneur, whose company Aquaa Partners helps older businesses partner with tech startups.

He points to a report published by Prologis which predicts e-commerce will rise hugely as a result of the pandemic and that shippers will look for an 'originalised' approach and a more resilient supply chain. "The two tools the report suggests will emerge to support this are robotics and 3D printing, the same things we've been talking about to our clients for the last few years," he says. "These tools will increase factory productivity and allow for locations that are adjacent to the end user, instead of shipping goods halfway across the world."

Danish giant Maersk, Cuatrecasas suggests, is the perfect example of an ageing company, laden with fixed assets and low gross margins, that has very little strategic flexibility. Over the last five years the value of Maersk shares have dropped by around 67%. By contrast, investors place a higher valuation on emerging freight tech companies, providing services such as end-to-end supply chain management and tracking.

He also expects autonomous transportation to come to the fore, but while autonomous vessels and road vehicles may have a role to play, the real transformation could come from the development of flying cargo drones. "When you combine drones with 3D printing, robotics and AI software you have a completely different ecosystem of transportation, one that's extremely resilient to any kind of shock."

Parcel drone services, such as Amazon's much-publicised air deliveries, could have a trickle-down effect and accelerate technological know-how, spearheading a projecting rise in e-commerce from 14% today to around 60% by 2030. But

Paul Cuatrecasas

the bigger implications for maritime, in particular container shipping, could be larger cargo drones, where companies such as China's Sichuan Tengden Technology are developing eight-engine drones capable of carrying a maximum cargo of 20tonnes up to 7,500km.

"When you start to look at that in the context of ships you start to question whether you really need them anymore. Of course they're not going away completely but we're talking about the rapid evolution of new technology and not having to involve humans in the supply chain."

While, given the economy of scale, this may have fewer implications for dry cargo ships and tankers, Cuatrecasas believes that the changing use of materials will also have a significant bearing on the quantities and types of materials needed.

"In the future a lot of goods will be 3D printed and assembled locally. If there's a 10 or 20% reduction over time, because more things can be transported by cargo drone, what will that mean for the shipping business? As Maersk illustrates they are already under pressure from a cashflow and profit perspective. And if these companies can't survive who's going to be doing the shipping?"

Cuatrecasas thinks that one of the most effective ways for maritime companies to adjust to this new era is to find the right technology partners and be willing to learn from them. "Maersk has been very active in partnerships and has a venture capital (VC) fund, but if you're an established player the key is to do it in a very considered way.

"The challenge established companies have in trying to do things in-house is they really don't know how to do things that differently from what they've done before. Unless there's an external catalyst a large organisation can't change in the way that it needs to."

He cites the example of General Motors (GM), which was bailed out by the US government in the wake of the 2009 financial crisis. Realising that the future was in self-driven electric vehicles, in 2016 GM acquired Cruise, a self-driving car company with just 25 employees and negligible revenue, at a cost of an estimated US$1-2billion. Two years later, Cruise was employing 2,000 employees and effectively given carte blanche by GM to help guide the parent company's future.

Moreover, he thinks if the current crisis is prolonged it may create the climate for reverse takeovers. "Their VC backers have plenty of cash… it could be some of the tech companies that say at these prices we might as well buy this, strip out a lot of the costs and replace a lot of what was done by humans with AI machinery and software."

Nowadays tech businesses occupy many of the top places in lists of the world's biggest companies, positions which as recently as a decade ago would have been occupied by the oil majors. Yet demand for oil is currently so low, and supply so excessive, that it's prices might even go negative given the cost of storing it until demand picks up. Cuatracasas thinks that with the rapidly declining prices of renewable energy it could become superfluous, at least for some sectors, within the next year to 18 months.

"In the last four years solar prices have dropped 250-fold. The sun provides enough energy in five days to exceed the entire proven reserves of oil and gas on the planet. When you combine the exponential increase in solar with the ability to store it as batteries it suggests everything will ultimately go electric and autonomous." *NA*

Denmark's shipping industry focuses on carbon emissions

The Danish flag registry hopes to use its growing influence to push for a mandatory R&D fund with IMO

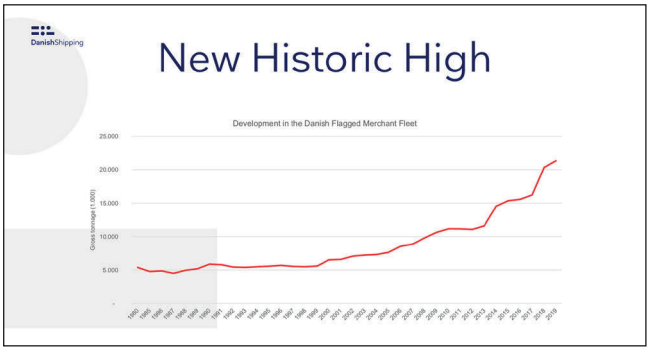
Since 2017, Danish Shipping has seen a growth of 7% in its number of ships and has surpassed its 10% target increase in operational tonnage. As its flagged fleet continues to grow, so does its potential influence on international framework conditions, which it intends to utilise during R&D proposal discussions scheduled to take place at MEPC.

At a recent press briefing, it warned that efforts to meet 2030 and 2050 carbon targets will be futile without the implementation of appropriate mandatory funding. "No matter what we do in terms of short-term measures, no matter how much we are getting more efficient on the fleet we already have, we will never get to carbon neutrality, or to 50% reduction in 2050, if we don't have the right R&D up and running to find new carbon neutral fuels," insists Anne Steffensen, Danish Shipping's director general and CEO.

Announced in January, the International Maritime Research Fund (IMRF) initiative proposes a mandatory US$2 surcharge for every tonne of bunkered fuel. Its proponents, including the International Chamber of Shipping, claim the scheme could generate US$5 billion over a 10-year period to be fed into global R&D decarbonisation projects, though it remains unclear how the funding would be distributed between potential OEMs.

Danish Shipping will support the proposal at MEPC 75 and attempt to influence IMO to make further discussions at MEPC 76, as it believes this to be the best means of accelerating decarbonisation. Maria Skipper Schwenn, executive director for security, environment and maritime research, comments that since the fund is being proposed is an amendment to MARPOL its implementation could be accelerated. Schwenn adds that the organisation also plans to push IMO to have the R&D fund fully functioning by 2023.

As the fifth largest flag registry (calculated by operating tonnage), Danish Shipping could foster its own independent R&D funding, but believes IMO involvement to be essential. "Otherwise you would always have companies around the world who wouldn't contribute if it was a voluntary measure. That's why we need a mandatory measure adopted by the IMO," says Schwenn.



Danish shipping reaches a historic high in its merchant fleet

Steffensen admits that, although undesirable, it will be impossible to avoid a competitive landscape between existing R&D funds, but hopes for regulatory equality. "What we want to see is a global level playing field in terms of how we are going to meet a high degree of carbon neutrality. As with everything else, there will probably be competition on different findings, but as shipowners it's really important that there is some regulation on what you have to achieve at what time, and that it's the same for everyone, no matter who gets to the new fuel first," she adds.

Although Danish Shipping would be fulfilling its own targets once its fleet achieves carbon neutrality, Stephenson believes that shipping's social obligations go beyond this. Notably, the Danish government has set a more ambitious target of a 70% reduction in CO_2 by 2030 for country's land-based emissions. "The challenge of climate change is so big that nobody can rest on their laurels and say 'we have solved our small part of the problem'. We need to see this on a bigger scale and, as an industry, be ready to take responsibility for getting the whole supply chain carbon neutral."

The cooperation of land-based sectors and other industries in the realisation of a global carbon neutral supply chain could be a pipe dream, as ultimately IMO's remit does not extend to onshore operations. But Steffensen hopes that with the introduction of the project by IMO, other industries will fall into line. "Shipping is not going to solve this (GHG emissions) by itself. We hope that when this fund is up and running, we will be able to have other parts of the supply chain involved, in order to get the correct structures in place for the future."

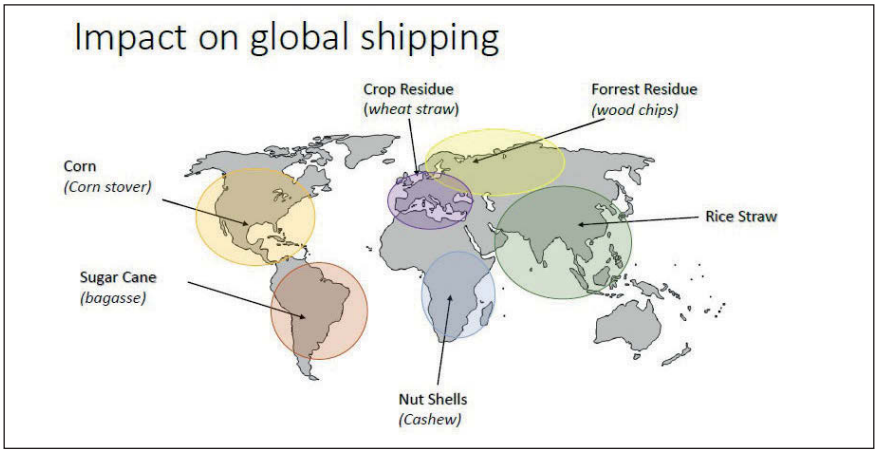
To that end, some short-term carbon offsetting may be necessary to ultimately reach GHG emission targets. Schwenn states: "We (Danish Shipping) do not support offsetting, but at the same time as long as were still developing, testing and upscaling new fuels, we still need to have some room to manoeuvre."

Steffensen moreover remains optimistic that offshore wind can play an important role in powering carbon neutral ships, with 45 of its members already involved in windfarm building, maintaining or transportation. "We think that this part of the future, in terms of producing enough electricity which is carbon neutral, and which can also be used to produce e-fuels that our ships will be running on in the future," she concludes. *NA*

Collaborative project aims for biofuel-powered ship trials

Kvasir Technologies, a partner of Danish joint industry initiative ShippingLab, has been working with shipping company Norden to develop a liquefaction-based biofuel

In 2019, ShippingLab embarked on its three-year mission to create Denmark's first autonomous, environmentally friendly ship. One of the initiative's three working packages focuses on developments in decarbonisation and, at the start of the project, its aim was loosely defined as demonstrating the viability of zero emissions power supplies (see *TNA*, April 2019, p25). But could the collaboration between Kvasir, a spin out project from the Technical University for Denmark, and Danish shipping company Norden, see the first feasible production and implementation of biofuel in shipping?



Kvasir Technologies' biomass map of the world

According to Kvasir's CEO and co-founder, Joachim Backmann Nielsen, the company's biofuel is the most efficient and potentially cheapest solution to decarbonisation in shipping. "The name 'Kvasir' derives from an old Norse word that literally means crushing and squeezing the juice out of something – which is what we are doing when converting biomass into liquid product. Except we are doing what nature achieves in millions of years in a couple of minutes," says Nielsen.

The company's patented technology is a liquefaction process that transforms non-edible biomass such as wood chippings into stable 'bio crude'. Kvasir states that its method is best described as 'pressurised cooking in alcohol', where biomass is broken down into smaller fragments and expels oxygen as it is heated in ethanol to 400°C. The supercritical ethanol atmosphere created within the reactor stabilises the reactive biomass fragments to create a liquid biofuel oil.

Nielsen insists that the resultant biofuel is significant not only because it's zero sulphur, but also as its raw material originally comprises up to 40% oxygen. "Typically, you can't produce a stable product when there is oxygen present in the blend, as possible microbial activity can break the fuel down and cause it go bad over time," he adds.

He believes the technology is 100% sustainable as Kvasir exclusively converts non-edible plant material mainly containing lignin: a complex organic polymer that forms structural materials in the secondary cell walls of plants (and some algae) but is most commonly found in wood. Nielsen claims that this gives Kvasir biofuel a market advantage as it utilises previously untapped resources. "We use products from all over the world, known as lignin cellulose, a material no one has been able to use in the past."

Kvasir claims that there is a nearly infinite supply of lignin, with several usable raw materials globally (see Fig.1). Additionally, Nielsen insists that as the company would not need to rely on a single source, the risk of high feedstock costs could be mitigated, which would be beneficial for global shipping companies (such as Norden) that are subject to fluctuations in feedstock prices.

In 2018, Norden first trialled used cooking oil biofuel as a drop-in solution on its product tanker, *Nord Highlander*, which left Antwerp burning fossil fuel then switched to biofuel after a visual engine inspection took place. Last year, a second trial took place on the 49,600dwt chemical/product tanker *Nord Sustainable*, which completed a journey from Ventspils, Latvia to Alger, Algeria, using entirely biofuel (see *TNA*, April 2019, p16). "We've already conducted a couple of tests based on biofuel derived from used cooking oil, and concluded that there may be enough to power our own fleet, but definitely not enough for the whole world, which is where Kvasir comes in," says Henrik Røjel, decarbonisation manager at Norden shipping. "Supplying our entire fleet operating across five different sectors is quite a challenge. We are not able to just wait for somebody to build us a perfect zero emission vessel, especially if we are going to charter 300 to 400 ships, the only solution that we can see, at least in the near future, is biofuel," he adds.

As it stands, Kvasir is still in the beginning stages of its biofuel production. However, in 2020, the company intends to begin upscaling, for which it will first need to create continuous bio oil production using stirring vessels. By 2022, Kvasir aims to have stored 30 – 50tonnes of biofuel using a pilot plant, in preparation for ship trials with Norden. To generate this amount of biofuel equivalent to HFO, the company requires 75 – 125tonnes of dry biomass, such as wood or straw, which would ultimately fuel a maximum of two days voyage on a Norden ship. ***NA***

Customer expectations accelerates coating innovations

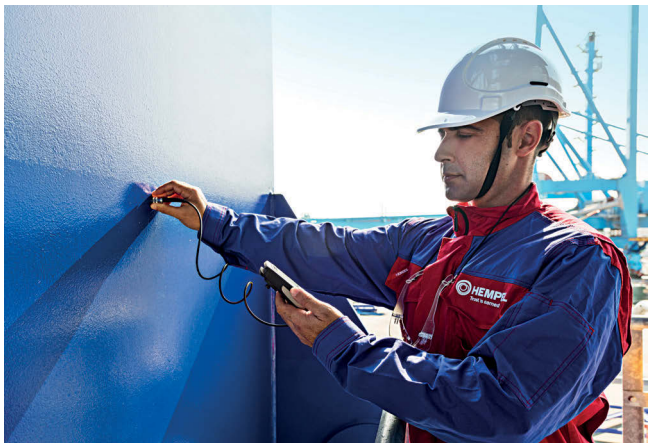
Danish coatings expert Hempel is confident its products meet the demands of greener customers looking ahead to 2030/2050 global emission targets

The implications of increasingly strenuous GHG emission restrictions on shipping is putting pressure on suppliers to find new ways to single themselves out as the greenest option available on the market. Although reducing fuel consumption and associated CO_2 emissions is still the core focus of Hempel's products, the company is also looking more broadly at its overall carbon footprint in order to remain a sustainable supplier of the future.

Recently, Hempel explained in a press briefing that it has been working towards sustainability for years, but developments in 2030/2050 carbon emission targets have increased the expectations of its customers. "There is no doubt that the acceleration of the carbon emission agenda has led to the acceleration on our side, in our technology and innovation department, to make sure we are also, from a sustainability point of view, relevant to our customers in the future," says Michael Hansen, executive vice president and chief commercial officer at Hempel.

Hempel became a partner in the Getting to Zero Coalition in October 2019, which Hansen says is an opportunity for the company to play a role in the future of global shipping. The multi-stakeholder coalition aims to accelerate the shipping industry's decarbonisation with the development of commercially viable zero emission vessels by 2030. "Through initiatives like this, we have a role to play, and even an obligation. We have actual commitment with the customers to find technology that does not yet exist today, as well as solutions that can help the economy of the shipping industry," Hansen adds.

The company is also making moves to reduce its own internal carbon emissions. Hempel's 2019 annual report states that it reduced its relative energy consumption by 6.5%, including an 11% decrease in electricity use, and an 18% reduction in waste to landfill. "Both from a customer and emissions point of view, we have cut down on the electrical consumption of our factories, made sure to source and use green energy in our factories, and more generically in our supply chain footprint we have optimised our land transportation," comments Hansen.



Hempaguard MaX's Hempel Services ensure optimal application and surface smoothness

Internal emissions aside, Hempel claims that its flagship silicon-based coating, Hempaguard X7, has reduced the equivalent of 10 million tonnes of CO_2 emissions. The coating has been applied to over 1,700 vessels since 2013 and, according to the company, has saved a collective fuel bill of more than US$500 million. However, Andreas Glud, group segment manager for marine and dry docking at Hempel, notes that next challenge is in looking beyond the coating product alone. "Hempaguard itself was a success for us, the test is to figure out how we can make things better, for something that already works quite well."

According to Glud, Hempel is making cost and efficiency savings in other areas with its newest package product, Hempaguard MaX, a system that includes a primer (Hempaprime Immerse 900), tiecoat (Nexus II 27400), topcoat (Hempaguard X8), an in-dock project management service and lastly, SHAPE – Hempel's propulsion monitoring and analyst system which documents a vessel's performance. Glud claims that the SHAPE technology will indicate whether the ship is operating at its optimum and that it could encourage customers to replenish coatings irrespective of the minimum demands set by classification societies.

Hempel insists that the system is the most efficient hull coating solution on the market, saving time in dock with its three-coat system and faster application time. The company states that complete application of the Hempaguard MaX coating can take seven days while the ship is dry docked, which is a two-day improvement on its previous coatings. After application, Hempel claims that the system results in a maximum 1.2% speed loss over five years and allows the customer's vessel up to 120 days protection while idle. "There is full flexibility for the owner, they can sail wherever they want without fears of fouling. All in all, the system improves performance, increases savings and reduces fuel costs," adds Glud.

As of February 2020, over 30 applications of Hempaguard MaX have been completed since its introduction three months prior, but Glud anticipates another 100 applications in the next year. Though he admits that the system has been introduced mainly on existing ships, he expects that newbuilding applications will increase. "A lot of shipyards are approaching us to deliver our silicon coatings because they are under pressure to deliver a difference themselves, there is no doubt." *NA*

CE Delft study gives cautious approval to green methane

The report, commissioned by SEA/LNG, judges bio and synthetic liquified methane, but cautions that further investment is needed

Ever since the announcement of IMO's greenhouse gas strategy in April 2018 there have been questions concerning the adoption of liquified natural gas (LNG) as a clean marine fuel. For its proponents LNG is the greener, more efficient and no-sulphur alternative to HFO and there continues to be a steady uptake of LNG as a marine fuel.

Conversely, its detractors point out that while there is a reduction of around 25% in CO_2 emissions, there is currently no comprehensive solution to the problem of methane slip. Some cynics have even gone so far as to say that LNG is a dead end that's been promoted by those with vested interests.

However, as the industry grows increasingly pragmatic about the available options for cutting GHGs, the pro-LNG lobby is regaining some traction. "There's no question that we must act today. Inaction is not a plan," according to Pete Keller, chairman of multi-sector industry coalition SEA/LNG. "LNG is the only option that moves us forward and we can do that now. To wait only exacerbates the situation we live with today and we encourage all shipowners to look very carefully at their future plans."

Moreover, there is now gathering momentum behind another option: liquified biomethane (LBM) made from biomass, or liquified synthetic methane (LSM) which could be produced from renewable electricity, sometimes referred to as 'power to gas'. Since they are chemically identical to fossil fuel-derived LNG, such fuels could be used interchangeably based on availability, and utilise the same bunkering infrastructure. By contrast, alternatives such as hydrogen and ammonia demand more radical tech upgrades and infrastructure investment.

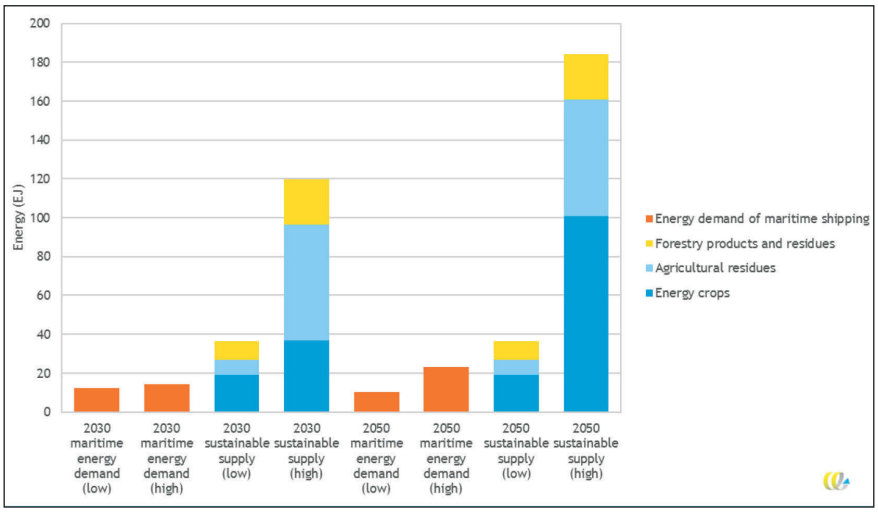


Figure 1: Maritime energy demand and global maximum sustainable supply of LBM in 2030 and 2050 (Source: CE Delft)

Although such developments remain in their infancy, SEA/LNG recently commissioned Netherlands research consultancy CE Delft to investigate the availability and costs of LBM and LSM, as well as the potential obstacles the industry faces in scaling them into viable marine fuels.

"The study clearly shows that LNG with the use of LBM and LSM offers a pathway to decarbonisation," says Keller. "If we can put that together with the benefits that have been identified in in our [earlier] 'next steps' study of 21% on a well-to-wake basis and 28% on a tank-to-wake basis we certainly see a path forward to 2030 and 2050 as regards carbon reduction.

"It's also important to note that these potential fuels are essentially the same as fossil-based LNG, so there's no issue of stranded investments or issues regarding conversion of assets that have been built for fossil LNG to these carbon-free fuels."

Availability and cost

The CE Delft study, which is primarily based on a literature review, analysed the maximum conceivable sustainable supply of a variety of biomass streams: energy crops, agricultural residues, forestry products (and residues) and aquatic biomass. Of these, aquatic biomass is a comparatively immature technology with few studies so far. Figure 1 compares the global maximum sustainable supply of LBM (excluding biomass) with maritime energy demand for both 2030 and 2050, finding it to be more than adequate.

Predictably, the cost of LBM is expected to fall dramatically, from the current levels of US$19-49/MMBtu to 2050 levels of US$15-21/MMBtu when produced using the anaerobic digestion process. Gasification technology, which is currently less developed and more costly, could ultimately cost as little as US$13/MMBtu.

Table 1: 2030 plant gate cost price estimates for different renewable bunker fuels (Source: CE Delft)

	Cost price at plant gate (USD/MMBtu)
LBM	21-48
LSM	26-113
Liquid ammonia	17-105
Liquid hydrogen	19-72

LSM, which is derived from the synthesis of CO_2 and hydrogen, can only be considered a truly zero emission fuel when achieved via water electrolysis and powered by renewable electricity. Although a comparatively mature technology, at present levels the current global share of renewable electricity would be insufficient to produce sufficient LSM (see Figure 2).

While the report projects this will improve, it also cautions that LSM is likely to be competing for its share of hydrogen with other fuels such as green hydrogen and ammonia. This uncertainty extends to the price projections which indicate the cost could be anywhere between US$15 and US$60/MMBtu.

Although it's widely expected that carbon taxes will be applied to fossil fuels in the near future, the report warns that even a mark-up of US$50-100/t CO_2 will not be sufficient to incentivise a switch from traditional LNG by 2030. However, it's more positive about 2050, stating that if a carbon price of US$300-400 is adopted, consistent with policies to keep within the 2°C limit on pre-industrial temperatures under the Paris Agreement, then a switch to LBM becomes more attractive.

LBM is also favourably disposed when it comes to comparison with ammonia and hydrogen (see Table 1). Although the more optimistic estimates for the cost at plant for these fuels by 2030 put hydrogen and ammonia lower, this would largely depend if the production location has conditions favourable to renewable electricity. LBM and LSM also benefit from having a technically mature bunkering infrastructure compared to hydrogen and ammonia.

"The future maximum conceivable sustainable supply of LBM and LSM exceed the energy demand from the shipping sector, provided that biomass is used to produce methane and sufficient investments are made in renewable energy production," according to CE Delft's senior researcher/consultant Dagmar Nelissen.

"Production costs of LBM and LSM need not be significantly higher and could be comparable to those of some other zero carbon fuels," she concludes. *NA*

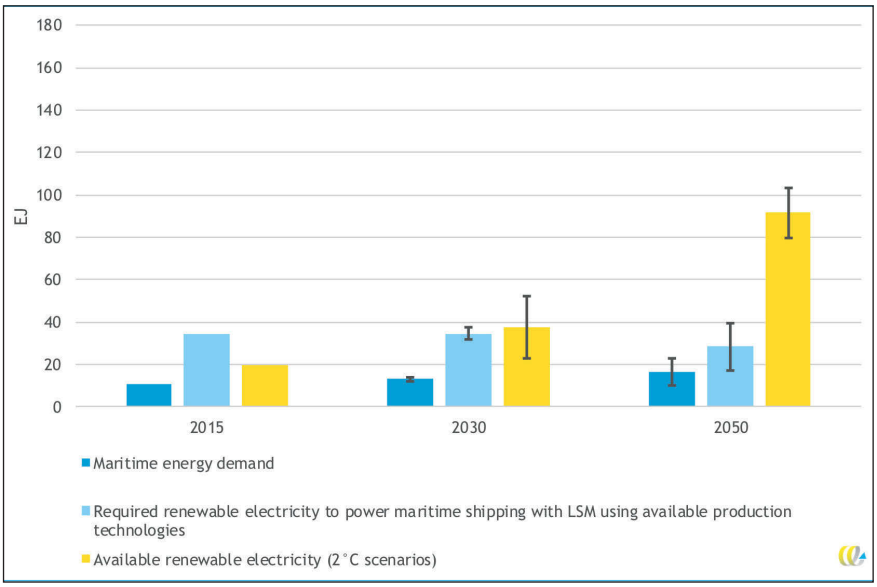


Figure 2: Maximum potential supply of LSM compared with maritime energy demand given a renewable electricity supply in line with a 2°C degree scenario (Source: CE Delft)

Scrubbing more than just SOx

Could a simple, cost-effective method for producing alkaline water be used for reducing exhaust greenhouse gases?

While scrubbers have been in the spotlight in recent years as a technology for achieving compliance with IMO's sulphur cap, their potential as a solution for tackling other greenhouse gas emissions, such as NOx and CO_2, generally receives less attention. However, marine engineer Dr Robert Allen put forward a proposal that enhanced alkaline water could serve as a washing medium for capturing other exhaust gases.

Speaking at a technical seminar of the Clean Shipping Alliance 2020 in February, Dr Allen highlighted that a largely forgotten two-stage scrubbing system trialled by Singapore-based company named Ecospec, which used a combination of conventional seawater and electrolysis, might be made cost effective with a simple addition.

The chemistry of scrubbers

Traditional open-loop scrubbers rely upon the alkaline buffering properties of calcium carbonate ($CaCO_3$) in the seawater to neutralise the sulphur dioxide (SO_2). Because the concentrations of $CaCO_3$ in the water are low, large quantities of seawater are needed to achieve this.

But closed-loop scrubbers take a different approach, using sodium hydroxide (NaOH), otherwise known as caustic soda, in fresh water to neutralise the SO_2. The alkaline nature of NaOH comes from the hydroxide ion (OH-) which, when dissolved in water, is a very strong base.

The neutral form of this ion, the hydroxyl radical, reacts readily with SO_2, CO_2 and NOx, and there are already several onshore test sites exploring its potential of NaOH for carbon capture and storage. It also reacts with hydrocarbons and serves as the basic reaction of UV-based ballast water treatment for killing organisms.

Once spent, the NaOH solution can be carried onboard for discharge at port and replenished with fresh caustic soda. Alternatively, the water can be made alkaline again through use of an electrolyser, which

dissociates the water to form hydrogen ions (H_3O+) and hydroxide ions. Electrolysis is, in fact, the most common means of achieving this.

CSNOX

In 2009, Ecospec made a presentation to IMO's MEPC for CSNOX, its two-stage scrubbing system. The system was said to have raised the pH of scrubbed water to an alkalinity of between 9.2 and 9.5 using what was described as 'ultra-low frequency electrolysis' which had raised the frequency of hydroxide ions. In addition, a trial of the system onboard the Aframax tanker *Coral Sea*, and verified by classification society ABS, had achieved the removal of 92.9% SOx, 82.8% NOx and 74.4% of CO_2.

"This information is still available on the internet, but there's been no further published information beyond 2014 on CSNOX, and no takeup by the marine industry," Allen explains.

"The trial, I suspect, was not on a continuous basis and it took time to produce the amount of water needed. Nor was the flow rate specified and there were no details on the power requirements, which could have been significant for continuous scrubbing."

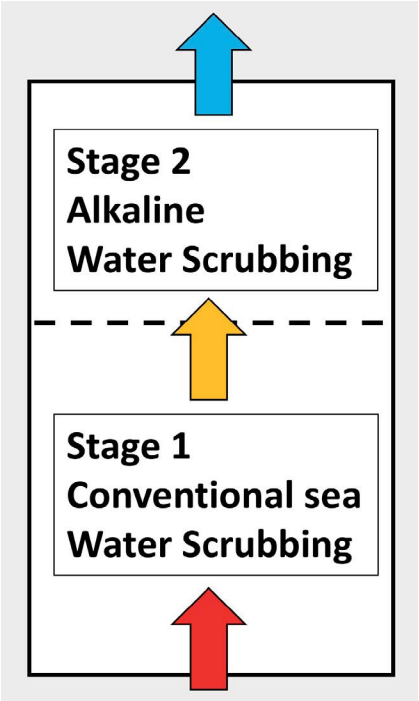
However, it led him to question how they had achieved such impressive results. The key, he believes, was the two-stage process. "SOx is 50 times more soluble than CO_2 and NOx, so you've got to remove it first. Then in the second stage the alkaline water can now react with CO_2 and NOx without being overwhelmed."

Alternative methods

Since electrolysis via the CSNOX route was seemingly not commercially viable, Allen began considering what other methods might be used to produce alkaline water. He turned his attention to work undertaken by the Japanese researcher Tetsujiro Kubo, who in the early nineties took out several patents based on research into the mineral tourmaline. Tourmaline carries a faint electrical charge of 0.06mA and, irrespective of how finely ground or crushed its crystals may be, possesses a permanent polarity.

Kubo's patents, which remain pending, describe how when the crystals are embedded in a suitable material, such as small ceramic balls of 3-5mm diameter, they are ordinarily electrically insulated from one another. However, when these balls are placed in an aqueous medium they also come into contact with each other, generating an intense electro-magnetic field that creates OH- radicals. Industrial grade tourmaline is widely produced across the world and these ceramic balls are already a medium-sized industry in China, where they are put to uses such as water filtration.

Several years back, Allen decided to attempt some small-scale lab testing of the principle, with a simple rig using a fluidised bed of tourmaline balls with continuous recirculation of water. "What I was looking at was how fast you could actually produce alkaline water using tourmaline balls and how much power was required to do that," he says.



The scrubbing system removed most of the SOx in the first phase, allowing the alkaline water to react with the NOx and CO_2 in the second

Starting with de-ionised water of pH7 he was able to raise four litres of water to pH9.5 in 10 minutes using 24Watts of pump power. By scaling up, he estimates that 20m^3 of water with the same alkalinity could be produced onboard a ship for less than US$10/hr, taking into account additional costs such as the need for a reverse osmosis pump for the production of fresh water. The tourmaline balls themselves would also need to be periodically replaced due to natural wear and tear. However, he warns that the cost depends very much upon the volume of alkaline water required and the scrubbing effectiveness.

Replicating results

Whether it's truly feasible to transfer the technology from simple domestic water purification to large-scale marine operations is, Allen admits, hard to determine. "Anybody who wants to take this on will want to replicate the findings to prove it for themselves. It's a mixture of engineering and chemistry and would probably require some funding. That would need to be a recognised establishment, organisation or company that can conduct further tests. They would probably want to move it to pilot-size large scale testing and scrubbing performance on gases."

One possible source of financing, he suggests, might be the proposed fund to support research and development of ships, which was due to be discussed at MEPC 75 in April (until that event's cancellation). Being himself retired, Allen says he has no personal interest in pursuing the technology's potential, but given it might be a feasible, cost-effective way of scrubber performance covering NOx Tier 3 and IMO 2050 requirements he believes all options need to be considered.

"We need to examine all the available technologies out there. Some may fall by the wayside and some may reach the finish line. Much of this isn't my own work, there's a lot of information out there, it's just a question of joining the dots." *NA*

Ceramic tourmaline balls are widely used, particularly in China, for water purification

The path to hydrogen with a zero-carbon footprint

Hydrogen is essential to many alternative fuels being considered, but maritime faces competition from other sectors for green sources. Dr Dino Imhof, head of turbocharging solutions, ABB Turbocharging, considers the possible options and transitional solutions for hydrogen production

With protests taking place around the world to help raise awareness of climate change, the International Maritime Organization's (IMO) stringent decarbonisation targets for the maritime industry have never seemed more relevant. The Initial IMO GHG Strategy sets out ambitions for the maritime industry to reduce CO_2 emissions by 40% in 2030, by 70% in 2050 and reduce total GHG emissions by at least 50% in 2050 compared to 2008 levels.

The challenges in finding alternative fuel sources

The maritime sector currently requires around 270 million tons of oil equivalent (Mtoe) per year, and the biggest challenge is finding viable alternatives to current fossil fuels. Biofuels have been discussed but questions remain: sustainability, traceability, the overall GHG reduction impact as well as the availability of biofuels in sufficient volumes for shipping are just a few of the details to be ironed out.

For example, it's projected that 6.3–7.8 Mtoe of advanced biofuels will be produced in the EU in 2030 – which won't even be enough to supply the business-as-usual EU road and rail energy demand in that year. Other industries including the road transportation and aviation sectors are also interested in biofuels as an alternative to fossil fuels. Full electrification is another approach, but difficult in deep-sea shipping due to the large distances, the high energy demand for powering deep-sea ships and space requirements.

While biofuels are limited in the amounts available, and electrification might play a bigger role in short-sea and inland shipping, fuels based on hydrogen with a zero or net zero carbon footprint are key if the deep-sea shipping industry is to drastically reduce GHG emissions.

When considering fuel options that do not contribute to atmospheric carbon, there

Dino Imhof, ABB Turbocharging

is a distinction to be made between zero and net-zero carbon fuels. Zero-carbon fuels are hydrogen and ammonia derived from renewable, non-carbon electricity sources such as wind, solar or water. Net-zero carbon fuel is any kind of hydrocarbon that is produced from CO_2 that is captured from the atmosphere in the same quantity as will be released during combustion.

All these energy sources have hydrogen as a starting point. There are four ways shipping might use hydrogen as a zero-carbon fuel: it can be pressurised, liquified, loaded into a liquid organic hydrogen carrier or converted into ammonia. These are the zero-carbon pathways. The net-zero carbon pathways – green methanol, synthetic methane or synthetic diesel, for example – take hydrogen and add captured carbon.

Each pathway, zero and net-zero, has advantages and disadvantages. Hydrogen and ammonia are more difficult to handle on board a ship. Synthetic methane or synthetic diesel are more easily manageable. But they are also likely to be more expensive due to the greater energy losses involved in their production – a key factor in determining the cost of new fuels.

Today, the shipping industry is not yet able to decide which of these fuel pathways will be most viable. We must therefore remain open to as many options as possible. But regardless of the fuel, zero-carbon hydrogen will be a building block.

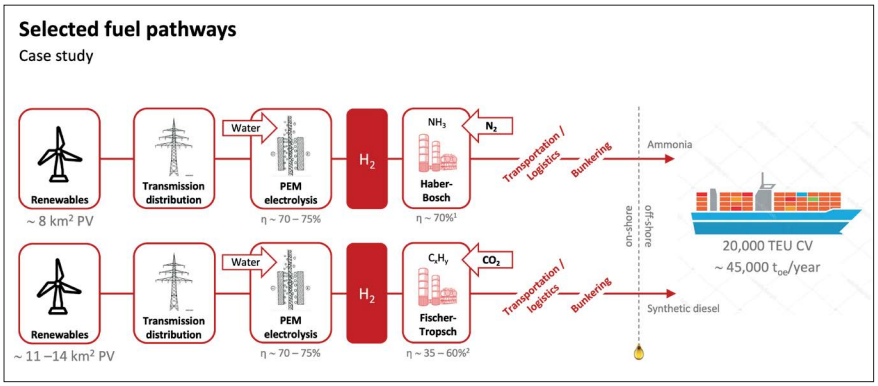
Producing hydrogen through electrolysis

Hydrogen can be produced through electrolysis using electricity from renewable energy sources like wind, solar or hydro. During electrolysis, water is split into hydrogen and oxygen. There are different forms of electrolysis, including alkaline (ALK), proton exchange membrane (PEM) and high temperature electrolysis.

ALK electrolysers are well established and the most wide-spread form of electrolysis for hydrogen production. PEM electrolysers are commercially available, are more flexible in operation and are more reactive than current alkaline electrolyser technology. Generally, electrolysis has efficiency levels between 60-80%. Low temperature electrolysers like ALK and PEM currently have an efficiency level of about 65% on average. Higher efficiency levels can be achieved through optimisation, but this also leads to an increase in costs.

High temperature solid oxide electrolysers (SOE) may offer the potential of improved energy efficiency (80-90%), but it's a process that still needs to mature. While PEM electrolysers require significant amounts of platinum for their catalyst, SOE production mainly requires ceramics and fewer rare materials.

With existing efficiency levels, electricity supply needs to be almost 100% from renewable sources to have a net reduction effect for shipping. It will take a long time until most public grids are fully renewable, however, and other more efficient processes are in the pipeline. The alternative is to



Energy consumption for fuel production drives upfront investment costs

produce hydrogen at dedicated production plants, which will also take time and significant upfront investment. This means there's a risk that hydrogen from electrolysis will not be available on time and with sufficient volume to have the required impact for the maritime industry's 2050 ambitions.

Using steam methane reforming, pyrolysis and CCS to produce hydrogen

With large-scale electrolysis and renewable electricity in short supply, at least in the near future, other hydrogen production pathways could offer an alternative for a transitional phase. Using carbon capture and storage (CCS) with steam methane reforming (SMR), or carbon sequestration with pyrolysis, could enable a faster transition to a large-scale hydrogen supply for many industries. Even though these pathways do not produce hydrogen with a zero-carbon footprint, they do offer the possibility of reducing emissions in the short-term, with the ability to transition later on to a production based solely on renewable energy sources.

Today, 95% of hydrogen production is fossil-fuel based, with SMR the most common production process. Mainly natural gas is used for SMR with high temperature and pressure, and the help of a nickel catalyst. The captured CO_2 from the exhaust gases of SMR could be used in other industry sectors or it could be stored. However, CCS is not mature enough, and it's also an energy-consuming process once transport and storage is factored in, requiring the establishment of a sound and standardised regulatory framework and monitoring to avoid negative environmental impacts or carbon leakage.

Hydrogen can also be produced using pyrolysis, which is the thermal decomposition of carbon-based materials in the absence of oxygen. During pyrolysis, carbon is extracted in its pure form as a powder (char). Unlike CO_2, the logistics for pure carbon handling and disposal are simple, and long-term underground storage is easily possible. It can also be used in the chemical industry. Production costs may be lower than the hydrogen pathway from renewable electricity via electrolysis, at least for a transition period.

Competing for hydrogen

The maritime sector will be in competition for hydrogen with various sectors globally, and many industries which currently still produce hydrogen from natural gas need to consider switching to zero carbon energy sources for hydrogen production in the future.

The growing global population will also require its share; the entire natural gas pipeline infrastructure required for heating and power generation purposes on a seasonal basis must be fed by renewable energy carriers based on hydrogen. Additionally, other transport sectors like aviation, off-highway or road transport are also looking for solutions besides electrification to reduce emissions.

However, renewable electricity is limited. Any growth in renewables seems mostly reserved to deliver fossil-free electricity to support increasing demands on the public grid.

That means the maritime industry will need huge investment if it's to meet the IMO's ambitious targets using hydrogen as a fuel source, with dedicated production facilities required to generate renewable energy for the large-scale production of hydrogen. Using pyrolysis to produce hydrogen is one way to work towards those targets and still ensure fuel supply while renewables infrastructure is being built up. But it will not be cheap or easy. *NA*

Hydrogen derived from renewable energy is often seen as the great panacea, but it's likely to be decades before it's abundantly available

Caspian river/sea tanker represents a milestone for Azerbaijan

As the most significant delivery to date of Azerbaijan's Baku Shipyard, *Lachin* carries not just oil and chemical products, but also the country's hopes for the future

Although it commenced activities just seven years ago, Baku Shipyard has already established itself as the Caspian Sea's preeminent shipbuilding facility. A joint venture between the State Oil Company of Azerbaijan (SOCAR), the Azerbaijan Investment Company (AIC) and Singapore-based Keppel Offshore Marine, the Baku shipyard builds a variety of vessels including offshore support vessels, general cargo ships, tugs, crane ships, and passenger ships, as well as repairing 80-100 ships per year. It is also of vital economic importance to Azerbaijan, employing 1,500-2,000 workers.

In December last year, the yard achieved a significant milestone with the delivery of *Lachin*, its first river/sea tanker and the first tanker of any sort to be built in the country. The launch ceremony was attended by the country's president, Ilham Aliyev, and the national pride in the achievement extends to the vessel's name, which it shares with a town in Azerbaijan's Kashatagh Province, a region is still under the de facto control of Armenia following the war between the two countries in the early nineties. Geographically located at a crossroads between North, South, East and West, Azerbaijan has been keen to promote itself as a Eurasian transportation hub. As such, the continued growth of both the Baku yard and *Lachin*'s owner, Azerbaijan Caspian Sea Shipping (ASCO), the largest operator in the Caspian, are of clear strategic importance.

Constructed to the RST12C design developed by Odessa Marine Engineering Bureau, itself an evolution of the RST12 type, *Lachin* is the first of four vessels being built for ASCO. The next in the series, *Kelbadjar*, is expected later this year. *Lachin* will be able to trade in the Caspian, which is bordered by Iran, Russia and Kazakhstan, but the design also satisfies the dimensions of the Volga-Don Canal and Volga-Baltic Waterway, giving it access to much of inland Russia.

Lachin moored at Baku Shipyard prior to its naming ceremony in December 2019

However, while many vessels with Volga-Don max dimension carry only 4,000-5,000tonnes the design of *Lachin* allows it to carry a maximum of 5,600tonnes. In the Caspian, where the draught is 4.54m, the ship has a deadweight of 7,875tonnes and impressive block coefficient of 0.94. This is a significant improvement on the designer's popular RST27 design which has a 7,072dwt and capacity of 8,100m^3, compared to the RST12C's 9,190m^3 across its six cargo tanks. There is also a pumping arrangement that allows for two grades to be carried simultaneously.

The vessel is principally designed for crude and oil products with density of up to 1.015t/m^3, including gasoline, without restriction on the flash point, ensuring the carriage of goods with a temperature of 50°C, as well as chemicals such as methyl alcohol, ethylene glycol and urea/ammonium nitrate. It has been certified with the Russian Register's ECO-S notation, meaning that it has met the more stringent requirements than those of the standard ECO notation for environmental standards.

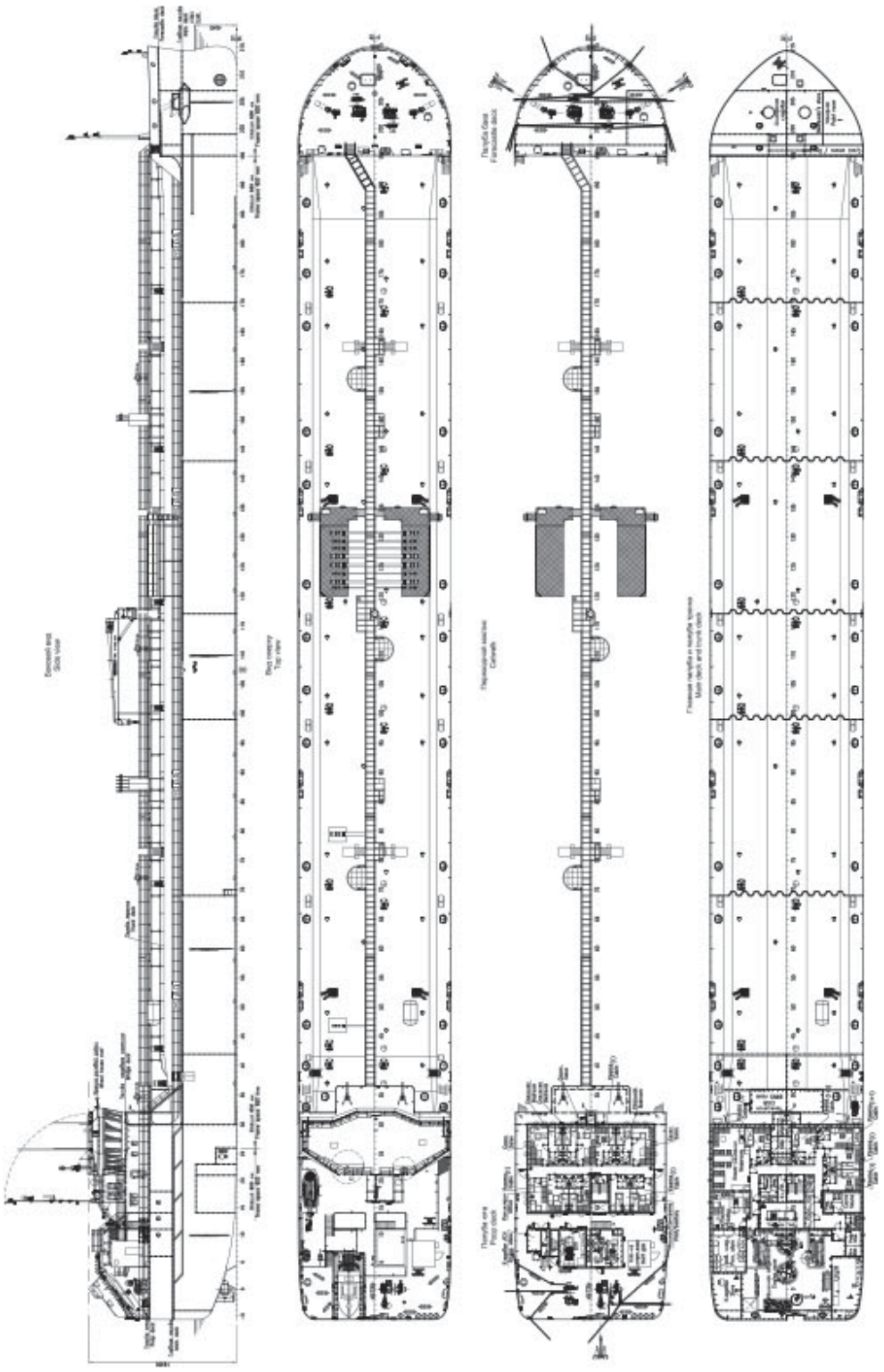
In addition to a bulbous bow and transom aft end, *Lachin* has a twin skeg hullform typical of vessels requiring a low draught or high beam-to-draught ratio. Two fully rotating fixed-pitch rudder propellers provide both propulsion and manoeuvring capabilities. Power comes from a pair of Wärtsilä 6L20 medium speed diesel engines, each with an output of 1,200kW, which drive a Wärtsilä WST-14 steerable thruster unit specifically designed for river/sea vessels for a service speed of 10.5knots. *NA*

TECHNICAL PARTICULARS

Lachin

Vessel type:	River/sea tanker
Length (OA):	141.00m
Breadth moulded:	16.90m
Depth, to main deck:	6.00m
Deadweight (design):	5,447dwt
Capacity:	9,190m^3 (in Caspian)
Complement:	6 officers, 6 crew
Attained EEDI value:	14.81
Required EEDI value:	14.93

General Arrangement of *Lachin*



Growth of LNG bunkering and associated design and operational considerations

Following on from an article on small scale LNG published in October 2018's edition of *The Naval Architect*, Keith Hutchinson and David Dobson of Tyneside based Safinah Group focus on the adoption of LNG as a fuel and specific issues facing LNG bunker vessel designers and operators

Development of LNG bunkering

The liquefied natural gas (LNG) bunkering market was initially developed early in 2002, regionally in Norway, to deliver this new bunker fuel to small ships, such as offshore supply vessels (OSVs), fishing vessels and coastal ferries. However, the environmental regulations put in place by both international and local (regional and national) regulatory bodies are now driving shipowners to build new ships or convert their existing ones to LNG fuel, displacing other traditional bunker fuels such as heavy fuel oil (HFO) and marine diesel oil (MDO) etc. This choice of LNG as a marine fuel has necessitated the growing need for LNG bunker vessels (LBVs) to support large deep-sea ships that cannot receive sufficient bunkers by road tanker.

Figure 1: 2017 newbuild 6,500m³ LBV *Cardissa* underway from her builders STX in South Korea (copyright Shell)

At present there are 32 small scale LNG carriers (LNGCs) in service, all built in European, Japanese or Chinese yards since the early 1990's. These have LNG cargo capacities ranging from 1,000 to 20,000m³, but none have been specifically designed and built for ship-to-ship (STS) LNG bunkering operations.

There were seven dedicated LBVs and LNG barges in operation by early 2019, and this number is expected to increase to 20 by late 2020. Initially these dedicated LBVs are being introduced to service medium to long-term charter parties that will be supplemented by ad-hoc opportunities. One LBV is designed specifically to service only one dedicated ferry service. The 12 LBVs currently under construction range between 200m³ and 18,600m³.

The evolution of the LNG fuelled fleet has been slow, but a number of large ships are expected to be delivered from 2020 onwards. At the beginning of 2019, a total number of 140 ships using LNG as fuel were in service, with over 160 ships on order, including at least 35 large tonnage ships. These include ultra large container ships, bulk carriers and Aframax oil tankers, etc. Of the 116 cruise ships that have been ordered in recent years, for delivery in the period 2020 to 2028, 30 of them feature LNG propulsion. This requirement has been driven by the strict local and national environmental regulations at ports in sensitive areas and by the cruise operators wishing to exhibit a 'greener' outlook. These ships will require a larger bunkering capability in ports away from general trading routes. There has therefore been a clear evolution since the first LNG powered ships incorporating only a few hundred cubic metres of storage capacity to the recent ultra large container ships currently under construction, which have a total LNG fuel capacity of 18,600m³.

The development of LNG bunkering for larger ships requires a dedicated service within a major port or adjacent ports in close proximity. Services are typically being driven by the needs of a major LNG user or producer. New bunkering hubs are also developing which will leverage existing bulk LNG infrastructure, and the majority of the world's top 10 bunkering ports are now either offering LNG bunkering or have firm plans to do so by the end of 2020. Currently LNG bunkers can be obtained at 11 European ports, with a further 14 ports with immediate plans to develop such a service.

As the number of LNG consumers (receiving ships) increases the number of LBVs required will need to increase to meet the growing demand. It is likely that a range of LBV types will be developed to suit individual port and regional requirements. Smaller ports may well utilise a multi-fuel capable bunker vessel that can carry, for example, LNG, liquefied petroleum gas (LPG) and conventional MDO or HFO in order to remain competitive.

LNG bunker vessel scoping and development

The development and design of LBVs is a new and evolving sector. Due to the infancy of the concept, at present

there are no fixed and industry accepted designs because everyone requires, or perceives they require, something different. The shipping industry is currently to some degree 'feeling it's way' and 'learning by mistakes' as when many of the current LBVs were being specified, procured and built, no one knew what the future was going to be and in some instances did not even know with any certainty how the receiving ships, to which they would be bunkering LNG, could possibly be configured.

It is obviously very difficult, if not impossible, for shipowners to produce a shipbuilding specification for an LBV which is as robust and mature as that they would issue to shipyards for more established ship types, such as coastal or small-scale feeder LNGCs of a similar capacity. The only current exception to this, and hence avenue for reducing uncertainty, is if a LBV is being procured to solely bunker only one or two specific ship types, the requirements for which are well known and fixed. However, such dedicated operational scenarios are in the minority and if the utilisation of the asset, namely the LBV, is to be maximised it is likely it will still have to service other ships with configurations and requirements. These are probably conflicting and are either unknown or cannot be predicted with any certainty when the shipbuilding specification is being produced.

This inability of shipowners to produce a shipbuilding specification with any certainty is a major issue for many, if not most, shipyards as one of their primary goals is to propose a low risk compliant technical response which has commercial advantage over its competitors. This obviously requires an unambiguous specification. In addition, designs offered by shipyards to shipowners are often what the shipyard wants to build (to suit their production processes and throughput) rather than what the shipowner wants and needs. In addition, shipyards typically may not fully appreciate the operational profile and novel aspects of a specific ship type.

Therefore, regarding the realisation of a holistic near-optimal ship design the above can be viewed as 'a perfect storm'! On one hand we have the shipowner, who may not be able to robustly bound the operations of the ship to be procured and may not have the required resources to guide design development. On the other hand we have the shipyard, who may not have the resources or time to intelligently interrogate and question a shipbuilding specification, assess its validity to be transposed into a cohesive design, and then have the ability to distil out and develop a ranked set of dominant design drivers and requirements from which a 'solution cloud' can be produced and analysed in order to robustly down-select solutions for incorporation into the building blocks for an near-optimal operationally effective ship design.

The solution to the above is not straightforward but is achievable given time, as the LNG bunkering sector matures. It will require the determination of all stakeholders (trading ship operators, LBV shipowners, ship designers, shipbuilders, industry organisations, regulators, etc.) to work together in a collaborative manner.

Figure 2: 2018 newbuild 7,500m^3 LBV *Kairos* bunkering MS *Visborg* at Visby on the island of Gotland, Sweden, in the Baltic (courtesy of Schulte Group)

LNG bunker vessel design for operation

Compatibility of the LBV with the receiving ship(s) is the key issue in designing a near-optimal LBV and the primary driver is alignment, so the driving force is knowing to whom you are going to supply. Hence, a thorough and robust compatibility study is now key in the ship design process. Although typically shipyards will not like this as, as discussed above, they typically want to build an LBV that suits their production processes. However, shipyards together with shipowners are learning quickly that LBVs are different to both traditional oil bunker barges and also coastal trading and small-scale feeder LNGCs. Hence, both parties need to understand with certainty and to some depth what the design must achieve in operation and then undertake additional investigations, design and engineering, compared say to a small-scale Feeder LNGC, to address this.

Noting the above, the LBV hull must of course be of sufficient size and configuration for:

- LNG cargo capacity and containment system, and possibly fuel oil capacity;
- Cargo configuration – number and distribution of tankage;
- Navigational constraints for operations in certain ports and waterways – length, breadth and operational draught, and maybe also air draught due to bridges etc. and possibly implications regarding line of sight etc.;
- Limiting/good dimensional relationships regarding global strength, intact stability, roll motions, freeboard (regulatory and for survivability) etc.;
- Internal topology – subdivision is critical not only for damage stability performance, but also for efficient operation and maintenance;
- Water ballast capacity – number and distribution of tanks and is constant draught required/desired during bunkering evolutions to minimise freeboard change, or can a 'ballast free' design be facilitated with maybe only trimming ballast;
- Bunkering and transit environments – possible requirement for low wash hull form for operation in restricted waters with very good slow or zero speed manoeuvrability characteristics, good motions whilst bunkering for safety and operations;
- Mooring and enlarged multiple fendering systems, and operations;
- Bunkering systems / allowance for station (manifolds) offsets, together with bunkering and crew transfer operations;
- Machinery, and propulsion and manoeuvring systems, for very good slow or zero speed manoeuvrability, usually incorporating dynamic positioning (DP);
- Accommodation block, probably including enhanced crew levels over those for small-scale feeder LNGCs; storing and associated laydowns etc.; life saving appliances (LSAs) etc.;

The three key and unique aspects driving the design of LBVs, in addition to standard ship design drivers, are:

- Parallel Middle Body (PMB) length – To facilitate safe and efficient mooring operations. The outcome is quite often a longer LBV, with non-typical dimensional ratios compared to traditional coastal trading / small-scale feeder LNGCs or oil bunker barges. However, such a design will have a significantly larger operational envelope and hence potential utilisation and earning potential advantage over a slightly shorter LBV of typical dimensional ratios which may have a marginal advantage on first (construction) cost, manoeuvrability, etc.;
- Manifold(s) location and alignment – LNG bunkering has been undertaken with the LBV moored side-by-side with the receiving ship, hence LBVs are typically fitted with midship manifolds, potentially more than one set at different heights above the waterline (or main deck), with associated equipments and craneage to facilitate hose handling. A number of newbuild LBVs have high-reach cranes and long LNG hoses and associated storage reels to accommodate bunkering high freeboard receiving ships in the open-air on their main deck, however 'gun port' doors located in the side shell above the waterline, as is standard for bunkering of fuel oil etc. has now emerged as the preferred option for cruise and container ships etc. negating the requirement for such craneage and hoses. Receiving ships with LNG bunker manifolds on the bow or stern are now appearing, hence requiring LBVs to have additional manifolds at the extreme bow or / and stern with associated craneage etc. to facilitate hose handling which could obviously lead to issues related to relative locations of the LBV and receiving ship PMBs and the location of the fenders on the LBV. At present tandem mooring has not been adopted, even when there are very difficult and complex bunkering operations, however given time LBV designs will probably evolve to facilitate tandem bunkering operations as this would by default eliminate the required parallel body length issue for safe mooring;
- Access from the LBV to the receiving ship – Access from the LBV to the receiving ship is obviously a major safety issue in preparing for and concluding mooring and bunkering operations. Typical solutions involve the utilisation of ladders or man-riding cranes. The current adoption of 'gun port' doors located in the side shell of the receiving ship is assisting this situation.

Conclusions

As eluded to above, the design of an LBV is not simply an exercise of taking an existing design for a small-scale feeder LNGC, adding some cranes and fenders etc. and adapting the cryogenic cargo system to export LNG. It is so much more as it is a little-known and very advanced ship type which is operationally and technically unique with very specific and different design drivers in addition to standard ones.

The design and capacity of LBVs varies vastly at present due to current perceived demands, charters etc. and is obviously to some degree influenced by the current and proposed shore infrastructure. Hence, the design of LBVs will also change as local infrastructure develops as well as the design of receiving ships, to be bunkered with LNG, evolves.

Due to the complexity of LBVs, they attract a cost penalty compared to a standard small-scale feeder LNGC of the same capacity. Hence, in developing a robust solution for bunker operations the utilisation of purpose-built LBVs must be closely considered and managed with care to justify the investment needed.

Consequently, this requires some new thinking and collaboration on behalf of both the LBV owners (and the operators of potential receiving ships) and ship designers. In addition, the development of an operationally robust LBV requires the sometimes significant adaption of current marine technologies and incorporation and marinisation of some new ones to both the hull and its systems. *NA*

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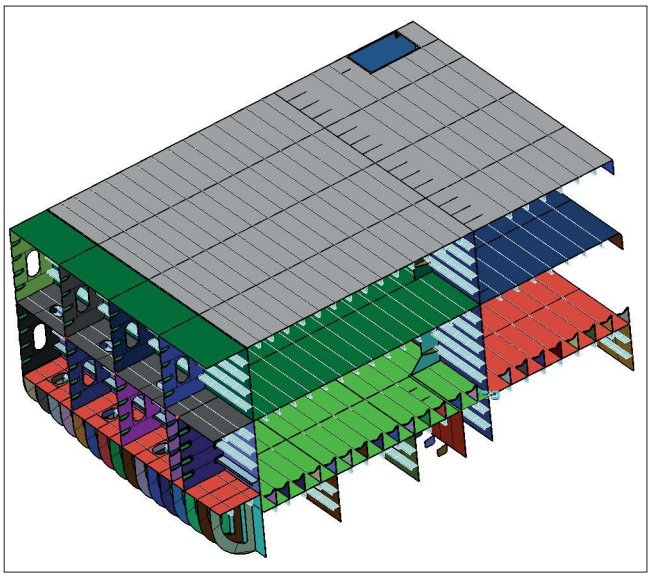
MSC Software and DNV GL partner for streamlined design and simulation

Smoother workflow using the MSC Apex and Sesam software platforms promises improved productivity

A common criticism of the maritime industry is that it lags behind other industries when it comes to workflows and upgrading to new technologies. It's a problem compounded by the many different CAD tools in use, which have to be carefully, but laboriously, converted before a design's safety can be properly assessed for finite element (FE) analysis.

So a tool that can automate that process and take a model from almost any CAD system and simplify the meshing process has an invaluable role to play. That was certainly the view of class society DNV GL, which in February announced it was entering a strategic partnership with MSC Software to connect workflows using its Sesam structural and hydrodynamic analysis software with those of MSC Apex. The partnership will see DNV GL sell MSC Apex as a tool for translating from CAD to CAE.



CAD to CAE meshing with MSC Apex

Geometry and meshing

First launched nearly six years ago, MSC Apex has evolved considerably, according to Stefan Tynelius, Apex business development specialist at MSC Software. "The first release of MSC Apex focused on the CAD-to-Mesh process based on its strong geometry and meshing tools. Over the years we have built out MSC Apex to a full-blown pre and post processor, with its own built-in solver, while continuously strengthening the geometry and meshing tools."

Tynelius, naturally, thinks there are a number of things that make MSC Apex unique, but draws particular attention to the thought and energy that went into developing a tool that is both intuitive and easy to learn. "In fact we've received several awards for the MSC Apex GUI [graphical user interface] and its ease of use."

Because Apex can import most CAD formats it removes the need to invest in additional translators. Another innovation is its Python based scripting, which makes it possible to automate and speed up workflows.

"Whatever new functionality we implement, we set a goal to ourselves to make the workflow 10 times more efficient than how it is done traditionally. This shows particularly well in our geometry tools and methods, which is often the key driver for new users," says Tynelius.

Although MSC Apex is only just starting to make inroads into maritime, it represents a small but growing sector that builds upon its larger uptake by the aerospace industry. "Interestingly enough, a ship and an aero structure, for instance a fuselage or wing, are designed and analysed with very similar methods. Both structures need to be stiff yet weight efficient and, in addition, its panels need to resist buckling under pressure."

The greatest time and cost savings from a tool such as MSC Apex come during the model generation phase, where the stripping out of tedious tasks can reduce the time taken from weeks to days. Starting with an existing 3D CAD, which are often both large and very detailed, the geometry tools allow the user to idealise a detailed CAD to the right level, conforming with the strict modelling guidelines prescribed by classification rules. The user can automatically remove small, unnecessary details in the geometry, or align and extend geometry together, but also replace stiffeners with 1D beam representations that have the right properties and offset.

Design compliance

As such, it dovetails with the functionality of DNV GL's Sesam platform. "Sesam is used to show compliance of the structure with the design rules, in this case particularly the Common Structural Rules for Bulk Carriers and Oil Tankers, DNV GL Ship 1A and Offshore rules. Based on FE structural analysis, the design is evaluated with regards to buckling, yield and design," explains Ole-Jan Nekstad, Sesam product director at DNV GL.

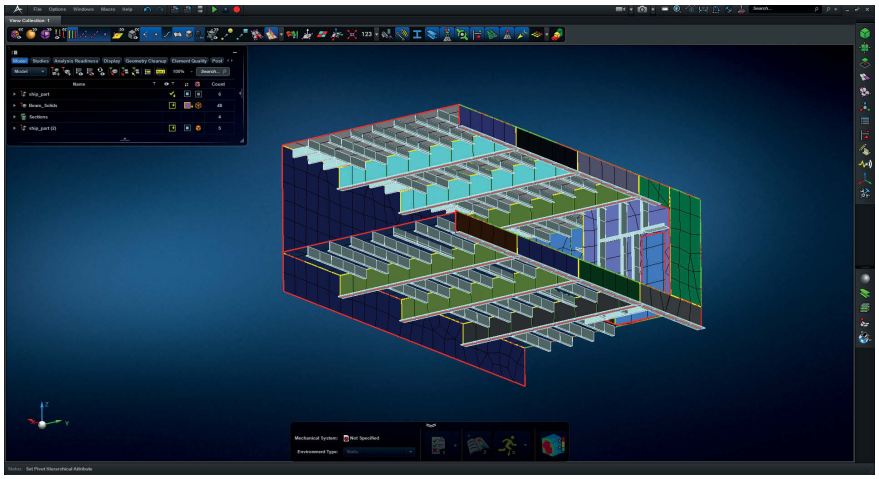
"MSC Apex is a very powerful tool with great opportunities for automating and scripting the preprocessing of the CAD assembly, running in batch," he notes, adding that the two companies already have a long-term relationship through their collaboration in the development of the

Sesam Patran-Pre software for geometry and FE modelling.

"The first workflow we are targeting [under the new partnership] is the model generation and meshing phase, where the FE model is built and attributed (with material, beam property and thickness data) before applying the ship-specific loading in the Seasam/Nauticus Hull tools for further analysis and code check," says Tynelius.

Shipbuilding is cautiously moving towards model-based plan approval, replacing the old drawing-based approach. DNV GL's own APPROVED project, which led to the development of the Open Class 3D Exchange initiative for defining a neutral exchange format (see *The Naval Architect*, May 2019), is helping to create a smoother workflow between yards and designers.

MSC Apex exports in the so-called Nastran bulk data format, which itself has become an industry standard for FE models. "Most, if not all, commercial CAE packages have a way to import and export in Nastran," notes Tynelius. "In addition, we can export geometry to the Parasolid, IGES, STEP and SAT formats. We've streamlined the exchange between MSC Apex and the DNV GL tools to preserve all information between the two applications." *NA*



The tool can be used for the optimisation of all large fabricated structures, but is gaining popularity for ship design

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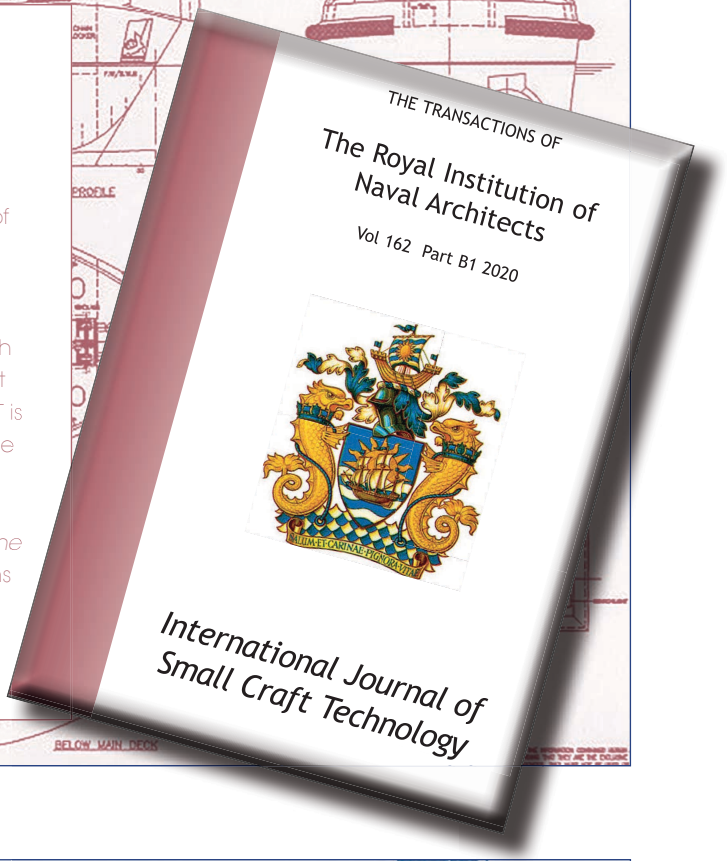

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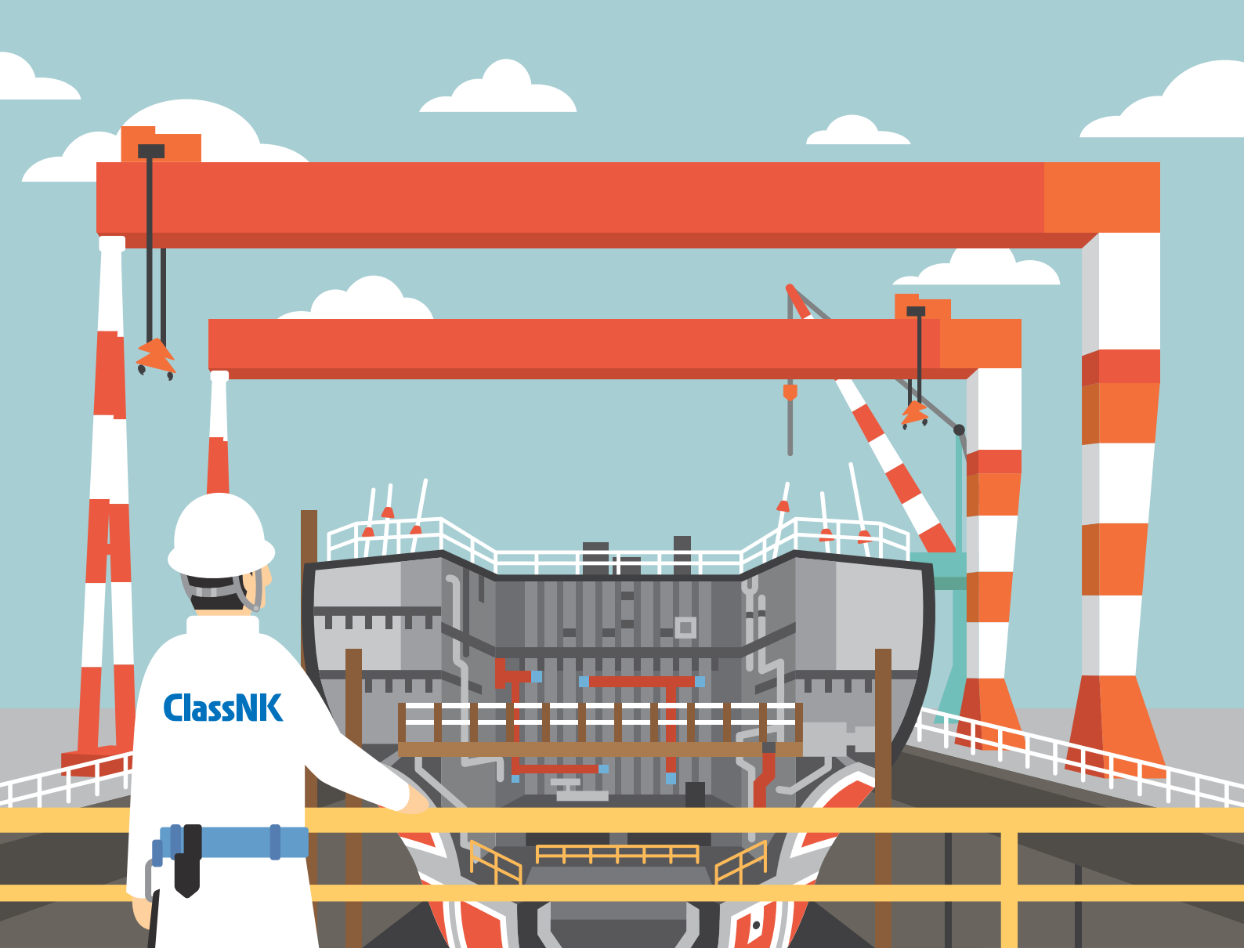

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