DECEMBER 2021

THE MOTORSHIP

MARINE TECHNOLOGY

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ExxonMobil: Helping operators map the route ahead for marine industry sustainability

Supporting operation during a period of change

ExxonMobil continues to provide the services, low-sulphur fuels and related lubricating oils vessel operators need to help achieve the International Maritime Organization's (IMO) ambitions of reducing international shipping's carbon intensity and greenhouse gas emissions.

Talk to the experts

ExxonMobil, in partnership with The Motorship, recently hosted a virtual roundtable, 'The role of fuels and lubricants in helping meet future marine industry sustainability ambitions'.

The discussion explored the role of cross-sector collaboration, future fuel options and a stable regulatory framework in supporting the maritime sector meet the upcoming IMO ambitions.

Read the full write-up of this discussion, which includes input from industry experts from IBIA, WinGD, Bureau Veritas, Danaos Shipping and SeaRiver Maritime.

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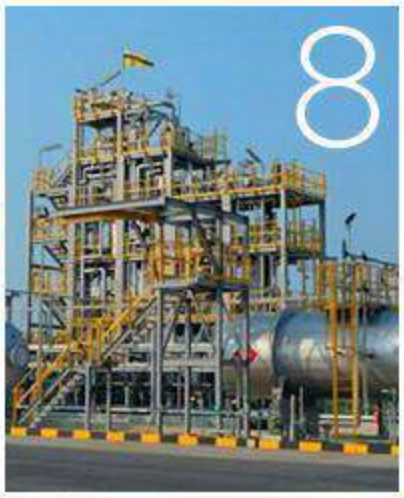

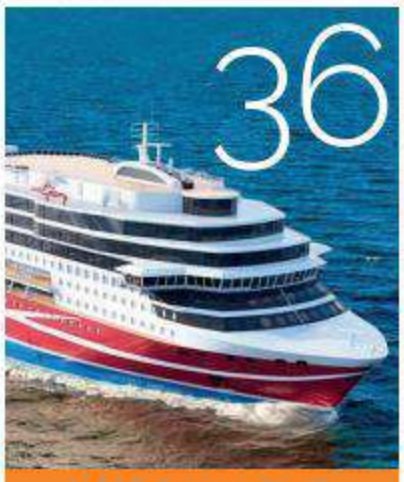

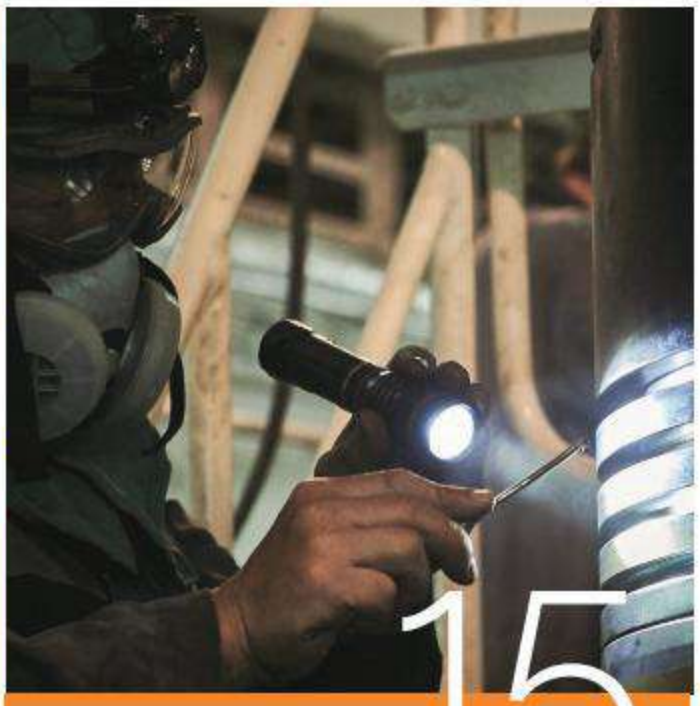

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Putting our house in order

Without downplaying the structural difficulties facing the IMO in maintaining a consensus about greenhouse gas reduction targets, given divergent national strategic objectives and commercial considerations, there remains an urgent need for the maritime industry to reach a sustainable solution. Not least because the industry needs to speak with one voice to outside actors seeking to impose solutions upon it.

Two particular looming decisions illustrate the complexity of the task. The recent 77th session of the IMO's Marine Environment Protection Committee (MEPC) agreed that a revised version of the IMO Strategy on Reduction of GHG Emissions from Ships would be considered at MEPC 80 in 2023. Advocates will call for targets to be raised towards zero emissions by 2050.

MEPC 77 also hosted wider ranging discussions about the potential introduction of market-based measures, with a variety of different approaches under consideration. The 12th Intersessional Working Group on the reduction of greenhouse gases from ships will consider such issues among others.

However, the rapid pace of regulatory development in other areas outside the maritime sector is continuing to advance apace. To take one example, climate-related financial disclosure requirements were originally introduced on a voluntary basis in 2017. By the time the MEPC 80 meets to consider the revised strategy in spring 2023, mandatory reporting requirements will have been introduced in the UK and the EU.

While many of our readers may not have a personal interest in climate-related financial disclosure requirements, charterers and beneficial cargo owners have been preparing for the introduction of tighter reporting requirements for some time. Similar proposals are under consideration in the US.

Exactly how mandatory reporting of Scope 3 emissions, which encompass downstream supply chain emissions for mining companies and oil and gas companies, is likely to affect chartering requirements for shipowners remains unclear. After all, there is little likelihood of spot availability of LNG-fuelled vessels for the largest bulks or crude oil trades emerging any time soon – and little appetite to introduce premiums for lower emission alternatives, as analysts tell us in a focus in this month's issue.

Yet the parallels with the inexorable rise in investments in alternative fuel projects are clear. Both are changes with wide ranging implications for the maritime sector imposed from outside shipping. We include reports on the first string test of a large-size Ballard PEM fuel cell set-up at Kongsberg's facility in Norway, as well as hydrogen and CCUS projects in the Netherlands in this issue.

What is equally clear is that engine designers and suppliers are rising to the challenge of developing innovative solutions. Hans Jensen Lubricators discusses achieving a feed rate of 0.5g/kWh for six-cylinder MAN B&W ME-C engines in one feature.

In our most intriguing story, Wärtsilä's Sangram Kishore, General Manager of the Product Management & Engineering department within Wartsila Ship Power 2 stroke business, explains how Wärtsilä has developed a cryogenic fuel supply and combustion concept for existing 2-stroke engines. The patented technology will be launched commercially as part of Wärtsilä's 2-stroke future fuels conversion platform during the first quarter of 2022.

METHANOL SOLUTIONS FOR FOUR-STROKE ENGINES

Source: MAN Energy Solutions

MAN Energy Solutions has announced plans to bring a dual-fuel, medium-speed engine capable of running on methanol to the market by 2024, with a dual-fuel hydrogen engine for the stationary market expected in 2023. The introduction of medium-speed dual-fuel engines capable of operating on ammonia would follow the emergence of consumer demand.

MAN Energy Solutions is enabling its customers to exploit a multitude of synthetically manufactured, climate-neutral fuels.

"In 2022, we will offer engines that are designed for later conversion – if required – to methanol operation. From 2024, we will make solutions for the use of methanol in four-stroke engines available."

Krems identified the development of green future fuels as central to the decarbonisation of shipping. "By 2050, greenhouse gas emissions in ship transport must decrease by at least 50%. We will therefore make future-proof solutions available to our customers, which will make the diversified use of green fuels possible – both for new engines and engines in the existing fleet."

For MAN customers who want to implement sustainable solutions today, Krems idenfitied biofuels as a potential ship fuel that could reduce emissions. "Sustainably produced biofuels, for example those derived from waste woods, can reduce CO2 output by up to 85%," said Krems.

The Motorship has reported that MAN engines using power-to-X fuels such as synthetic natural gas (SNG) can be operated totally climate-neutrally.

Ammonia

Turning to ammonia, Krems noted that: "In container ships with a two-stroke engine, ammonia will certainly play a decisive role and such an engine will be available from 2024. When it comes to the four-stroke segment, we have already discussed the relevance of this fuel in great detail with our customers. Cruise ships or ferries, for example, are basically floating cities and have especially high safety standards. Here, we only see options for ammonia's use if initial, positive operating experiences have been gathered in other segments."

"As soon as there is a demand for an ammonia solution, we will be ready," emphasized Krems. "With our two-stroke engines, we are the pioneers when it comes to ammonia and we have the necessary, developmental competence. Together with partners – as part of the 'AmmoniaMot' research project – we have already defined the steps necessary for the development of a four-stroke, multi-fuel engine that can also operate on ammonia. As soon as relevant fields of application emerge, we will be able to handle them."

Hydrogen

The company's Alexander Feindt discussed the company's plans to develop 4-stroke combustion engines capable of operating on hydrogen fuel at The Motorship's conference in Copenhagen in early November. The first of the two concepts under development is a dual-fuel H2 engine, using port fuel injection, which will be able to operate on hydrogen at up to 25% combined with LNG or diesel, which could be introduced as soon as 2023. The second concept is a compression ignition engine that would be capable of operating on pure hydrogen, which could be introduced as soon as 2026.

ROLLS-ROYCE USES BIG DATA TO EXTEND TBO INTERVALS OF MTU SERIES 4000 ENGINES

Rolls-Royce has announced that it is introducing significantly extended engine running times of up to 96,000 hours between overhauls (TBO) for the latest generation of its mtu Series 4000 engines for commercial marine.

The engine manufacturer is now recommending that its latest generation of mtu Series 4000 engines can now run for up to 25 years before they need a major overhaul. While the precise time will depend upon the duration and intensity of use, this is seven years more between overhauls than previously recommended.

Rolls-Royce's first step is to adjust the TBO and maintenance intervals of the latest generation of Series 4000 (M05) for commercial marine. This is valid for all load profiles. Specifically, this means that, for example, the TBO of a 16V 4000 M65L tugboat engine in the lowest load profile for this application ("Tug low") will be doubled to 54,000 hours. The longest TBO of all engines in the series is offered by the mtu engine of the type M55R with a running time of 96,000 hours in the lowest load profile.

The revision to the TBO intervals has been enabled by Big Data analysis of tens of thousands of real engine data sets, which has enabled Rolls-Royce to accurately predict engine and component running times. Rolls-Royce has a database of more than 50,000 data sets from 18,000 engines in service. On this basis, Rolls-Royce can predict exactly which components can be operated for how long, so that replacement only takes place when it is necessary.

While the new TBO intervals and maintenance schedules apply to new engines of the type 4000 M05, Rolls-Royce is also planning to adapt the TBO intervals for the M03 and M04 engine generations of Series 4000 in the near future.

Denise Kurtulus, Vice President Global Marine at Rolls-Royce Power Systems, said: "Making the operation of commercial vessels more sustainable and climate-friendly is a key driver for us. That is why we are particularly pleased that our customers will be able to use their mtu engines in an even more resource-efficient way in the future. The longer intervals between major overhauls mean, among other things, that fewer parts have to be produced and the amount of travel among service personnel is significantly reduced, which is good for the climate. Lifecycle costs are reduced for our customers, helping them to compete in the tough marketplace."


Rolls-Royce

Rolls-Royce is extending the time between overhaul time for new type 4000 M05 engines following Big Data analysis of tens of thousands of real engine data sets

VOLVO PENTA IN POWER-BY-THE-HOUR TEST

Volvo Penta has announced plans to trial a new power-by-the-hour business model in 2022. The company is planning to pilot the new business model with Hurtigruten when Norwegian expedition cruise operator takes delivery of a new hybrid day tour vessel.

The new M15 passenger vessel, which will be powered by a twin D4-320 DPI Aquamatic hybrid solution, is intended to be used by tourists visiting Svalbard in the Arctic Ocean. The day boat is due to be delivered to Hurtigruten in May 2022. During the trial, Hurtigruten Svalbard will pay by the kilowatt-hour for its operation.

The trial offers advantages for both parties, as Volvo Penta will gain insight into customer behaviour and hybrid usage patterns. The engine manufacturer also noted that "e-mobility-as-a-service" model offers a potential solution to the higher upfront costs associated with battery-hybrid solutions, which represent a particular barrier to adoption for smaller-sized boats.

Source: Volvo Penta

Volvo Penta will trial a power-by-the-hour concept with Hurtigruten in 2022 for a hybrid M15 day boat.

BRIEFS

Microsoft inks deal

Microsoft signed a partnership deal with Wärtsilä in December to industrialise the marine Internet of Things (IoT). The deal will support an intensified focus by Wärtsilä on remote operation capabilities, shared data standards, and cybersecurity. The deal will bring together Wärtsilä Voyage products on a common platform, enabling faster deployment and easier maintenance of technologies and software.

DNV acquisition

DNV announced a deal to acquire cyber security specialist Applied Risk in November. The two companies will operate together under the DNV brand, with a goal to build the world's largest industrial cyber security business, offering cyber security services to the maritime sector and other industrial sectors. As maritime assets' control systems become increasingly connected, the risks posed by as well as the frequencies of cyber-attacks are increasing.

First AI Register

LR launched the first standardised digital register of LR-certified Artificial Intelligence (AI) providers and solutions in November. The register encompasses applications ranging from digital twins and virtual commissioning to autonomous navigation systems. The technology providers listed include heavyweights such as Furuno, HAT Analytics, KSOE, SHI, HHI and ZhenDui Industrial Artificial Intelligence.

Data modelling JDP

WinGD is contributing to a JDP with ABS, NYK and the MTI to build a digital model of a PCTC's hybrid propulsion and electrical generation and distribution system. The modelling and simulation project is intended to evaluate the impact of new technologies on a design, allowing granular simulations of the potential for greenhouse gas (GHG) reduction and optimisation of the vessel's propulsion and electrical plant.

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JAPAN ADVANCES HYDROGEN SUPPLY CHAIN BASED ON LOHC

A string of partnerships across Australasia are taking shape as Japan looks to secure a commercial hydrogen supply chain using a liquid organic hydrogen carrier by 2025.

Japan currently depends on fossil fuels for about 94% of its primary energy supply and was the first nation to adopt a national hydrogen framework in 2017. It plans to expand its hydrogen market from two to three million tons per year by 2030, increasing to 20 million tons per year by 2050.

Key to the plans is Chiyoda's SPERA Hydrogen™ technology based on the liquid organic hydrogen carrier Methylcyclohexane (MCH). This carrier, produced from toluene, can be used to safely store hydrogen under ambient temperature and pressure in large quantities for long periods, resulting in a volume of approximately one 500th that of hydrogen at ambient temperature and pressure. It can be in a liquid state from -130˚C to 100˚C, can be carried by existing chemical tankers and is compatible with existing industrial petroleum-based infrastructure. After dehydrogenation, the toluene can be repeatedly recycled to produce more MCH.

Source AHEAD

■ **Trials of seaborne shipments of MCH from a production facility in Brunei (pictured) to Japan where successfully completed in 2020.**

Australian potential

In November, Japanese energy company ENEOS furthered its collaboration with Chiyoda and the Queensland University of Technology in Australia by expanding the scale of their technical verification of a supply chain initially tested in 2018. A technology produced by ENEOS significantly simplifies the production of MCH by producing it directly from water and toluene. Previously, it was necessary to store hydrogen produced via water electrolysis in a tank before converting it to MCH. ENEOS says the new electrolysis process can reduce production costs by approximately 50%. In 2023, ENEOS plans to complete a 150kW electrolyser, with an electrode surface area of about 3m3. By 2025, it plans to have a 5MW system.

ENEOS signed an MoU with Australian energy company Origin in August to study the development of a supply chain out of Queensland shortly after signing one with Neoen exploring the potential for a supply chain out of South Australia. Neoen has over 2GW of renewable energy generation in operation or under construction in Australia. In South Australia, the Goyder Renewables Zone and Crystal Brook Energy Park combine wind, solar and battery storage to provide a stable renewable energy supply. ENEOS is also exploring the potential for MCH exports from Western Australia with Fortescue Future Industries.

Refinery trials

In Brunei, ENEOS, Chiyoda Corporation, Mitsubishi Corporation, Mitsui & Co. and Nippon Yusen Kabushiki Kaisha (NYK) have agreed to use hydrogen produced in Brunei for ENEOS's refinery decarbonization trials. The hydrogen, delivered as MCH, will be supplied by the Advanced Hydrogen Energy Chain Association for Technology Development (AHEAD), an organization that was jointly established by the partners in July 2017. The ENEOS trials are being funded by Japan's consortium for resilient oil supply (CROS).

Trials of seaborne shipments of MCH from a production facility in Brunei (pictured) to Japan where successfully completed in 2020.

AHEAD successfully completed trials of the world's first international shipment of MCH and stable extraction of its hydrogen in 2020 when it delivered MCH produced in Brunei to Japan. AHEAD used 24-kilolitre ISO tank containers to ship the MCH, but it plans to use 10,000dwt chemicals tankers for the ENEOS trials.

At present, most of the industrial-use hydrogen in Japan is consumed during the desulfurization process at petroleum refineries. This is so-called grey hydrogen which is derived from fossil fuels in processes that emit CO_2. Replacing it with CO_2-free hydrogen derived from MCH can help to reduce industrial CO_2 emissions.

ENEOS is also collaborating with Petronas in Malaysia on the development of a CO_2-free hydrogen supply chain. The two companies plan to convert hydrogen produced in Malaysia into MCH for transport to ENEOS refineries. Petronas plans to use co-product hydrogen produced at its petrochemical plants, a source it sees as highly stable. Green hydrogen derived from renewable energy and blue hydrogen produced from fossil fuels will also be considered.

Chiyoda makes global plans

Separately, Mitsubishi Corporation, Chiyoda and Sembcorp Industries have agreed to explore the development of a commercial-scale, green hydrogen supply chain for Singapore. Sembcorp plans to test the blending of green hydrogen with natural gas via its domestic power generation assets and also plans to supply carbon-neutral hydrogen to local customers for fuel, chemical feedstock and other applications.

Chiyoda and Mitsubishi Corporation are also teaming up with Port of Rotterdam Authority and Koole Terminals to determine the feasibility of importing MCH into Europe. The companies aim to import up to 200,000 tonnes a year in 2025 and to double that by 2030.

Chiyoda anticipates that demand for MCH will continue to grow as hydrogen demand around the world grows exponentially.

■ Vale's Ponta da Madeira Maritime Terminal (pictured) has nominal loading rates as high as 16,000t/h.

SCOPE 3 REPORTING RULES TO ALTER CHARTERING MARKET

While operators have not seen any direct effect of Scope 3 emission reporting on chartering of ships, analysts expect improved visibility to lead to lower GHG emissions becoming a minimum threshold for larger charterers

The announcement by the UK government on 29 October that UK businesses with a turnover of above £500 million with be required to report their Scope 1, 2 and 3 emissions from 1 April 2022 may not have made front page news in the shipping media. But the expected introduction of the EU's own Corporate Sustainability Reporting Directive on 1 January 2023, and US moves to require greater disclosure indicate that Scope 3 disclosure requirements are likely to have a significant impact on the market.

There is a precedent for environmental considerations affecting operations and earning potential. Tankers International, the London based operator of VLCCs notes that its fleet of 62 ships are divided in three separate sub pools. The first one encompasses modern vessels fitted with scrubbers, the second one modern ships that have not been equipped with exhaust gas cleaning systems while the third one covers ships aged 15 years or more.

"Vessels with different attributes have specific trading patterns and earnings potential and this division ensures fair sharing of earnings and costs between similar vessel types. This division is purely financial and from a commercial perspective all vessels trade as one single pool," the company notes.

However, the impact of Scope 3 reporting is likely to be felt as major charterers and beneficial cargo owners announce plans to lower their own supply chain emissions. This has led to renewed interest in investments in LNG powered bulk carrier newbuildings from other shipowners in the bulker market.

However, this may not be the way ahead for everyone. "We do see a higher focus on Scope 3 emissions in general. We are not particularly keen on LNG as it has problems regarding methane slip that needs to be addressed. Also logistics and availability would be challenging for our markets," Anne-Louise Dam-Rasmussen, Head of Communications at D/S Norden in Copenhagen, told *The Motorship*.

Shipping along with other modes of transportation

The Greenhouse Gas Protocol defines Scope 3 emissions as ones that occur from sources owned or controlled by other entities in the value chain, such as materials suppliers, third-party logistics providers, waste management suppliers, travel suppliers, lessees and lessors, franchisees, retailers, employees, and customers.

"The scopes are defined to ensure that two or more companies do not account for the same emission within scope 1 or scope 2," the organisation says in its accounting and reporting standards report.

The Carbon Trust in the UK summarises the matters by saying that Scope 1 covers direct emissions from owned or controlled sources. Scope 2 covers indirect emissions from the generation of purchased electricity, steam, heating and cooling consumed by the reporting company. Scope 3 includes all other indirect emissions that occur in a company's value chain. For iron ore or bauxite producers, seaborne emissions are dwarfed by emissions from smelters or blast furnaces downstream.

The European Commission points out that since the organisation itself is not emitting these emissions itself it can be difficult to obtain the necessary information about them and at the same time the organisation has less influence on reducing these emissions.

To identify best practical examples of reporting Scope 3 emissions, three organisations have invited submissions of methods for reporting Scope 3 emissions in a competition open for Eco-Management and Audit Scheme (EMAS) registered German or German speaking organisations that closed in November. The best examples would be used to facilitate Scope 3 reporting.

In the US, the Environmental Protection Agency (EPA) has produced a number of emission factors and information on how to calculate Scope 3 emissions from Scope 1 and 2 ones. Transport and distribution, both upstream and downstream, are included in the emission factors currently available, it says on its website.

CSSC's first dual-fuel VLCC for COSCO Shipping entered sea trials in September

The company operates a fleet of 527 vessels, of which 356 are dry bulk carriers and the rest product tankers that include the Norient pool It has committed to only order vessels with the latest zero emission technology from 2030 and it intends to reach net zero emissions by 2050, which requires a shift to the use of new fuels.

Realignment of economics and environment needed

Shipping analysts that The Motorship spoke to said that a key challenge that the shipping industry is facing at the moment is that charterers by and large are not willing to pay a premium to charter ships that utilise green technologies. Instead, they want to focus on ones that offer lower fuel consumption than the benchmark standard design in the category in question.

"In car carrier markets, customers might be willing to pay more (for green technologies), because they often highlight the green credentials of the vehicles they produce," said Petter Haugen, shipping analyst at ABG Sundal Collier in Oslo.

"The question whether Scope 3 emissions reporting affects chartering decisions is yes, but in practice, the question is about what alternatives are available," said Jorgen Lian, shipping analyst at DNB Markets in the Norwegian capital.

A problem is that the cost of chartering ships is a fairly small item in the overall expenditure of a large oil company or a miner. However, there is little indication that they would be prepared to pay a premium for ships that use greener technologies than the standard tonnage on the market.

So rather than seeing the emergence of different charter rates, some charterers may simply introduce a minimum eligibility requirement.

Commodity traders that also are major charterers of tanker and dry bulk carrier tonnage have small margins in their core business. This reduces their willingness to pay higher rates for ships that are greener.

"What we would have to see for the situation to change is see the realignment of the economic realities with the environmental goals," Lian summed up.

Haugen noted that unless funding is made available in the form of grants to finance more expensive, green technologies, regulation would be the key to drive to reduction of emissions from ships.

There is a considerable financial risk for a ship owner to proceed with these technologies as there is no certainty at the moment which one or ones of the various potential candidates will eventually emerge as viable, he concluded.

More consolidation, new business models

Clouded as the horizons may be at the moment, this does not mean that nothing would happen. "Experience from previous disruptions indicates that markets could be significantly changed by the mid-2030s. The ownership landscape could become more consolidated and new business models are likely to mature," Danish Ship Finance (DSF), the Copenhagen based shipping bank said in its market report in November.

"A fragmented approach to decarbonisation and fleet renewal may increase costs without bringing significant opportunities for additional value creation from standardisation, digitalisation and business model innovation."

"With the introduction of servitisation models, vessels can be improved regularly without asset owners being asked to invest in upgrades with long repayment profiles. We need a race to the top, led by pioneering companies. This will spur all stakeholders to take bolder action," DSF stated, adding that those owners who miss out would lose out.

Charter rates should begin to reflect vessels' energy efficiency in order to improve operational efficiency. "In today's charter market, it is uncommon for the vessel owner to bear the burden of a vessel's inefficient fuel consumption, since it is the charterer that pays for the fuel.

This could begin to change with the introduction of CII ratings – or the charter model could lose competitiveness with owners operating their own vessels (potentially in pools)," the bank said.

Ship owners who are responsible for their own fuel bills may well calculate that energy efficiency investments offer a higher rate of return compared with higher cost alternative fuels. This may increase the attractiveness of energy saving device solutions, such as air lubrication or wind-assisted propulsion solutions, compared with alternative fuels.

The picture becomes even more complex when one bears in mind that owners often receive risk adjusted return on investment only in an occasional super cycle on the freight markets. This fact is partly due to the very fragmented nature of many shipping markets, where small and medium sized owners dominate the landscape.

Otherwise, selling a ship at a profit is the only way to make money. This again is a disincentive for large scale upgrades of existing ships or innovative thinking when it comes to newbuildings, DSF concluded.

MAJORS TARGET SCOPE 3 CUTS

The introduction of Scope 3 emissions reporting will accelerate the focus for extractive industries, such as oil and gas producers as well as miners, to lower the carbon footprint of their supply chains.

These efforts can have a material effect on shipping, but they also provide an opportunity for shipping and its customers to develop new, greener technologies that will help both to reach their environmental targets.

Several oil majors have set their strategies to reduce their CO2 emissions and the London School of Economics and Transport Pathway Initiative have calculated how major European integrated oil and gas companies intend to proceed, including their Scope 3 emissions

Among the observations that the research team headed by Simon Dietz, professor of environmental policy, was that if the companies increase their renewable sales exceed those of fossil fuels, then the carbon intensity of their operations would decrease. For this reason, it is important that emissions are looked also in absolute terms rather than relative ones, they noted.

The world's first dual fuel LNG powered VLCC started sea trials in September in China and Total was the first oil company to opt for this fuel on a VLCC when in 2020 it agreed to take on charter two newbuildings due to enter service in 2022.

It is not just the oil companies that are looking to reduce their Scope 3 emissions, but also those in the mining sector. The proportion of shipping of the total Scope 3 emissions may be rather small, but these companies have taken shipping under scrutiny as well and quite a few have set targets to reduce them significantly.

Brazil-based mining major Vale has announced a target to reduce its net Scope 3 emissions from its client and supply chain by 15% by 2035, with further reductions likely to be announced at 5-year intervals.

To put the scale of such a reduction into context, Vale's transportation-related Scope 3 emissions in 2019 accounted for 3% of Vale's total greenhouse gas emissions, or around one-third more than its Scope 1 and 2 emissions put together.

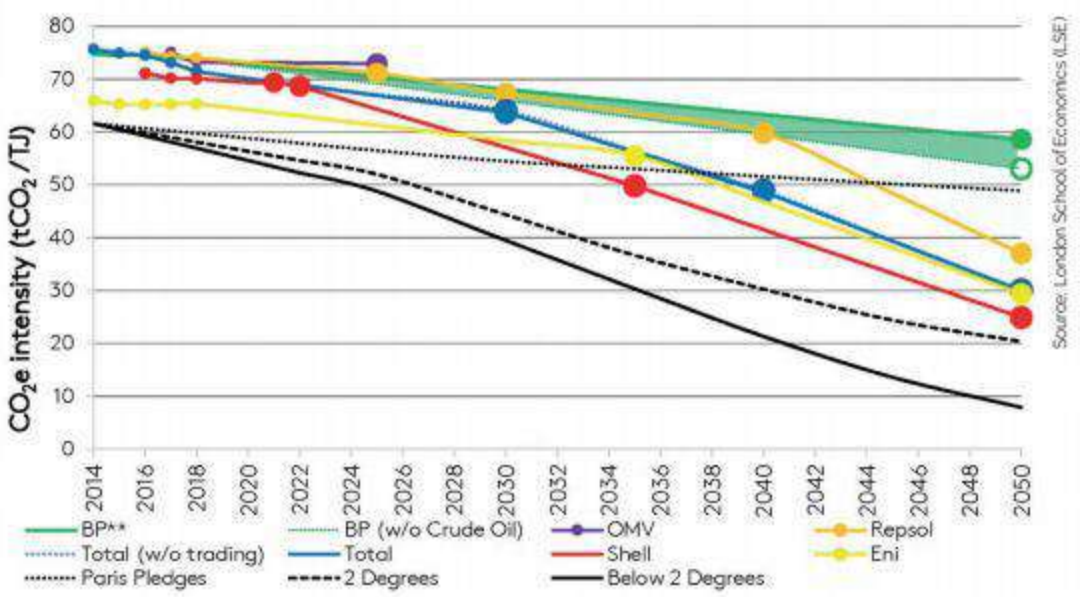
Other mining companies have also announced plans to amend Scope 3 emissions. Anglo American PLC, the London based mining company, which has calculated that its Scope 3 emissions amounted to 225.37 million tonnes of CO2 equivalent in 2018. Upstream transportation and distribution of purchased goods accounted for 0.45 million tonnes of this and the company says this is not considered to have a material impact on the overall Scope 3 emissions.

On the downstream side, these admissions were about ten times greater, 4.31 million tonnes and the company said it considers emissions from its iron ore business as material to overall Scope 3 emissions. "This product type accounts for most emissions arising from downstream transportation and distribution activities, due to customer distances being notably greater than for the other commodity types and the significance of the bulk product moved," it noted in a report on its emissions.

It regards emissions from this category as material, as well as considering climate-risk exposure and the company's influence over supplier practices.

LNG and biofuels in spotlight

The company has committed itself to reach carbon neutrality in shipping operations that it controls - the company operates a fleet of about 30 bulk carriers - by 2040 and a reduction of 30% in emissions by 2030, it said in a strategy unveiled in early November.



Scope 3 emissions reduction targets for oil majors

"Our ambition to decarbonise our controlled ocean freight activities is aligned with our climate related goals set out in our Sustainable Mining Plan. We aim to fulfil it through a framework of comprehensive solutions that will include alternative marine fuel options and will be backed by regular and validated emissions performance reporting," Silvia Danti, communications lead, marketing told The Motorship.

"At this stage we have committed to four LNG-fuelled Capesize plus vessels. The vessels will be owned by U-Ming Marine Transport and are expected to be delivered by 2023," she added. The ships were ordered in 2020 and their CO2 emissions should be 35% less than those of a comparable size vessel using conventional fuel.

Rio Tinto, the Anglo Australian mining giant, has set a target to reduce its Scope 3 emissions by working together with steelmakers to cut carbon intensity of this process by at least 30% from 2030, with carbon neutrality as an aim by 2050, according to a report by IHS Markit.

This - and similar statements by other companies - could be significant for the shipping industry, given their importance in a number of major commodities carried by Capesize bulk carriers.

Rio Tinto has also opted for LNG powered ships to reduce its Scope 3 emissions. These totalled 519.4 million tonnes of CO2 equivalent in 2020, of which transport and distribution accounted for 8.1 million tonnes.

To reduce these, the company has agreed to take on 10 year time charters 12 Newcastlemax vessels that will use LNG as fuel and which will be owned by Eastern Pacific in Singapore and H-Line Shipping in South Korea.

The ships, which will be built at two Chinese shipyards, will have high- pressure ME-GI engines from MAN Energy Solutions and have two 3,100 m3 C-type LNG storage tanks. Each vessel will cost $67 million and they will be delivered from late 2023 to early 2024.

Australia-based BHP, which announced plans to end its dual-listing in London in August 2021, was the first mining company to agree a deal for LNG powered Newcastlemax ships. In late 2020, it decided to take on five year time charter five ships that Eastern Pacific would order in China, with deliveries set for 2022.

LESS CAN BE MORE: OPTIMISING FEED RATES WITH CONDITION

Rasmus Mandrup Jeppesen, AfterSales Manager at Hans Jensen Lubricators discusses the reduction of lube oil consumption to 0.5g/kWh on two K-Line bulkers

Given the importance of cylinder lubrication for the reliable operation of 2-stoke marine engines, it is unsurprising how much attention lube oil consumption receives from many shipowners and fleet managers. K-Line Bulk Shipping UK is no exception and has since 2019 been using HJ Lubtronic 2.0 SIP (Swirl Injection Principle) as their main engine lubricator. This system allows for an optimum cylinder condition compared to a standard cylinder lubricator, which was key elements for the company.

Since December 2020, K-Line has been working closely with the Aftersales & Service department at Hans Jensen Lubricators in order to find the optimum balance between having a low consumption of lube oil combined with good cylinder conditions. The aim of the project was to reduce the feed rate to 0.50 g/kWh, from around 0.9 g/kWh, using a BN 70 Lube Oil only. This corresponds to a reduction of daily consumption from 97 litres to 47 litres, which is equivalent to a daily saving of more than US$100.

Hans Jensen Lubricators has extensive experience in supplying advanced cylinder lubrication systems gained over the last century. The conditions the equipment faces in the harsh environments on board a vessel require planned maintenance as well as a crew that fully understands how to operate and make the most of the possibilities of our cylinder lubrication system. Through good cooperation the above can be controlled in a superior manner.

The marine engineers within Hans Jensen Lubricators' Aftersales department understand the importance of delivering consistently high performing lubrication systems. Several of the engineers have sailing experience. The team has numerous references where superior pe formance has been achieved, with specific guidance on attaining low feed rate with good cylinder conditions, and prompt follow-up.

Preparation and prior training

Before project startup, K-Line opted for specify a training webinar, which was attended by both vessel staff and office staff. The purpose of such a webinar was to familiarise both crew and superintendents of the lubrication system including countermeasures to take in different scenarios. Furthermore, the webinar offered instructions about which parameters can have an impact on cylinder conditions and how to evaluate them.

The webinar was well received and has been used for training and familiarisation for the crew. It is believed that this activity has contributed significantly to the success of the project success and efficiency of implementation.

Project background

The shipowner selected two bulk carriers, powered by 6-cylinder MAN B&W S50MC-C and S60MC-C main movers respectively, for the project.

Technological aspects

Important parameters to take in to account when undertaking a project like this are:

Vessel Names	Albion Bay / Vittoria
Year of Build	2011 / 2013
Vessel type	Bulk Carrier
Engine type	6S50MC-C / 6S60MC-C
2020 Compliance	Low Sulphur <0,5 % S
CLO BN	Navigo 70 MCL AW

Parameter	Description
Feed rate [g/kWh]	Main parameter for optimization project
Cylinder oil in use	Main parameter for a single BN oil in use
Daily consumption of	Used for visualizing savings of
cylinder oil [L/24h]	the feed rate reduction
Port Inspection Report - PIR	For evaluation of cylinder conditions
Scrape Down Analysis – SDA	For evaluation of cylinder conditions
- On board	
- Laboratory tested	
Fuel type / fuel report	For evaluation of cylinder condition with regards to cat fines
Purifier performance report	For evaluation of cylinder condition with regards to cat fines
Shop test report	Used for comparison for collected data
Main Engine performance test	For evaluation on engines performance with regards to cylinder conditions
Maintenance history for:	Used for evaluation of cylinder condition for proper recommendations
- Liners	
- Pistons	
- Piston rings	
Liner wear records	Used for comparison for the effect of the implementations of the feed rate reduction

By evaluating the data before the beginning of the project, the team will be able to focus on the aspects of the lubrication system that are affecting the cylinder conditions. In turn, this offers pointers as to where the team should focus during the cylinder condition optimisation process.

"In our experience, over lubrication is quite often a contributor to sub-optimal cylinder conditions, despite common perceptions to the contrary,". Rasmus Mandrup

"In our experience, over lubrication is quite often a contributor to sub-optimal cylinder conditions, despite common perceptions to the contrary," Rasmus Mandrup Jeppesen, AfterSales Manager at Hans Jensen Lubricators told *The Motorship*

Credit: Marine Traffic/©Iwan Afwan

The *Vittoria* (pictured) was mostly operating in the Pacific basin during the project.

Jeppesen, AfterSales Manager at Hans Jensen Lubricators told *The Motorship*.

"It is a common response to turn up feed rates when issues occur with cylinders and liners. Man times, we've seen that lowering feed rates actually enhance cylinder conditions and reduce maintenance requirements." A good place to start is to help get this point across so crew members understand the dynamics behind it.

Project timeline and Methodology

The plan is based on a progressive 5-step feed rate reduction programme to be carried out over a 7-week period, with a minimum of 100 running hours between each reduction. The project timeline was tailored to fit the specific vessels' operating profile, taking into account the vessels'schedule and the duration of port stays.

The process towards an optimal balance between feed rate and cylinder condition follows Hans Jensen Lubricators' 'SL920166 How to succeed with SIP' service letter. In this publication, it is clearly described how to establish an index point, optimize feed rate and finally conclude that an optimum has been reached. 100 running hours in each phase is chosen because each adjustment needs time to settle in the system before an evaluation of sufficient quality can be made, in order to conclude if further reduction is possible.

Index point / starting point

Starting up a project like this where primary focus is to lower the feed rate, a well-documented index point is of utmost importance. For that, a thorough analysis of Port/piston conditions, oil sample analysis, liner measurements and the current condition of the lubrication system are conducted.

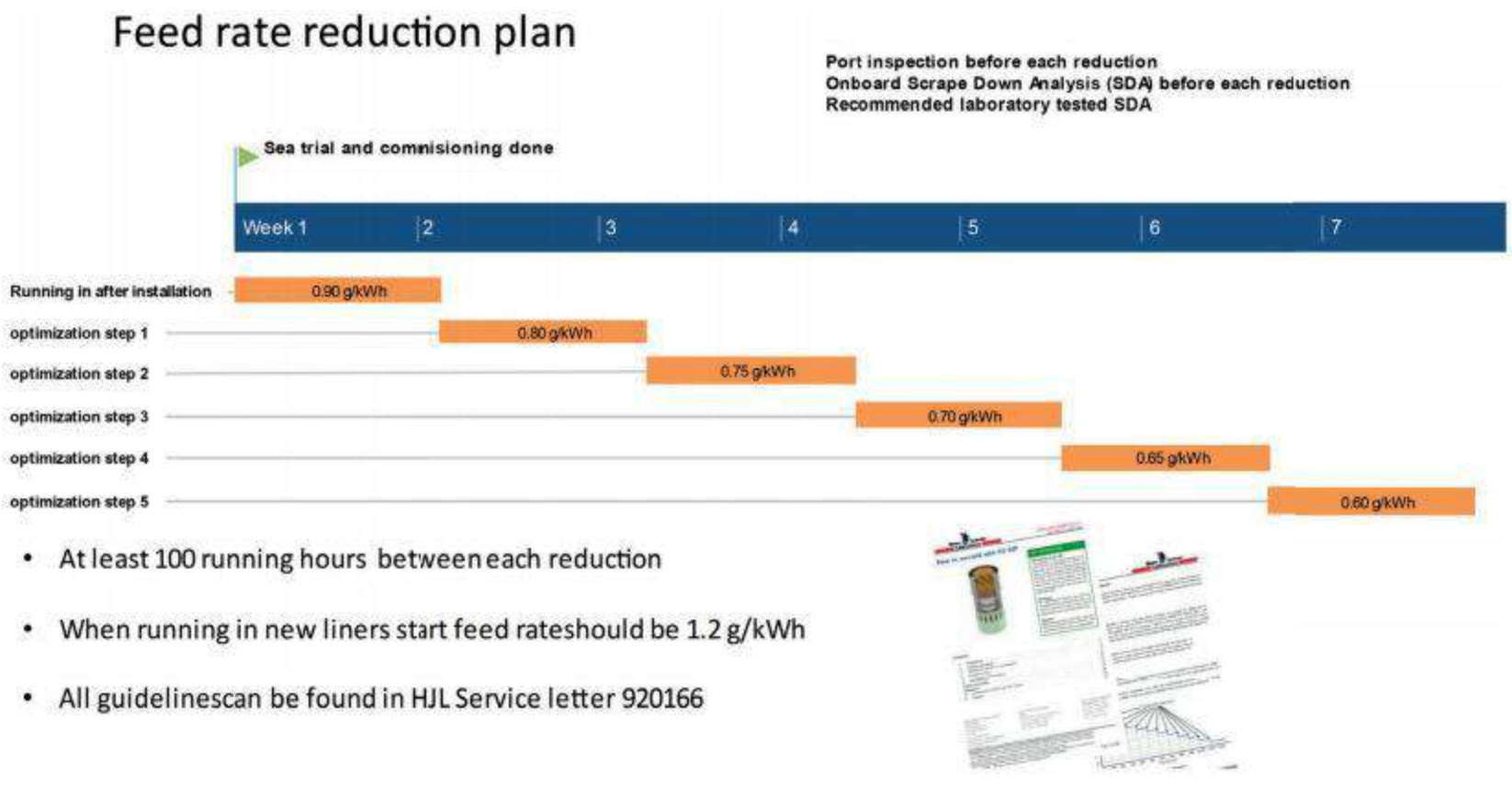
For the vessels in question a target feed rate of 0.5 g/kWh was set. While the feed rate target included a margin for iterative improvements, it was based on the supplier's prior experience gained with similar vessels.

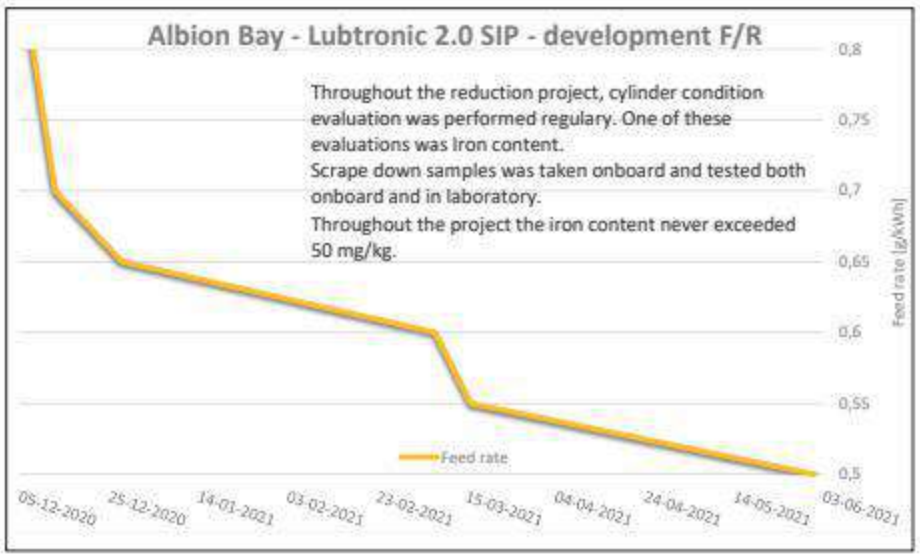
Optimization process

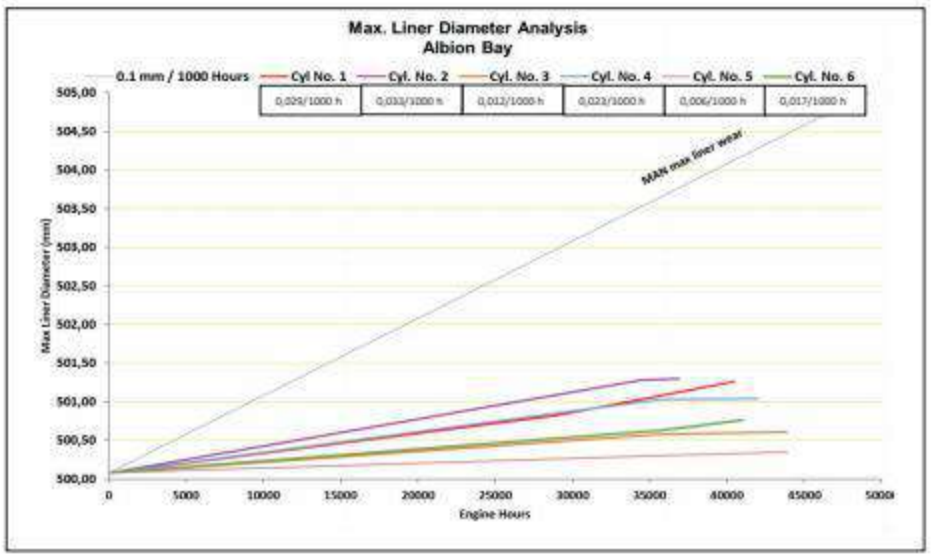
The optimization process is an iterative evaluation of cylinder condition based on port inspections and Scrape Down Analyses. These confirm the cylinder condition and indicate readiness to go for the next step. Each Scrape Down Analysis is made into a thorough report by the Aftersales Service Department at Hans Jensen Lubricators – a so-called Feed Rate Optimization Programme "FROP". With reduction steps of 0.05 g/kWh, every 100 running hours, it has been possible to reduce the feed rate continually, together with the thorough FROP, to the target feed rate of 0.50 g/kWh.

Cooperation

Throughout the project, close cooperation between Hans Jensen Lubricators and K-Line was maintained. Hans Jensen Lubricators technicians observed the progress of the







vessels on a daily basis in close contact with the K-Line superintendents. K-Line's General Manager, Mr. Georgi Yorgakiev, commented: "Your advice to our superintendents throughout the project has been invaluable."

Underlining the productive cooperation between the teams, the HJ lead technician for the project praised the close working relationship:

"Throughout this project good communication and understanding has been key for the success. Technical superintendents and HJ technical support have been in close contact from day one. Thorough guidelines have been provided by HJL and implemented by vessels accordingly, any uncertainties or doubts has been thoroughly discussed so all involved parties have been confident with the implementation steps. It has been a delight working with K-Line, which has shown a high level of commitment for the project."

Scrape down analysis

Throughout the project, as the feed rate was gradually reduced, it was found that iron content (FE) [ppm] remained below 50 ppm which indicates low abrasive wear – *Iron is appearing in scrape down samples when abrasive wear is present in the cylinder. Normal range for this when using HJ SIP valves is 0-250 ppm.*

Another important parameter to follow is the residual BN [mg KOH/g]. *The BN in the cylinder oil is used as a detergent for cleaning the cylinder. When excessive amounts of BN is present in a cylinder this can lead to calcium deposits build up on pistons and around piston rings.*

Referring to the above graphs, an onboard scrape down was taken between each feed rate reduction. Furthermore laboratory tested scrape down analysis was carried out several times through the project.

The development showed that the iron content never exceeded 50 mg/kg, even though the feed rate was reduced. As feed rate is reduced the concentration of the oil samples get more concentrated. The more concentrated the oil samples are, it can be expected that wear particles in the scrape down oil can be higher. However, throughout the project period, the wear particles amount remained below 50 mg/kg. This is a strong indication that less abrasive wear is present in the cylinders. Furthermore, as feed rate was reduced the residual BN content became higher. This is also due to the fact that concentration in the sample was getting higher. Under normal circumstances, a high residual BN can lead to deposit build up on the pistons and around the piston rings. However, we found that deposits were decreasing and cylinder condition was improving throughout the project as the feed rate was reduced," Jeppesen said.

The low iron content is supported by liner measurements which were taken throughout the project.

Port inspections

Port inspections has been carried out by crew at each port where time allowed it.

Before project start the cylinder conditions were evaluated as being acceptable with room for improvement:

After each step of reduction evaluations were made by scrape down analysis and port inspection. This showed a steady improvement of the cylinder conditions.

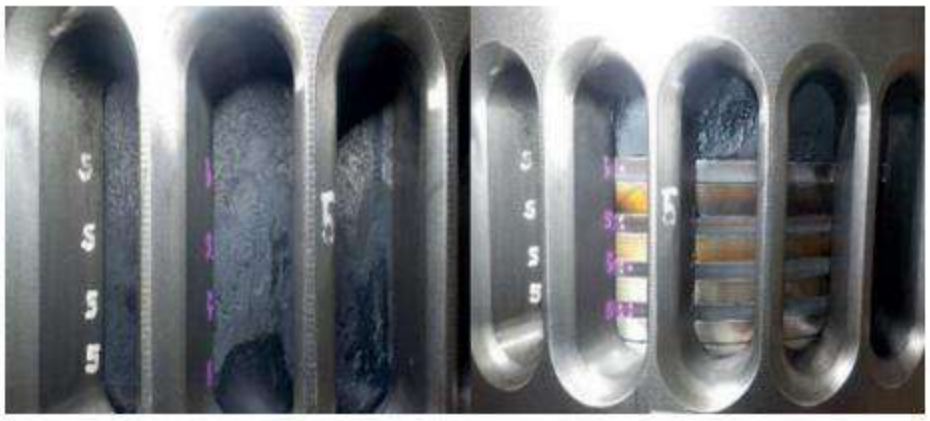
After the last reduction was implemented cylinder condition had shown much improvement:

Calcium deposits has decreased and pistons and piston rings are looking very good.

Project Conclusion

Apart from achieving an all-time low in terms of lube oil consumption, it has been possible for the vessels to use one type of cylinder oil only. The reduction plan was presented for the vessels and adjusted according to feedback. Besides the two vessels that have been part of this project, K-Line has nine other vessels with similar system setup.

K-Line has now seen in practice how to manage the reduction of feed rate while ensuring good cylinder condition, partly through the training webinar and partly through the project. K-Line intends to apply the methodology used in this project to the rest of the fleet.



Left: Above pictures taken 16-09-2020 before project startup at feed rate 1.00 g/kWh. Right: Above pictures taken 24-06-2021 after last reduction with feed rate 0.50 g/kWh

MAN OFFER NEXT-GENERATION CYLINDER PISTON CLEANLINESS

With the arrival of the first approved Category II cylinder oils, ship operators will finally have a single, simple solution for safeguarding piston cleanliness in two-stroke engines running on very low sulphur fuels

In 2019, the biggest designer of two-stroke marine engines changed the requirements for how its newest engines could be lubricated. Two years later the challenge that MAN Energy Solutions set with its Category II lubricant standards has finally been met for engines running on very-low sulphur fuel oil (VLSFO). The first MAN ES Category II 40BN to pass ship testing is just 2,000 engine-running hours away from final approval.

Underpinning that achievement is a lubricant additive package developed by Lubrizol that offers the high level of cleanliness MAN demands with the low alkaline content (indicated by base number or BN) appropriate for use with very-low sulphur fuel oils. To get there, the company has worked closely with an oil company partner and deployed new-to-marine additive technology that can help safeguard piston and cylinder condition - not just for newer engines under Category II, but also older engines which may struggle under a long-term regime of lubricant switching.

Lubrizol's product manager for marine engine oils, Edward Ng explains: "It has taken more than 18 months of intensive development and testing to meet MAN's demanding specifications. After a lot of discussions between February 2020 to July 2021 about those requirements, it is now time to focus on the benefits these new chemistries will bring to engine operators."

The immediate advantage of MAN ES Category II lubricants is that operators can end the ungainly practice of switching between high- and low-BN cylinder oils. MAN recommended the interim measure because traditional, Category I 40BN cylinder lubricant does not ensure the standard of cleanliness the engine designer requires. The frequent switching to a product with higher basicity aims to minimise abnormal deposits or wear that may occur in engine cylinders using conventional low-BN oils. The switching regime – currently employed on most main engines running on VLSFO – adds complexity to shipboard operations and procurement. And there are other disadvantages too, says Edward.

"The handling of two oils onboard has obvious disadvantages. Some vessels don't have two lubricant tanks, for example. But there is also greater potential for human error during the switching process. Then there is the added risk of overbasing engines, supplying too much alkalinity. If you use a higher-BN product frequently, this can actually lead to increased deposits on the piston crown, with reports of subsequent issues with turbo wear and aftertreatment system fouling."

While the use of Category II 40BN oil is strongly recommended for MAN's newest engine models – Mark 9 or newer – these same advantages can be gained on older engines. Operators of these engines are also currently recommended to switch between high- and low-BN oils in the absence of a Category II solution. Edward explains that depending on their operating profile, load cycle and the severity of their cylinder condition, older engines can also benefit significantly from switching to a Category II oil, reducing downtime and potentially cutting maintenance costs.

Credit: Lubrizol

Lubrizol has contributed new-to-marine additive technology to the Category II 40BN cylinder oil.

"Is it healthy or sustainable in the long-term for the engine to be constantly switching between oils, between being clean and dirty," asks Edward Ng. "What long-term influence will that have on the engine, the post-combustion systems and the vessel?"

The robust 40BN solution Lubrizol developed before IMO 2020 came into effect – designed to limit the impact of variable VLSFO quality on cylinder condition – has formed the basis of its new Category II additive package. While the first Category II oils await confirmation approval, Lubrizol's additive solution has already been accepted by MAN's research engineers.

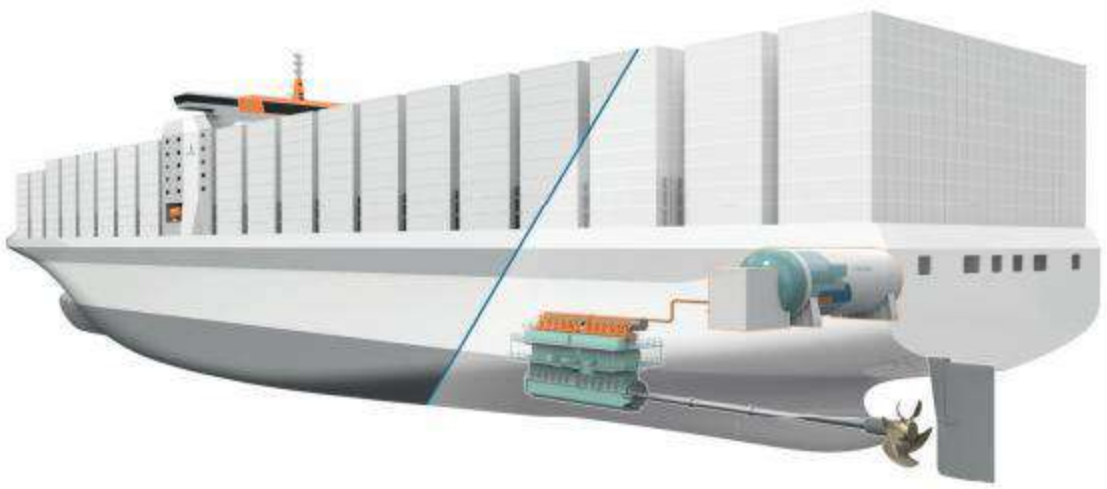
The 2020 40BN solution relied on dispersants as well as the traditional detergents to keep pistons deposit free when faced with the challenges of a wide variety of VLSFO blends. The new Category II product adds anti-wear additives to the mix, among other innovations, to bolster the cleaning power of lubricants further. In formulating the additive package, Lubrizol has drawn on its wide experience with similar additives in other sectors, including automotive and heavy-duty engines.

The indications from engine developers are that similar cleaning capabilities to MAN Category II will become the norm as new engine designs and new fuels enter the fray, posing even more challenges for piston running and ensuring the overall safe, efficient, effective lubrication for ship's engines. Those future engines will require even more innovation in the formulation of lubricant additives. For the time being, ship operators can already bring next-generation, OEM-approved cylinder lubricants to their engines – new and old – as the first Category II oils hit the market.

CRYOGENIC FUEL COMBUSTION FOR MULTI-FUEL RETROFIT KIT

Wärtsilä has developed a cryogenic fuel supply and combustion concept that combines the advantages of Diesel and Otto cycle technology and comes as a modular add-on for existing 2-stroke engines

The patented technology will be launched commercially as part of Wärtsilä's 2-stroke future fuels conversion platform during the first quarter of 2022. The platform will enable the fast and cost-effective conversion of 2-stroke main engines to operate on clean-burning future fuels. The conversion will initially enable operation on LNG with negligible methane slip from the engine, but the modular design provides a platform that will be further developed to allow for the adoption of alternative green fuels such as ammonia and methanol as they become commercially available.



A technology demonstration project of the cryogenic LNG concept will be completed on a large MSC Shipmanagement container vessel powered by a Wärtsilä RT-flex96C-B main mover by the end of 2022.

Cryogenic fuel

A world-first feature of the concept is the cryogenic fuel supply system and new combustion concept. Cryogenic LNG is supplied directly to the engine at around -150°C and at low pressure, rather than heating it to around 40°C as is done for other engine types. This eliminates the need for expensive, energy-demanding and high-maintenance equipment and means the footprint of the fuel supply system is minimal, maximising retrofit installation flexibility. On-engine pressure amplification and gas expansion using existing energy sources mean further savings on equipment and energy costs.

Sangram Kishore, General Manager of the Product Management & Engineering department within Wartsila Ship Power 2 stroke business, says the system combines the best of Diesel and Otto cycle combustion. It has the negligible methane slip and high compression ratio of Diesel cycle without the bulky, expensive fuel supply components and the simplicity and low energy demand of Otto cycle without the methane slip.

"We have been working on this for around two and a half years now, and through our testing we were successfully able to go from the pre-mixed combustion that you typically see in Otto cycle to diffusion combustion, characteristic of the Diesel cycle. It is something very different, and the standard formulas for fuel behaviour do not apply," says Nanda, who notes that the testing has involved the full-scale LNG supply system to simulate onboard conditions.

Energy efficiency has been a key consideration. The fuel pressure is amplified using servo oil power already available from the engine and jacket cooling water is used to raise the temperature of LNG to expand it to gas. "We looked at the GHG emissions impact of the whole platform, not just the engine itself," he says. "In this respect, it is a fundamentally different concept to existing systems, because the fuel supply is extremely simple with submerged pumps in the LNG tank sending the cryogenic fuel to the engine, and up until then, nothing else is needed. All the fuel preparation happens on the engine." He notes also that the new system is specifically designed to be easy and safe for crews to operate and maintain.

The development program has recently been concluded with successful initial engine tests in the Wärtsilä two-stroke engine laboratory in Trieste. Tests on a single cylinder will be expanded once the test engine is fully converted early next year. With such a new concept, testing protocols and simulations have had to be developed from scratch, said Nanda.

The packaged platform

The new equipment required for retrofit is skid mounted where possible to expediate installation. To ensure fuel flexibility, storage tanks and piping can be specified to be future-fuel compatible in advance, and a new flexible steel pipe has been incorporated to ensure retrofit is possible even where space is limited.

The modular add-ons for retrofitting include an additional control system for the new cryogenic fuel added adjacent to the engine's original one which will continue to control diesel combustion. The cylinder cover has been redesigned and two new injectors added, to ensure flame propagation and complete burn of the injected fuel. "It's like a shower," says Nanda. "This is new. It has not been done before, and we will continue to test different configurations."

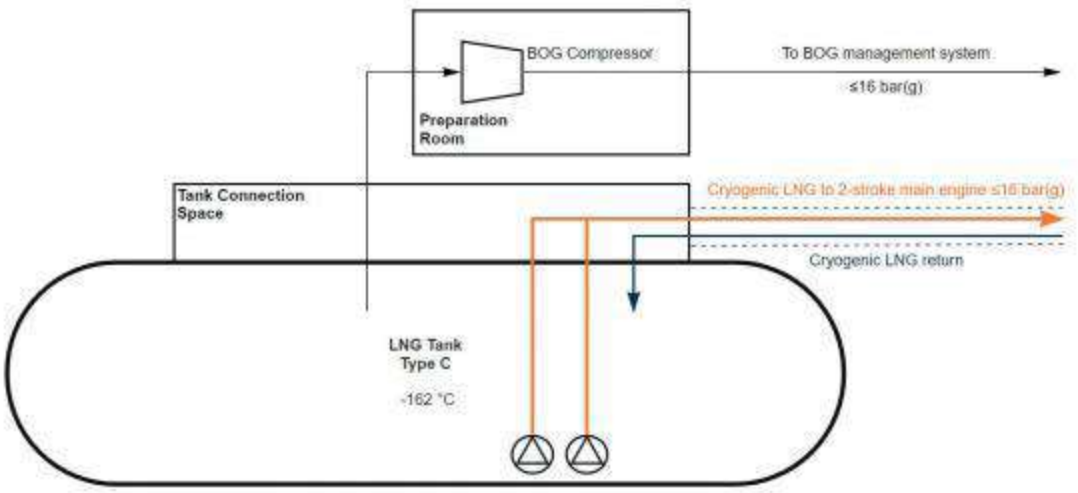
Fuel flexibility

The platform has the flexibility to handle methanol or ammonia and the higher volume of diesel needed for its

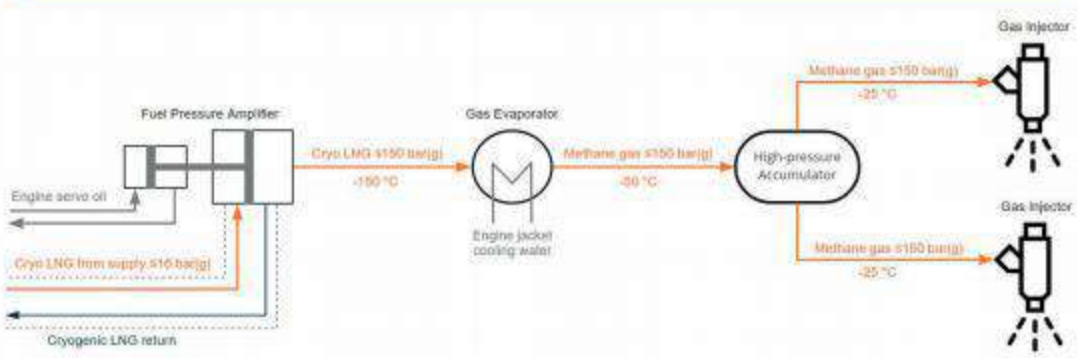
Sangram Kishore, General Manager of the Product Management & Engineering department within Wärtsilä's maritime 2-stroke business

combustion with only minor modifications to, for example, the pressure amplifier and the accumulator that distributes the fuel to the injectors. The aim is to enable ship operators to switch between fuels with minimal effort. This could mean using LNG for a time on a particular route then switching to ammonia or methanol for different operational profile if bunkering of those fuels becomes available.

Hydrogen fuel is an option for the future, but is not being pursued immediately because the relatively large fuel storage tanks required make it unsuitable for retrofitting on ocean-going ship, at least at present. To overcome this, Wärtsilä is also working with class society RINA, ABB, Helbio – a subsidiary of Metacon, the Liberian Registry, and an energy major to develop an onboard LNG to hydrogen reformer. The concept is based on combining LNG with steam to produce hydrogen and CO2. The hydrogen produced would be used directly in a mix with natural gas in internal combustion engines or in fuel cells, thus eliminating the need for hydrogen to be stored onboard.



A simplified fuel gas supply system for Wärtsilä's new cryogenic LNG concept



The on-engine fuel preparation solution for cryogenic LNG

Conversion potential

The multi-fuel retrofit platform is aimed at vessels operating with two-stroke, electronically controlled engines, including both large and smaller bore engine types. Initially Wärtsilä/WinGD branded engines will be targeted, but the technology can be applied, in principle, to any electronically-controlled 2-stroke engine.

Key benefits of the retrofit include reduced emissions and GHG footprint with negligible fuel slip and overall low energy consumption, long-term CII compliance and extended operational lifetime for the vessel, straightforward retrofitting concept minimising off-hire, fuel flexibility future-proofing and short pay-back time and access to sustainable financing.

Stam Achillas, Head of Business Development & Sales, 2-Stroke Fuel Conversions, notes that many shipowners have vessels that are five to 10 years old and that ships that run on VLSFO are still being built. "There are tens of thousands of vessels in the existing fleet that will still be sailing in the 2040s and it would be illogical to scrap them all. That is the reasoning behind this new system from Wärtsilä's perspective," he says. "We see the trend to towards future fuels and lower emissions, certainly, but newbuildings alone cannot solve the problem of shipping's decarbonisation. We need to do something today, and we made a promise to our customers that technology would be available and it would be competitive and easy to retrofit. That was our pledge, and that is what we have done."

Achillas believes the business case should be evaluated in the broader context of decarbonisation. Shipowners should consider what it would mean for the commercial viability of their existing vessels if they do nothing. "The CAPEX of our system is lower than other solutions, making it a more modest investment with a shorter payback time."

System installation

The system can be installed in three weeks during a typical drydocking. The scope of the conversion includes per cylinder: cylinder cover with fuel/gas injectors, high-pressure accumulator, gas evaporator (LNG only) and fuel pressure amplifier. Per engine, it includes: rail box enclosure with ventilation system, engine control system upgrade, instrumentation, sensors, cabinets and cables, safety and monitoring system extension, turbocharger rematching, on-engine piping, on-engine platform conversions and safety spare parts.

Wärtsilä is able to specify and deliver the full spectrum of fuel conversion solutions for merchant ships. This means: fuel gas supply system including LNG tank, 2-stroke main engine conversion, 4-stroke auxiliary engine conversion or replacement, boil-off-gas management system and safety systems. The company also offers extended support to customers with its digitally-enabled lifecycle solutions.

Onboard testing

MSC Shipmanagement has collaborated with Wärtsilä throughout the development as a key partner in the piloting and advancement of the platform towards future fuel applications. "We have been following the development of this innovative conversion solution with high interest, and we regard it as a supporting element in MSC's journey towards net zero decarbonisation by 2050. Together with Wärtsilä we have high expectations for the next steps of this initiative, which starts with technology demonstration on one of our larger container vessels with a Wärtsilä RT-flex96C-B main engine, and which will continue to make our existing fleet ready to meet future emissions needs," says Prabhat Jha, CEO and Group Managing Director of MSC Shipmanagement.

A system is expected to be installed by the end of 2022, and this vessel will be used to test different fuel types, supported by connection to Wärtsilä's remote expertise centre. The first commercial conversion project is expected to be completed by mid-2023.

Stam Achillas, Head of Business Development & Sales, 2-Stroke Fuel Conversions at Wärtsilä

HIWAR GAS REFORMER AT HEART OF HYDROGEN CONSORTIUM

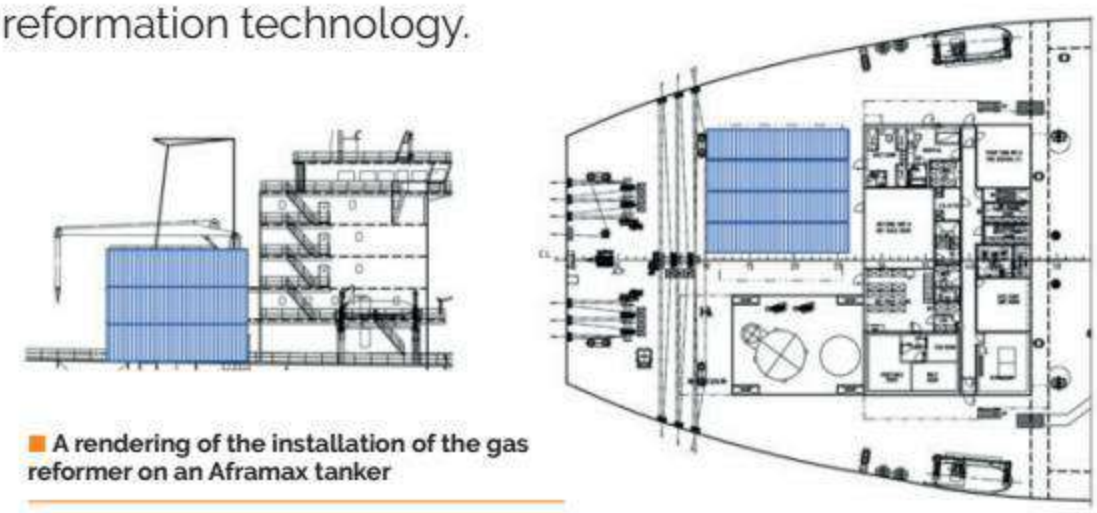
A consortium of industry participants, including class society RINA, ABB, Wärtsilä and the Liberian Registry have formed a consortium to deliver a marinized version of Greek developer Helbio's gas reformation technology.

The consortium, which also includes an unspecified energy major, believes it could accelerate the development of hydrogen as a marine fuel without the need for extensive infrastructure investment.

The difficulties and costs associated with the production, distribution and storage of hydrogen on board are barriers to adoption for hydrogen as a fuel. By producing hydrogen on board from LNG, the solution offers a potential route to exceed IMO 2050 targets for 70% reduction of carbon intensity in a much shorter time frame.

The concept is based on Helbio's patented Heat-Integrated Wall-Reactor (HIWAR) technology, which combines the ship's fuel (natural gas) with steam to produce hydrogen and CO2. The hydrogen produced would be used directly in a mix with natural gas in internal combustion engines or in fuel cells, thus eliminating the need for hydrogen to be stored onboard. *The Motorship* notes that the system can produce hydrogen with a purity of up to 99.999%, making it compatible with PEM fuel cell requirements.

The Motorship notes that the use of gas reformation technologies to generate hydrogen on board have been successfully developed and installed on board vessels previously. However, the use of such solutions has been limited to comparatively low volume solutions, such as FuelSave's FuelSave+ system, where the hydrogen has been used as an accelerant in combustion processes in diesel-fuelled engines.



A rendering of the installation of the gas reformer on an Aframax tanker

HIWAR technology

The HIWAR concept employs metal plates coated with a suitable catalyst arrayed so that exothermic and endothermic reactions take place on either side of the plate. The heat produced by combustion is conducted through the metallic walls towards the endothermic reaction of steam reforming, which take place at the opposite side of metal plate.

Helbio claims that the CPR (catalytic plate reactor) design offers superior heat transfer characteristics and minimal intra-catalyst diffusion resistance compared with conventional reactors. As a result, HIWAR reactors are smaller, lighter and have superior pressure drop characteristics compared with conventional alternatives.

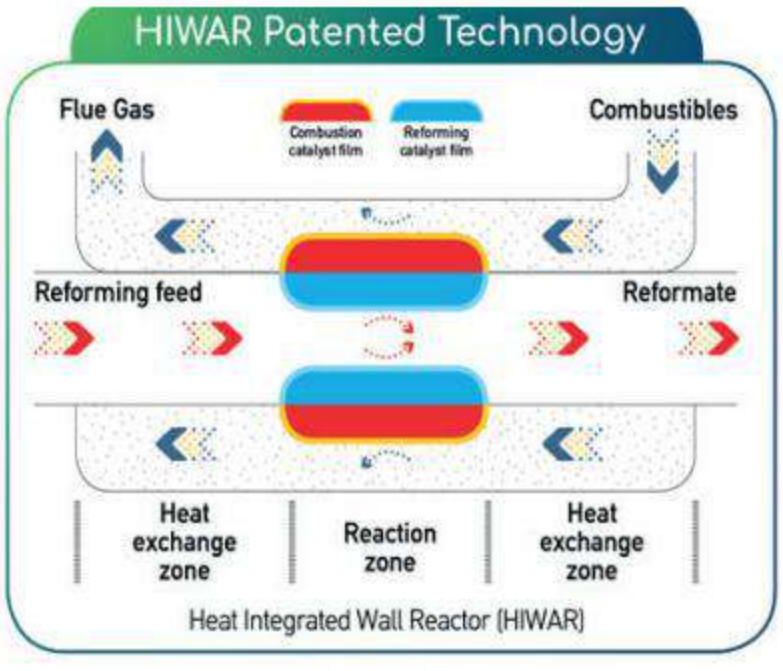
The company has also developed proprietary catalysts that improve the reformation of fuels, both in the steam reforming step and in the subsequent partial oxidation step. During the latter step, the CO2 will be liquefied by the cryogenic stream of LNG that would be used as fuel anyway and stored on board for later disposal ashore for carbon storage and use. In case of tankers, the stored CO2 can also be used as inert gas.

RINA notes that the necessary steam reformation and CO2 liquefaction equipment can easily be fitted on the deck of a commercial vessel in a progressive manner, at subsequent drydocks after the ship's delivery. The proportion of hydrogen consumed could be progressively increased by increasing the production of hydrogen on board, with a corresponding reduction in methane consumption (and associated methane slip).

Consortium

Wärtsilä and ABB will support the application of hydrogen in powering internal combustion engines and fuel cells respectively, while Helbio will provide the technology and manufacture the reformer. RINA and Liberian Registry will provide advice and guidance on the application of rules and regulations for novel concept alternative designs, based on Hazid/Hazop analyses, as well as specific rules for this kind of arrangement.

The Motorship notes that Helbio's HIWAR technology has already won orders for other applications, meeting manufacturing and safety standards applied in other industries. Helbio announced that it had successfully produced a Hydrogen Generator with a hydrogen production capacity of 50m³/h in June 2021. The generator was expected to be installed in Sweden in Q4 in a pilot installation for an automotive hydrogen refuelling station.



Helbio's technology utilises the concept of the Heat Integrated Wall Reactor (HIWAR), which offers very rapid heat exchange characteristics.

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PUTTING METHANE SLIP INTO PERSPECTIVE

Methane gained a lot of attention at COP26, and it could be good news for proponents of LNG as bunker fuel, but a global perspective is needed

The Global Methane Pledge proposed by the EU and US and supported by over 100 nations at COP26 in November commits the signatories to reducing methane emissions by 30% by 2030. While the Pledge's direct consequences are likely to be felt most keenly in the Upstream and agricultural sectors, it is likely to have an effect on IMO-level discussions around LNG.

Keller noted methane slip from all marine engine types is expected to be negligible by 2030, noting that WinGD had just set a record for Otto Cycle engines, successfully lowering methane emissions below 1g/kWh. Rather it is well-to-wake (WtW) emissions that are more concerning, and not just for LNG. Keller says that the Pledge highlights the importance of WtW measurement of GHG emissions from all marine fuels. These emissions include carbon dioxide, methane, and nitrous oxides as well as methane. "Comprehensive WtW measurement is the only way to accurately compare the viability of future fuels in a decarbonised shipping industry."

Multiple fuels, including LNG, will be needed to support shipping's decarbonisation, says Keller. Hydrogen, manufactured through the electrolysis of water using renewable electricity, when available at scale, will deliver a net-zero fuel for LNG powered vessels through the use of renewable synthetic LNG. It will be fully interchangeable with today's LNG engine, storage and bunkering infrastructure. Until then, bioLNG as a drop in fuel will offer significant GHG emission reductions beyond what LNG already delivers today, up to 23% on a WtW basis.

Dr Bryan Comer, Marine Program Lead at the International Council on Clean Transportation, emphasised that regardless of any reduction at an individual asset level, shipping was emerging as a relatively new and growing source of methane emissions. Methane emissions from ships grew 150% between 2012 and 2018, according to the Fourth IMO GHG Study.

"If countries are serious about reducing methane emissions 30% by 2030, then they should do everything they can to avoid new sources of methane emissions, including from LNG-fuelled ships. LNG only represents about 3% of global fuel consumption as of 2018 according to the Fourth IMO GHG Study, but by capacity, about one-quarter of cargo ships and half of new container ships are designed to run on LNG."

"The Pledge shows that the time for using natural gas as a bridge in all sectors has come to an end. The transition must now be from fossil fuels, including LNG, to renewable fuels that have low or zero life-cycle carbon dioxide equivalent emissions, paired with wind-assisted propulsion and hull air lubrication, as well as more efficient operations like slowing down, plugging in to shore power, or using batteries or fuel cells for zero in-port operations."

While over 70% of the global economy has signed the Pledge, mitigation potential varies. The largest potential in Europe and India is in the waste sector. In China it is from coal production followed by livestock, while in Africa it is from livestock followed by oil and gas. In the Asia-Pacific region, excluding China and India, it is coal and waste, and in the Middle East, North America and Russia it is from oil and gas. From this perspective, it is noteworthy that some largest exporters of LNG have not so far signed the Pledge: Australia, Qatar, Russia, Malaysia, Algeria and Trinidad & Tobago, Oman and Brunei.

Source: UNFCCC

Around 100 countries signed up to the Global Methane Pledge at COP26, committing them to reducing methane emissions by 30% by 2030, compared with 2020 levels.

Methane - the facts

Methane is a short-lived climate pollutant with an atmospheric lifetime of roughly a decade (CO_2 stays in the atmosphere for hundreds of years). Intergovernmental Panel on Climate Change (IPCC) research shows that it is responsible for at least a quarter of today's global warming. The recent Global Methane Assessment launched by the United Nations Environment Programme (UNEP) and the Climate and Clean Air Coalition predicts that cutting human-caused methane by 45% this decade would avoid nearly 0.3°C of global warming by the 2040s.

According to UNEP, methane from fossil fuels accounts for 35% of the total emissions resulting from human activity (agriculture accounts for 40% and waste for 20%). In the fossil fuel sector, oil and gas extraction, processing and distribution accounts for 23%. With pre-existing technology, a 75% reduction in methane emissions from the upstream oil and gas sector is possible, 50% of this could be done at no net cost. Actions include fixing leaks and reducing venting.

Source: UNFCCC

Methane slip from all engine types is expected to be negligible by 2030, Peter Keller, Chairman of SEA\ LNG said

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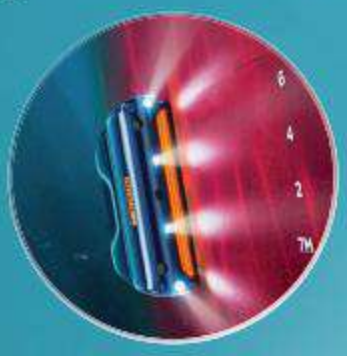

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WINGD LOWERS METHANE SLIP BELOW 1G/KWH IN TEST

During The Motorship's recent Propulsion and Future Fuels conference in Copenhagen, Dominik Schneiter, VP of Research and Development at engine designer WinGD, announced that the company had made a significant advance in reducing methane slip.

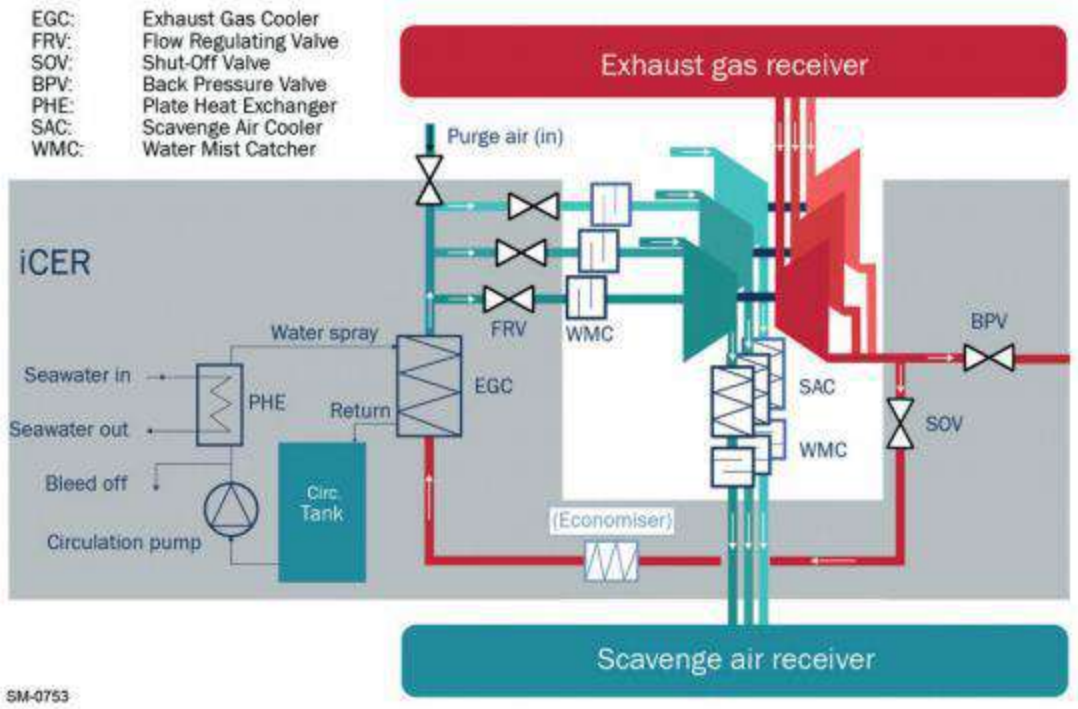
Schneiter revealed that WinGD had recently completed a test of concept trial of the extension of the Intelligent Control by Exhaust Recycling (iCER) solution to multi-turbocharger applications upon a production engine in China. During the trial it had successfully lowered methane slip emissions below 1g/kWh.

The achievement was a technical milestone in the reduction of greenhouse gas emissions from Otto cycle engines. Schneiter noted that this reduction below 1g/kWh represented "a record low for any lean-burning engine".

As reported by The Motorship, WinGD's iCER solution offers superior fuel efficiency and lower methane emissions by recirculating a significant proportion of exhaust gases.

In autumn 2021, WinGD has successfully validated the system, during a test of a 9X92DF engine rated at 42,560kW on a test system in China. The test system itself was designed to fit a larger 10X92DF engine rated at 51,680kW.

The trial results demonstrated that the solution was compliant with IMO Tier II in diesel mode, offering a fuel consumption improvement of >8g/kWh, but the more significant results were achieved in gas mode, where the solution was able to run higher compression ratios, resulting in a greenhouse gas emissions (GHG) reduction of "over 8%" using this technology. The NOx emissions were lowered below 0.5g/kWh during the gas mode, Schneiter added.



The concept was likely to be of particular interest to potential customers in the container vessel market, Dominik Schneiter noted, adding that the solution had been successfully demonstrated to selected customers and classification societies.

WinGD has successfully lowered its methane slip emissions below 1g/kWh in a recent trial of its Intelligent Control by Exhaust Recycling (iCER) solution (pictured) for multiple turbochargers

First AIP for firing boilers with methanol

Classification society ABS has granted Alfa Laval the first marine approval for operating boilers on methanol. Alfa Laval received an approval in principle (AIP) on 4 November 2021, based on extensive solution testing at the Alfa Laval Test & Training Centre.

Methanol, which is liquid at ambient temperatures and carbon-neutral if produced from green sources, is the next likely fuel step in decarbonising the marine industry. While methanol can be found on a handful of vessels and is planned for many more, its use has so far been limited to main engines. In the future, methanol operations will need to extend to boilers.

"Alfa Laval is looking at the full scope of methanol's influence on board," says Lars Skytte Jørgensen, Vice President Technology Development, Energy Systems, Alfa Laval Marine Division. "The most natural choice for boilers is to fire them with the vessel's primary fuel, but methanol's low-flashpoint nature and the differences in its energy density require a new approach to the burner and fuel supply systems. It was important for us to develop that approach, and we are proud to have it validated by ABS."

Alfa Laval has been testing boiler operations with methanol since early 2021 at the Alfa Laval Test & Training Centre, where engine combustion tests with methanol are also underway. Tests have been conducted using a pressure-atomising MultiFlame burner on an Alfa Laval Aalborg OS-TCi boiler, as well as a methanol valve unit (MVU) designed by Alfa Laval to meet the class requirements from ABS.

Initial results, obtained with both pure methanol and a methanol-water mixture, showed as expected that methanol is easy to ignite and results in very low emissions. Focus was therefore placed on securing the same steam output with methanol – despite its lower heat value – as would be the case using oil or gas as fuel. A solution was reached after a few adaptations, ensuing that a boiler of a given size can produce the same amount of steam regardless which fuel is used. This meant that development could move rapidly to optimising the fuel supply system and working with ABS on the methanol AIP.

With the AIP in hand, the next step for Alfa Laval will be a pilot installation on an ocean-going vessel. Results from field testing will be crucial in fine-tuning the methanol boiler solution and arriving at a commercial design.

Meanwhile, Alfa Laval is pursuing wider optimisation possibilities that will compensate for methanol's lower energy density and higher price. One of these is the use of an Alfa Laval Aalborg Micro economiser in conjunction with the OS-TCi. By absorbing waste heat from the boiler's exhaust gas, the Aalborg Micro would recover valuable energy and reduce boiler-related fuel consumption by roughly 10%.

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DUTCH PORT PROJECTS LOOK TOWARDS ANNEX III SOLUTIONS

While European port operators focus on the mechanics of upcoming EU regulations for shore power connections. Dutch projects are focused on developing alternative fuel supply solutions.

In an official statement in November Isabelle Ryckbost, ESPO's Secretary-General said: "Let's now work together with all policymakers and stakeholders to move forward towards investing in technologies that are effectively being used and that lead to effectively reducing the emissions of shipping, both at berth and during navigation."

Europe's ports have welcomed the review of the current AFIR proposal accompanied by provisions in the new FuelEU Maritime Proposal requiring vessels to use shore-side electricity infrastructure at berth.

There is a need for full alignment between what ports need to do and the obligations for shipping lines, including a full alignment of Article 9 of the AFIR proposal with Articles 4 and 5, as well as with Annex III of the FuelEU Maritime proposal.

The Motorship notes that the AFIR proposal currently only addresses the shore side electricity installation in the port, thereby overlooking the issues of grid connectivity, grid capacity and grid conversion.

ESPO has called for wider electricity grid strengthening issues to be tackled in the proposals as they are essential to make installed SSE operational. The installation of substations, as well as grid connections and strengthening the grid can be required to ensure the supply of shore-side electrical power to certain vessels. Such installations and upgrades are often outside the remit of the port authority/ port managing body.

Prioritisation is essential in that respect. For ESPO, it would be more effective to define the scope based on a minimum level of traffic volume per terminal (instead of per port) to prioritise busy terminals and avoid underused capacity being installed.

A separate issue relates to operational requirements, as ports will need to know if a shipping operator intends to use onshore power supply or rather one of the other alternative technologies foreseen in the Annex III of the proposal.

While ESPO looks forward to working with the EU Parliament and the Council to deliver a 'coherent package', the ports of Amsterdam and Rotterdam and stakeholders are still researching the viability of expanding shore power facilities for seagoing vessels.

Dutch shorepower projects

As yet there are no final results about the Amsterdam-based sectors that test a battery that can be fuelled with local wind energy or with biomass for shore power. Electricity supplier Eneco and the Port of Rotterdam still conduct a feasibility study for the use of cold ironing at the Vopak Europoort Terminal.

Due to the side effects of Covid, the studies are slightly delayed, although the building of a kind of hydrogen-powered port vessel – as part of the project – has been commissioned. The battery-electric 20-metre long vessel will be deployed in the port of Amsterdam in 2023.

The Port of Rotterdam, Eneco and Heerema materialized a joined study for cold ironing at Caland Canal. Recently their collaboration resulted in the installation of two 10 MW Shore Power connections to fuel the Heerema fleet.

The seaport and the City of Rotterdam are also busy completing a joint shore-based power strategy. The objective is to have eight to ten shore-based power projects in place before 2025. It is to be a learning process to roll out shore power on a large scale throughout the port area after 2025.

The Port of Rotterdam is currently active in the development of a CCUS project, the Port of Rotterdam CO2 Transport Hub and Offshore Storage project (Porthos).

Annex III technologies

In parallel with investment into shorepower connections, research into potential Annex III technologies is continuing in the Netherlands. The Dutch government recently allocated EUR150 million (US$169.7 million) towards eight industry-research institute partnerships to stimulate the development of decarbonisation technologies in the maritime, aviation and automotive even sectors.

Credit: ESPO

Isabelle Ryckbost, ESPO's Secretary-General

The partnerships include three projects focused on hydrogen carriers, methanol, and green LNG, respectively. LNG_ZERO to reduce the LNG propelled vessels substantially, MENENS that focus on methanol as a sustainable fuel for shipping, and Sustainable H2 Integrated Propulsion Drives for vessels.

LNG-ZERO

The LNG-ZERO project is intended to accelerate the development of an innovative circular approach using recycling CO2 captured on board LNG-fuelled vessels to produce synthetic LNG using electricity from renewable energy sources (such as offshore wind).

The project brings together Netherlands-based shipowners, such as Antony Veder and Heerema, with suppliers, such as VDL AEC Maritime with Carbotreat and Carbon Collectors, and TU Delft and TU Twente. The project is also being supported by Shell, as well as Port XL, a Rotterdam-based technology accelerator. The project has an EUR6.1 million budget, to which the Dutch government has contributed EUR4.4 million.

The project is also intended to develop technologies to significantly reduce methane slip (CH_4) and NOx emissions from LNG-fuelled vessels and will also examine potential integration with carbon capture use and storage (CCUS).

The Port of Rotterdam is currently active in the development of a CCUS project, the Port of Rotterdam CO2 Transport Hub and Offshore Storage project (Porthos). The project brings together Energy Beheer Nederland, Gasunie and the Port of Rotterdam, and is intended to store an annual amount of 2.5 million tonnes of CO2 from industry in empty gas fields beneath the North Sea from 2024.

ETS funds

European Community Shipowners' Associations (ESCA) President Claes Berglund takes R&D in environmental protection seriously from a broader perspective. In an official statement, he advocates for a dedicated fund to be set up under the EU ETS to stabilise the carbon price, which is especially important for the many shipping SMEs. "Importantly, generated revenues should support the uptake of clean fuels," he said, adding that ECSA's first preference always is an international regulation for shipping at the IMO level.

Dutch Royal shipowners' association KVNR environmental specialist Nick Lurkin underlines ESCA's statement for the Dutch affiliate, adding that the overall focus is not particularly on shore power. However, developments in cold ironing are mentioned. "We should stress the need for uniformity in connection and power of shore power supply onto smaller vessels and container carriers, preferably worldwide but certainly in Europe", he said.

He added that the safety and capacity of renewables are also topics in climate protection discussions. "IMO is sometimes accused of acting slowly, but the organisation is in the forefront in the development of safety in the use of hydrogen. As yet, it is still subject to find out the real benefits of use and the need to adjust vessels technically to this particular kind of fuel."

■ **The pure electric barge *Alphenaar***

Assistant Professor Marine Engineering Klaas Visser at the Delft University of Technology welcomes all developments in research and use of hydrogen and other renewables, shore power included, for seagoing vessels and inland navigation. When talking to *The Motorship* he mentioned the first Dutch electric propelled barge Alphenaar (length 90 metres, with 10.5, 1,900 tonnes carrying capacity). CCT deploys the pure-electric barge between Alphen aan den Rijn to Moerdijk for a daily service for brewery Heineken. The two ZESpack containers of 2000kWh guarantee two to four hours of propulsion to cover 50 to 100 kilometres.

Wider energy transition aspects

The Netherlands government announced a hydrogen strategy in April 2020. The strategy designated the north of the country as a Hydrogen Valley, with up to EUR850 million expected to be invested in industrial projects between 2021 and 2025. The strategy included a focus on the promotion and development of a fuel cell manufacturing cluster in the region.

The government is also supporting efforts to modify the country's existing natural gas transmission network to store and transport hydrogen as fuel. The country's gas network operator, Gasunie, is developing a hydrogen network to connect the northern seaport Delfszijl/Eemshaven with Amsterdam, Rotterdam/Moerdijk and southern Zeeland and southern Limburg by 2025.

> **"We should stress the need for uniformity in connection and power of shore power supply onto smaller vessels and container carriers, preferably worldwide but certainly in Europe**

■ **Assistant Professor Marine Engineering Klaas Visser at TU Delft**

FUNDING TO ACCELERATE DUTCH HYDROGEN FUEL CELL PROJECT

A Netherlands based consortium intended to accelerate the introduction of hydrogen into the maritime sector has been awarded a grant of EUR24.2 million (US$27.4m) from the country's R&D Mobility Fund.

The project – SH2IPDRIVE – is intended to develop the application of hydrogen in the maritime sector. The project has a total budget of EUR34 million, with the consortium's participants contributing EUR9.4m, which will be used to support research and development into multiple avenues for hydrogen.

While the consortium has a strong focus on inland waterway applications, which is the focus of two of the project's five concept designs (covering newbuilds and retrofit solutions for inland shipping), the consortium is also looking at special vessels, short-sea and coastal shipping and passenger vessels.

The consortium includes Royal Dutch Shell, Bosch Rexroth, a number of local research institutes including TU Delft and MARIN and a number of local shipyards, including Concordia Damen Shipbuilding, IHC Holland and Holland Shipyards. The Netherlands' hydrogen fuel cell cluster is well represented, including Future Proof Shipping and Nedstack Fuel Cell Technology.

The Netherlands' TNO and Defence Materiel Organisation (Defensie Materieel Organisatie) are also participants in the project.

The project includes representatives from the entire value chain, ranging from hydrogen producers, through storage and transportation suppliers, and naval architects and a local shipowner, Van Dam Shipping. Koedood Dieselservice B.V. will be one of the leads in the system integration package.

Innovative hydrogen carriers

The project includes separate work packages focused on hydrogen bunker and storage systems, hydrogen carriers and fuel cells, each coordinated by distinct working groups.

The hydrogen carrier work package will conduct new research into the development of safe technologies for: compressed hydrogen gas (CH2); liquid hydrogen (LH2); as well as hydrogen vectors such as liquid organic hydrogen carriers (LOHC) and finally borohydrides. The Motorship has previously covered Dutch research into several potential solutions under consideration.

Image: Nedstack B.V.

■ **Research into pairing a sodium borohydride storage solution with a PEM fuel cell was conducted under the the H2SHIPS project**

The fuel cell work package includes research into new fuel cell systems with a greater power density, and a longer lifespan, as well as the use of residual heat and the scaling up of fuel cells.

The full list of work packages includes: data collection and system validation; system integration; modular testing; ship design; and safety.

"SH2IPDRIVE will ensure the Dutch maritime sector is in a prime position to respond to the expected market demand for hydrogen systems by providing the necessary innovation stimuli to the technology developers, suppliers, shipowners and shipbuilders and will strengthen the country's competitive position as a leader in the field of maritime hydrogen applications." Klaas Visser, Ship Design, Production & Operations - TU Delft.

Visser told *The Motorship* that the alternative hydrogen vectors merited further research, noting that sodium borohydride's characteristics had implications for safety and fuel containment. Visser identified several key advantages associated with the hydrogen fuel technology, including a potential higher energy storage density (38.5 MJ/kg), that is similar to that of diesel fuel. While the material was flammable, it was slow-burning, by contrast with some other forms of hydrogen.

Visser noted that sodium borohydride also had a significantly higher volumetric density than compressed hydrogen. This meant that the space requirements for containment systems were lower, which was an advantage for PEM fuel cell applications. When based on a 250 kW PEM fuel cell, 5m³ of sodium borohydride would be sufficient to power the fuel cell for 70 hours of operation.

Source: Holland Shipyards

■ **The consortium includes Future Proof Shipping, which collaborated with Holland Shipyards on the retrofit of a 110m long inland container vessel for hydrogen-fuelled operation at the group's yard in Hardinxveld earlier in 2020**

SUCCESSFUL STRING TEST FOR PEMFC PROPULSION SYSTEM

Kongsberg successfully concluded a string test for a full-scale electric propulsion system based on 600kW of hydrogen-powered PEM fuel cells at a facility in Ågotnes outside Bergen on 1 December.

Kongsberg claims that the test was a world first for a full-scale, full-size, zero-emissions drivetrain powered by hydrogen-fuelled fuel cells designed for ships and ferries.

The full-scale HySeas III test at Kongsberg's facility in Ågotnes, Norway on 1 December 2021 was attended by Minister of Trade and Industry Jan Christian Vestre, Egil Haugsdal, CEO of Kongsberg Maritime, and Geir Håøy, president of Kongsberg.

The test formed part of the EU funded HySeas project, which has been running since 2013 to prepare and demonstrate a scalable hydrogen system for ships and ferries. Kongsberg has been the technical lead of the project, which has also involved Caledonian Maritime Assets Limited (CMAL), McPhy Energy and Orkney Island Council, as well as Germany's DLR Institute of Networked Energy Systems.

The installation of the Ballard HD-100 PEM fuel cells

The string test involves the assembly of key power-train components and testing them as a system, prior to the commencement of any ship building. The tests, which were devised and conducted by Kongsberg, are designed to evaluate and optimise system performance, response, control and safety. In this case, the testing mirrors the operational loads which would be experienced by a vessel on a route between Kirkwall and Shapinsay in Orkney.

The string test involved the fuel cell system, consisting of 6 x 100kW Ballard HD-100 fuel cells, two Multidrives, the vessel's energy storage system and energy management systems, transformers and switchboards. Variable load banks were used to simulate azimuth and bow thrusters. The vessel's hydrogen storage and piping system, cooling system and safety, alarm and detection systems were also included.

Kongsberg welcomed the string test, which will provide information about safe operation and the system's power and fuel capacity requirements.

"With a verified and tested hydrogen-based propulsion system, we take the next step in zero-emission solutions at sea. This project is another example of our world-leading Norwegian maritime cluster succeeding when we face the most demanding technological challenges", says Geir Håøy, president of Kongsberg.

The next step will be for land-based system to undergo a 4-month testing program for validation purposes with the aim of verifying the final design for an H2-powered RoPax ferry. The fuel cell-powered vessel will be designed by CMAL, which plans to complete the design in March 2022.

> **The test formed part of the EU funded HySeas project, to prepare and demonstrate a scalable hydrogen system for ships and ferries.**

Source: HySEAS

■ **The installation of the Ballard HD-100 PEM fuel cells**

Source: Kongsberg Maritime

■ **The full-scale HySeas III test at Kongsberg's facility in Ågotnes, Norway on 1 December 2021**

REGULATORY CLARITY NEEDED TO SUPPORT INDUSTRY TRANSITION

The Motorship hosted a vibrant online discussion in early October with ExxonMobil, bringing together senior leaders from ship owners, charterers, engine builders and fuel and lubricant suppliers, to discuss the challenges of decarbonisation and regulatory change and to identify potential solutions.

The event was the latest in a long-running series of roundtables, organised in conjunction with ExxonMobil, which have brought together high-level panels to discuss topical issues affecting the shipping industry. This year's roundtable identified the need for greater regulatory clarity, given the likely introduction of a number of alternative fuels into the marine fuel mix.

The discussion was smoothly moderated by Unni Einemo, Director at IBIA, who brought her expertise as IBIA's International Maritime Organization (IMO) Representative to bear when the focus of the roundtable turned to regulatory issues.

Since the IMO adopted its current greenhouse gas targets in 2018, the industry has begun to move through a period of changes. The IMO's initial greenhouse gas strategy targets a reduction of the carbon intensity of international shipping of at least 40% by 2030, and 70% by 2050, compared with a 2008 baseline, and may well be revisited in 2023.

"The IMO also aims to reduce overall greenhouse gas emissions from international shipping by at least 50% by 2050," Einemo noted. The level of emissions reductions required to achieve that target was harder to accurately predict, The Motorship notes, as it hinges on highly technical discussions on the basis of forecasts about the evolution in international trade volumes over multiple decades.

When Einemo asked how the industry should prepare for potentially tighter IMO emissions targets after 2023, members of the panel noted that a range of different responses would be required.

An evolving regulatory environment

Charlotte Røjgaard, Global Head of Marine Fuel Services VeriFuel at Bureau Veritas, expressed a hope that the industry would respond to the potential introduction of a range of different fuels with greater transparency. "We need more cooperation [between all stakeholders] in the industry," Røjgaard said. While individual shipowners' choices around fuels would need to be based on the particular circumstances of their individual assets (such as operational segment, route, vessel size and geographical basis), greater transparency would help ship owners know what to expect."

The need for such transparency would be greater in a potential multi-fuel future than in the present, given the potential range of different fuels, and the varying potential efficiencies offered by different technical solutions, Røjgaard concluded.

There was a broad consensus amongst the panel about the need for industry and academia to work together to develop viable solutions. The Motorship features an article in its November issue about WinGD's development of model-based predictive controls, which draws on research developed by an industry-academia partnership with technical university ETH Zürich, for example.

"We need more cooperation [between all stakeholders] in the industry," Charlotte Røjgaard, Global Head of Marine Fuel Services VeriFuel at Bureau Veritas told the roundtable

Consistent regulatory frameworks

However, several participants emphasised that regulators needed to play a role in establishing a level playing field (or boundary conditions, if you will) to allow OEMs and industry to develop and commercialise solutions. Christophe Pouts, Global Regulatory Affairs Advisor at ExxonMobil underlined "the industry would expect that the member states' regulatory bodies would provide a stable, predictable technology-neutral regulatory framework, supporting the important societal goal of reducing greenhouse gas emissions".

"The establishment of a low carbon market is essential to enable the effective transition towards the use of alternative fuels," Pouts continued, adding that: "ExxonMobil supports the creation of such a market." A performance based technology-neutral approach, such as a Low Carbon Fuel Standard (LCFS) aimed at a gradual reduction in the life cycle carbon intensity of the fuels consumed by ships, would offer an approach to achieving society's goals. Pouts noted here again regulators had an important role to play in ensuring the standards were appropriately designed and would achieve societal goals.

Yannis Chatzakis, Global Field Engineering Manager, Aviation & Marine Lubricants at ExxonMobil, emphasised that potential solutions would likely rely on a multi-faceted approach. "The world needs to come together from a legislative standpoint, from a technological standpoint and from a fuel specification standpoint, to make [the introduction of alternative fuels] happen safely and efficiently."

By contrast, Evi Politi, R&D Manager at Danaos Shipping, emphasised the role of the market and techno-economic factors in her answer. "From our perspective, as a ship owner, in order to proceed with ordering zero-carbon vessels, we would need to see the technology, the regulatory framework, fuel availability, port and bunkering infrastructure for the investment to be viable."

When Einemo widened the focus of the regulatory question to the EU's proposed extension of its Emissions Trading System to the maritime sector, Pouts commented that the proposed system went beyond the current level of IMO ambitions, reflecting the EU's ambitions to reach climate neutrality by 2050. However, it would be challenging for the global Marine Industry for the emergence of regional regulatory policies that are contrary to the intent of global regulations developed by IMO.

Einemo noted that while the ETS proposals might be modified following wider consultations, a number of other measures in the EU's recent Fit for 55 package would also affect the shipping industry, as they would lead to the introduction of requirements for the shipping industry to begin adopting renewable and low carbon fuels.

A pathway towards sustainable LNG

Having assessed the relative advantages and disadvantages of competing fuels, Einemo asked for the opinions of the participants about LNG's medium term and long term potential.

James Sagar was uniquely well placed to comment, leveraging his previous responsibility for LNG shipping value chains when he was Global Supply Chain Manager, Basestocks & Specialties, at ExxonMobil.

Given the volumes of fuel required to replace 300 million tons or so of annual consumption of fuel oils by the maritime industry, Sagar naturally began by focusing on bunkering infrastructure and fuel availability. The expansion in LNG bunkering infrastructure is gaining momentum, while the supply of LNG is increasing. From a technological perspective, Sagar reiterated the advantages of the dual-fuel engine systems, which offer a lot of flexibility and significant reductions in emissions, with –up to 20% reductions in GHG emissions compared to running of conventional low sulphur marine fuel oil .

"In my opinion, LNG is a great transition fuel over the next few decades," Sagar concluded. The fuel represented a good

"No single cylinder oil is likely to satisfy the different requirements of very different fuels under consideration," Yannis Chatzakis, Global Field Engineering Manager, Aviation & Marine Lubricants at ExxonMobil said

Perspectives on alternative fuels

The panel was fortunate enough to be able to draw on the expertise of Andreas Schmid, General Manager Technology Development of WinGD, who was able to provide a high-level summary of technical and regulatory considerations surrounding biofuels and ammonia as potential alternative fuels.

Biofuels

Potential drop-in fuels, such as biofuels and ethanol, represented a viable solution from a technology perspective, Schmid noted. "[They] were a very nice solution, because you have the engines already, basically, and the infrastructure will be there."

However, there were challenges on the supply side for biofuels, given the challenge of ensuring that production did not affect crops for human or animal consumption, while consumption from other industries was likely to reduce the amount of fuel available for the maritime industry in the short to medium term.

From a wider perspective, looking at lignin-based fuels as a potential solution for stationary power generation or other uses, Schmid was cautious about the scalability of biofuels, compared with potential synthetic replacement. "[From a plant-level perspective], it would be a lot more efficient to just… produce some synthetic fuels [from renewable electricity] … rather than plant trees. So, it can be a solution for very specific sectors. But they would be rather small applications, I would say otherwise, we might run into trouble."

Specific technical challenges around how to compare emissions between the biofuel sector with competitor fuels are addressed above.

Hydrogen

Unni Einemo introduced the topic of blue and green hydrogen. Christophe Pouts explained how hydrogen can be "produced from many sources, including natural gas or renewable energy, and burned in IC engines or oxidized in fuel cells. As far as blue or green hydrogen is concerned, they both produce significantly lower well-to-tank carbon emissions versus traditional pathways."

James Sagar agreed that "all these fuel choices and alternative fuels, especially the low carbon option, are something that we need to continue to progress".

Ammonia

Turning to ammonia, Schmid began by stating, that while ammonia may offer potential benefits as an alternative fuel, there are safety and training considerations that should be addressed. An initial focus on crew training to raise awareness of the safety requirements for using ammonia as a fuel would likely need to be supplemented by ongoing refresher training if ammonia were introduced more widely. With appropriate training and understanding, Schmid proposed that the potential risks of ammonia could be appropriately mitigated and managed. As Schmid noted, such risks are handled in the ammonia industry itself, and then posited that with the proper training and safety installations on board and at the port side and the production side, "we can handle this."

James Sagar, Global Marine Sustainability Manager of SeaRiver Maritime, noted the supply chain for Ammonia as marine fuels needs to be safe and regulated. Key challenges related to its toxicity, storage and handling are well known and technologies are currently being assessed in several projects to better understand the feasibility of using ammonia as a bunker fuel.

Evi Politi added that there were some narrowly focused technical challenges, surrounding issues such as material selections for piping, owing to ammonia's corrosive properties, double-wall requirements and limitations on venting during normal operations. A separate challenge was connected with the development of emissions after treatment solutions to limit the emission of nitrous oxide (N_2O).

solution to the upcoming IMO Carbon Intensity Index targets. "Longer term, if combined with bio-LNG or synthetic LNG from renewables, this could open a potential future pathway for LNG to stay viable as a lower GHG emission fuel."

Evi Politi concurred that LNG remains the cleanest maritime fuel available at scale today, but noted that meeting IMO 2050 decarbonisation targets would require deeper cuts in GHG emissions than LNG is currently capable of supplying. Similar considerations apply to LPG. "Both fuels could be considered as a bridge fuel in the transition towards zero carbon emissions with a midterm rather than a long-term horizon."

Future engine and fuel flexibility

The discussion around the safety, bunker infrastructure and supply availability of alternative fuels led naturally to a discussion about considerations for ship owners when making decisions about new vessels' fuel types.

Charlotte Røjgaard noted that while initial demand for alternative-fuel vessels had been driven by "operators that had an interest in burning the cargo", supply chain issues were increasingly coming to the fore as passenger, container vessel and bulker owners were looking at alternative fuels seriously.

James Sagar concurred, adding that the future fuel flexibility of assets, along with cost, availability, and crew safety considerations, were key variables for shipowners looking at assets that might sit within an owner's portfolio for 20 to 30 years.

Schmid noted that the entire engine design and supply sector was making investment decisions based on expectations of a multi-fuel future. A number of OEMs were working to increase the range of dual-fuel engine technologies available on the market within the next few years.

WinGD itself was looking to develop engines with greater fuel flexibility, with the intention that such solutions could be retrofitted to modern engines within its portfolio, such as its X-DF dual-fuel engines, "according to the customer's specific needs or requirements". However, Schmid added that it would be difficult to imagine extending dual-fuel engines' flexibility beyond tri-fuel versions, not least because of the safety issues, as well as simple containment storage requirements.

Future lubrication perspectives

The panel concluded with a discussion about the implications of a multi-fuel future for cylinder oil formulations. Yannis Chatzakis noted that given the different characteristics of some of the fuels under consideration, lubricant suppliers would be unlikely to provide a single cylinder oil to meet all eventualities.

Chatzakis added that the cylinder oils were also likely to be required to meet more challenging operating conditions, as the rapid evolution of engine designs was creating additional demands in terms of pressures and temperatures. "If you asked me to take a guess today, I would say that probably more specialised [lubrication] technology will have to be developed."

Schmid noted that from an engine designer's perspective, future fuels pose quite different challenges to those seen before. "It is quite complex to [model] the interaction between ammonia and cylinder oils before and after combustion," he noted. WinGD was working with partners in the lubricant area, but the different characteristics of the fuels, as well as the way that fuels might be mixed or intermittently changed, meant that he anticipated one fuel per oil on board, for now.

Chatzakis noted that it would be more important than ever for shipowners and operators to heed OEM guidance, while maintaining some of the best practice followed during the IMO 2020 transition, such as visual inspections and close monitoring of the engine.

"Shipowners looking at ordering assets are focusing on future fuel flexibility, cost, availability and crew safety as key variables," James Sagar, Global Marine Sustainability Manager of SeaRiver Maritime said.

Measure for measure

James Sagar concluded by noting that there is still a need for greater consensus around lifecycle assessment methodologies and common measurement metrics among industry stakeholders. He said that the industry can't effectively manage emissions until we can reach consensus and alignment on how we measure emissions.

The relevance of reaching alignment on common metrics was expanded upon later in the discussion by Christophe Pouts who reiterated the need for a widely accepted lifecycle assessment (LCA) methodology. This was highly topical, Einemo confirmed, as LCA methodologies are currently under consideration at IMO.

Einemo noted that the process of aligning LCA methodologies at IMO with those used, for example, by the EU in its RED II directive, which proposes to extend existing requirements for biofuel use in EU transportation fuels to the maritime sector, was "taking some time".

Pouts noted that such comparisons "should not only account for GHG emissions that are directly attributable to biofuel production and use but also to emissions that may be associated with the induced change of land use (ILUC). Robust LCA methodologies provide such metrics information that are beneficial to incentivise the use of biofuels."

Credit: IBIA

Unni Einemo, Director at IBIA

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ELECTRIFICATION DRIVING THE EVOLUTION OF DEEPSEA ZERO EMISSION SHIPS

Hybridisation of main propulsion and auxiliary systems is providing a baseline for the transition to zero emission configurations for large, ocean-going ships.

Courtesy Norsepower

The VLOC Sea Zhoushan has been fitted with five Norsepower rotor sails.

Analysing the likely electrification path for ocean-going vessels, Joel Pérez Osses, a mechanical engineering researcher at University College London and Universidad Austral de Chile and Dr Carlos Reusser of Pontificia Universidad Catolica de Valparaiso in Chile propose that a segregated system where main combustion engines are replaced by electric machines is a natural first stage of evolution. In this case, there are two segregated electrical distribution systems – one, using about 90% of the total installed power, is powering the propulsion system and the other ship auxiliaries. This configuration can be attractive for ships requiring high manoeuvrability and thrust, but limits power management flexibility and therefore optimal power usage.

In an integrated system, as a next step closer to full electrification, all power is supplied by the gensets which feed a single busbar or switchboard. Power converters with active front end then supply power to the propulsion system and provide the ability to recover energy in batteries or supercapacitors. This boosts flexibility, availability and system redundancy and facilitates the development of an energy efficiency optimisation strategy.

> “Less than 3% of the existing fleet is hybrid or fully electric now. We need to consider how many zero emission ships can be built each year and how many will be replacing old conventional ships

DC grids can reduce the size and cost of power electronic devices and ensure a stable voltage operation suitable for optimal integration for energy saving devices. In an electric power distribution system that consists of both AC and DC busbars, the DC busbar provides an interface for the energy saving devices and the electric propulsion motors are fed directly from it, reducing complexity.

Hybrid propulsion configurations are a short-term highly reliable solution for the current fleet, says Pérez Osses. He believes fuel cells are going to play a massive role, initially for auxiliary gensets, generating the baseline before moving forward in main propulsion systems. “The technology is out there, so we just need to apply it and monitoring its performance to start escalating it.”

He notes that the renovation and scrapping of existing vessels to meet 2050 targets is a task that involves the whole shipping industry. “Less than 3% of the existing fleet is hybrid or fully electric now. We need to consider how many zero emission ships can be built each year and how many will be replacing old conventional ships. With this ratio we can calculate a possible date for when we will have a zero emission fleet – it will be way beyond 2050 for sure.”

Shaft generators

In the trend towards electrification, Dr Jussi Puranen, Head of Product Line, Electric Machines at Yaskawa Environmental Energy / The Switch, says energy storage technology is

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The Switch is developing PM shaft generators with a capacity of up to 12MW

improving and becoming more common on vessels. If a shaft generator is also installed, it can be designed to also act as a propulsion motor (power take in (PTI) mode). This mode can be used to reduce emissions in port by driving the propeller using the shaft generator as a motor taking the electric power from batteries. The combustion engine is not needed, so there are no emissions in harbour area.

Shaft generators have already become a standard choice in many vessel types, especially on LNG carriers. The same trend is now also happening in large container vessels. "Our existing frame sizes are 1000 and 1500 (shaft height from ground level in millimetres), and now we are working with 2000. Typically frame size 1000 goes up to 2MW in power, 1500 frame size up to 4MW, and 2000 frame size even up to 12MW. In large container vessels, shaft generator ratings are typically below 6MW, but in propulsion motor applications the powers can be much higher, exceeding 10MW."

Modern shaft generator systems allow power production regardless of the propeller speed and therefore allow for slow-steaming. It is also quite common to include a controllable pitch propeller (CPP) so that propeller efficiency can be optimized at any given speed. A CPP combined with variable speed operation, so-called combinator mode, results in maximum efficiency in any given operation point. "And to get the best possible efficiency, a permanent magnet (PM) generator should be used instead of conventional types," says Puranen. "We have done the calculations for a 174,000cbm LNG carrier with two 2MW shaft generators to demonstrate that the fuel savings with PM machines as shaft generators were up to US$75,000 annually compared to conventional shaft generators."

The company is currently developing a new generation of frequency converters designed for MW range marine applications. The Switch single drives will be used for applications such as propulsion and shaft generators and The Switch DC-hubs will be used for multiple sources and loads systems with future flexibility in our product portfolio. The new power modules are optimised for DC-distribution with the option of combining several applications to one power module to optimise footprint.

"The main game changing technology is our semiconductor based ultra-fast protection concept which detects faults based on high resolution measurements and cuts the fault from system in microseconds," says Puranen. "This will further enable the system keep running even though a fault has occurred in some parts of it. This is a game changer compared to traditional passive protection concepts where response time is much slower, causing the loss of the larger system."

As a reference for the concept, he says it enabled such high system redundancy on the North Sea Giant that the vessel can achieve DP3 operation with only one generator, combined with batteries, connected to a DC hub. "We will expand our protection technology even further to enable higher availability of the system in the future."

Hybrid flexibility

All ship types with a variable power requirement will gain from a hybrid system with a combination of combustion engine and variable electric power via a Power Take Off/ Power Take In (PTI/PTO) system, says Henning Brautaset, R&D Manager, Brunvoll Volda.

He cites the example of a longliner operating 5,100 hours per year (Installed power: 1920 kW, Sfoc g/kWh: 186-241, Open CP-propeller: Ø2,8 meter) where there is the potential for huge savings during low-speed operations. In this case, running in PTI-mode could reduce fuel consumption by 325 tonnes per year as the propeller is powered from an electric motor. Estimating US$600 per ton of fuel, this gives a payback time for the gearbox with PTI/PTO of approximately three years, or less.

"Our 2-speed gearbox is a very efficient system that allows for different propeller speeds and using an electrical motor," said Brautaset. "The PTI/PTO function gives high flexibility in utilising different energy types to power the propeller, and our gear systems can be connected to diesel engines, LNG engines, and hydrogen combustion engines, and electric

Credit: Norsepower

Jukka Kuuskoski, Chief Sales Officer, Norsepower

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■ Wärtsilä will collaborate with ABS and Hudong-Zhonghua Shipbuilding to develop a flexible, future-proof, and modular LNG Carrier vessel concept.

motors. A PTI-unit with an electric motor means all relevant energy carriers can be energy providers."

Brunvoll continues to develop its electric propulsion offerings and is currently developing a contra-rotating propeller system using PM motors and also configurations with direct driven CPPs run by PM or other electric motors, and a series of azimuth propulsion systems. Brautaset notes the advantages that PM machines typical result in higher efficiency (lower energy loss) compared with asynchronous machines and building dimensions and weight are significantly less.

Integrating multiple energy saving devices

Wärtsilä is developing propulsion concepts based on advanced power management which include its CPP and fixed pitch propeller systems. With the integration of a shaft generator for PTI/PTO functionality, the propeller shaft line is transformed into a hybrid propulsion system that provides high operational efficiency and flexibility, a power boost mode and emergency propulsion power to the vessel. Several layouts exist with mechanical or full electrical executions aiming at a broad range of applications.

Dr Elias Boletis, Director Wärtsilä Propellers and Transmission, says the company is taking the concept further with the inclusion of energy saving technologies and renewable energy, such as rotor sails, hull air lubrication, solar panels and energy storage into the system. Wärtsilä is already collaborating with companies such as Anemoi Marine Technologies on wind assist propulsion and with Silverstream Technologies on air lubrication.

When the wind is providing a large percent of the thrust needed for propelling the vessel, the operational modes of the propulsion system need to be monitored and managed accurately and dynamically. The propeller can be feathering or wind milling. There are conditions when excess power can be directed through the PTO to the energy storage system (ESS). There are also conditions when the ESS provides power to the vessel grid to balance engine load to keep the vessel speed at the required level and engines operating at optimal level. This requires an advanced and integrated Energy Management System which controls and balances all the energy consumers and sources.

The automation and energy management systems need to be able to respond fast to changing wind conditions and forces such as the drift forces generated by wind propulsion, which requires adjustments to power and rudder correction to ensure that the vessel remains on course. Correctly designed rudder systems or advanced rudder technologies like the 'gate rudder' are complementing the package and delivering improved manoeuvrability and efficiency of the vessel.

A new hybrid propulsion system is under preparation for the first large Sailing Cargo vessel to be operated between Europe and South America, and now Wärtsilä is further advancing LNG carriers in collaboration with ABS and Hudong-Zhonghua Shipbuilding that incorporate wind, air lubrication and solar power into an integrated system. The aim is to develop a flexible, future-proof and modular multi-fuel electric concept which will deliver immediate CO_2 savings and be ready for the adoption of additional decarbonisation technologies and new fuels.

Energy saving devices

Jukka Kuuskoski, Chief Sales Officer at Norsepower, says the company's Rotor Sails suit many vessel types and ages in meeting upcoming requirements, partly due to the potential payback achieved and also because the Rotor Sails, with a design life of 25 years, can be removed and put on another vessel later on.

Kuuskoski highlights that judging energy saving devices purely based on percentage of fuel saved can hide the true financial benefits. "Although it's an easy measure to communicate and understand, the percentage measure

> **"We like to compare saved kWs of propulsion power, and combining that data with the annual sailing hours we get total saved energy (kWh) during a year. That's then easy to convert to saved fuel tons when we know the specific fuel consumption of the engines**

varies greatly with the ships installed (or actual) propulsion power used in specified sailing conditions. Savings of 5% on a high-powered vessel can be much more effective for fuel saving than 15% on a vessel with only half of the propulsion power. Even similar ships with just a few knots of difference in sailing speed can be presented with much different savings, leading the reader to think that the higher the percentage the better.

"We like to compare saved kWs of propulsion power, and combining that data with the annual sailing hours we get total saved energy (kWh) during a year. That's then easy to convert to saved fuel tons when we know the specific fuel consumption of the engines."

The integration of Rotor Sail performance data and ship's power management system opens new opportunities to improve the total efficiency of the ship, says Kuuskoski. A variety of choices can be made during the ship design process to optimise the combination of Rotor Sails and ships propulsion and power generation machinery. Choice of a controllable pitch propeller (CPP) provides flexibility in cases where the ship has a very variable speed profile. Power generation and electrical power sources can be chosen to maximise the efficient use of fuel, whatever the fuel is. For example, shaft generators can provide power during sailing for the Rotor Sails with a higher efficiency than the auxiliary power plant.

Efficient optimisation for ensuring maximum fuel savings can be done by integrating the Rotor Sail control system with the ship's power management system. Another area that requires further research is how various energy saving devices interact with each other. For example, it's unclear whether a slight sideways drift caused by the use of wind power might have an effect on an air lubrication system.

The company is keen to be involved in R&D projects. "We have, of course, already been involved in several different ones. That's a key element of early project development and building confidence for customers."

Research trajectory

Pushing the IMO for a decarbonisation R&D Fund, the International Chamber of Shipping (ICS) has published A zero emissions blueprint for shipping identifying 265 projects that could accelerate innovation, including 28 relating to electrification.

Key research proposals include the study of battery pack and cell degradation over time, hyper-charging systems for multi-MWh marine batteries, vessel safety standards and protocols for emerging high voltage components and novel battery technology development for marine applications.

Other topics also include complete ship redesign for battery electric propulsion, development of a 2-stroke hybrid demonstrator, flow battery design, ballast tank and thruster hybrid integration, engine management system for a hybrid transoceanic vessel, electric charging (bunkering) at sea, bunker vessel development for electric vessels and the end of life disposal of large marine battery systems.

These projects could take up to six years to mature. The IMO delayed a decision on the fund at MEPC77 in November.

TAKING CHARGE: HYBRID AND PURE-ELECTRIC OPPORTUNITIES

While the expected expansion of hybrid-electric and pure-electric propulsion solutions into the short-sea, short-hop and inland waterway markets has been slower than anticipated, the technology is continuing to advance.

Credit: Kongsberg Maritime

■ **Yara's groundbreaking full-electric coastal container carrier *Yara Birkeland* made its first voyage in November 2021**

Shipowners are continuing to identify higher upfront Capex costs as a challenge, while the performance of battery technologies over longer periods remains a concern as shipowners look for viable solutions for the future propulsion of vessels. As with all new technologies, it comes at a price and whilst it is expected there will be further developments in the technology, could also be playing a part in holding the industry back from adopting hybrid technology.

Tomas Tengnér, Global Product Manager Energy Storage Solutions, ABB Marine& Ports explains that the relatively small size of the maritime battery market and the relatively concentrated number of individual battery suppliers has led to price differentials compared with the mass market. Another difference that Tengnér notes between the maritime market and other industries such as automotive is also in the area of battery supply as the maritime market is a small consumer of cells.

Wärtsilä also see that the current prices for batteries on the market being a stumbling block for the adoption of the technology. "The battery prices in marine need to drop significantly at allow many more fuel and GHG savings with a good ROI. This will happen in the coming years," says Simone Greene Communications Manager, Wärtsilä.

Tengnér also notes that: "We see a general battery cost decrease of about 3-5% per year. Battery raw material costs have increased in the recent months and this may hold back the general cost decline trend in the short term. Within the next 2-5 years we do expect some stepwise cost reductions beyond the 3-5% figure, realised by the launch of next generation marine battery products."

Besides the costs, scaling up the technology to meet with the demand of larger vessels is also a challenge that the market is looking to address. However, due to the scalable nature of the technology this does not appear to be too much of a problem. However, Greene highlights that when looking at larger vessels: "The installation is more complex, you need bigger convertors and more safety measures. The most important difference is the functionality through: while a smaller battery is used for optimising the propulsion train, the larger one on top allows for zero emission operation."

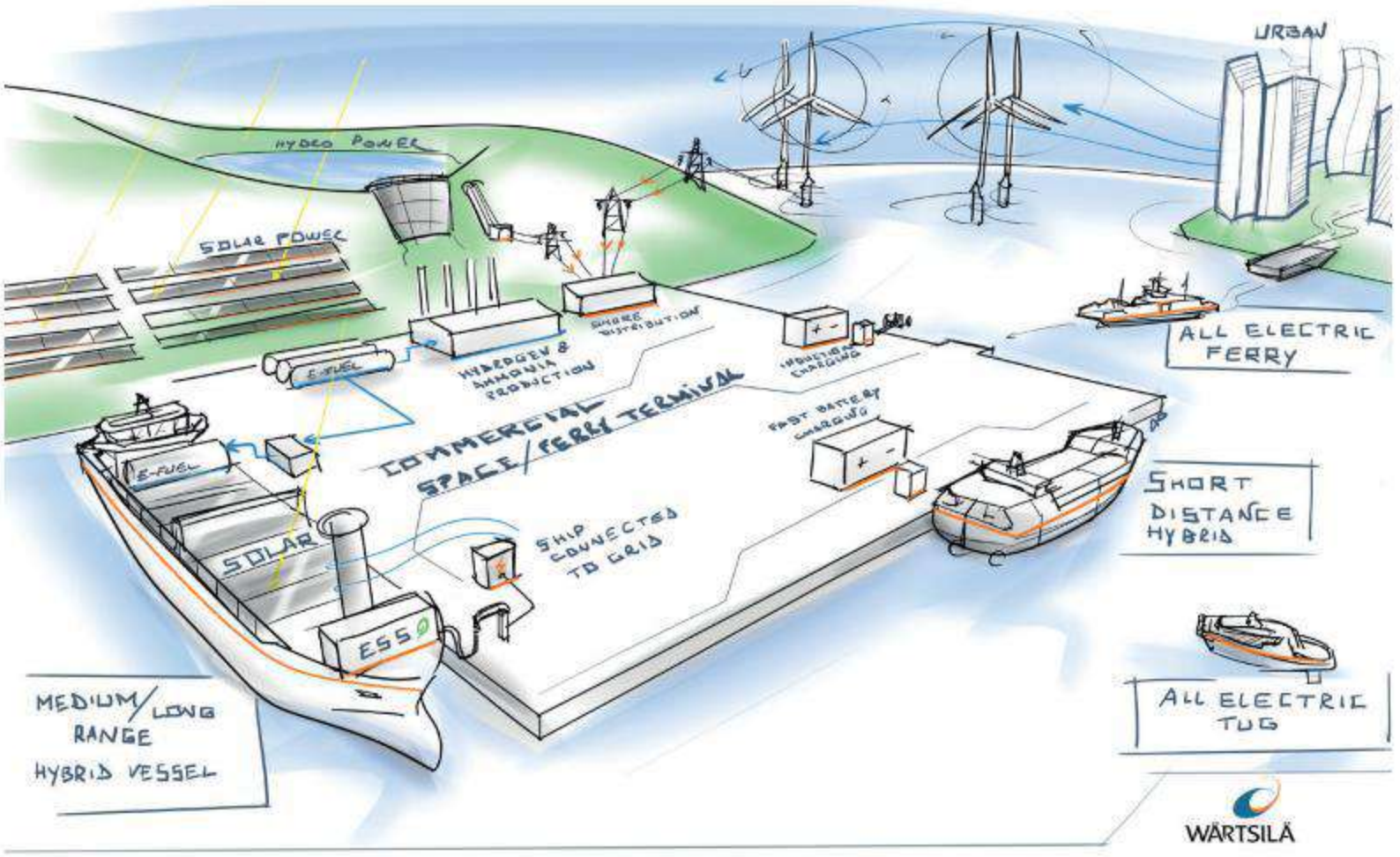
However, it is not just the technology that is installed onboard but also the technology that will be installed at shoreside that will allow for batteries onboard to be charged when they are in port. It is expected that under the EC's 'Green Deal' that shore power connections will be installed at the major TEN-T ports after 2025, and across the entire network in the 2030s.

Tengnér comments that: "Availability of shore power is a key enabler for realisation of the electrified hybrid or full electric vessels of the future, especially by enabling battery charging from renewable energy sources. Onshore energy storage systems can be considered for demand charge management and peak shaving, as well as for general ancillary grid services which will contribute to strengthen the local national electricity grids, rather than pulling them down."

> **"As larger vessel types adapts these type of new technologies, they will also benefit from this technology**

He also notes that larger vessels will also utilise the DC grid system. "As larger vessel types adapt new technologies such as batteries and fuel cells, they will also benefit from DC Grid technology. For power level requirements that exceed the capability of our Onboard DC Grid, we also offer solutions to integrate batteries and fuel cells into our Medium Voltage AC platform," he says.

There are currently different developments happening in the market around hybrid technologies. Wärtsilä notes that all these developments are just to do with the battery solution itself, but also the technologies around it, such as fuel cells, smaller containerised solutions, solar power support and expanding its energy management system to optimise all the solutions that it is working on.



Credit: Wärtsilä

Electrification is expected to play a central role in short sea and passenger ferry operations.

ABB notes that there is a slight change in the market as we move from early adopters to the technology now becoming more mainstream. "ESS and hybrid solutions are now being considered for larger vessels than before, meaning that also the install size increases significantly. In the past, the typical size was <1MWh, now we are even looking at ESS sizes of up to 100MWh or more."

Development in the market has also seen further orders in the industry for hybrid power vessels. AtoB@C Shipping has announced an order for six highly efficient 1A ice class 5,350dwt hybrid vessels to meet the growing demand. The total investment value of the six ships is approximately EUR70 million. AtoB@C Shipping also has the option to expand the order with several ships.

The greenhouse gas emissions, including CO2, per cargo unit transported will decrease by almost 50% compared to the existing ships. The vessels' battery packs, shore-side electricity solution and electric hybrid use enable completely emission-free and noise-free port calls. Ships can also arrive and leave the port with electric power only.

The new vessels will be built at Chowgule and Company Private Limited shipyard in India and will be delivered starting from the third quarter of 2023.

The design work of the ships and comprehensive model tests have been carried out together with the Dutch SMB Naval Architects. The company has been closely involved in the design of the vessels and has tailored the vessels to customer needs. Special attention has been paid to the energy efficiency and arrangements of cargo spaces.

UK-based CWind has also been working with naval architects to develop a hybrid SES crew transfer vessel, as projects move further from shore.

The work carried out on the designs has looked at reduced emissions and fuel consumption, increased speeds and range, and an ability to operate in higher sea states are factors influencing the design of the latest crew transfer vessels (CTVs) for the offshore renewables sector.

The vessels are being designed with hybrid propulsion, electric drives and an ability to operate in more remote locations for longer, as the offshore wind sector installs deep water fixed and floating turbines. CWind hybrid propulsion comes from Danfoss Editron's hybrid drivetrain. This consists of two inline power take-off and power take-in machines, one DC-DC converter for the vessel's batteries, grid solutions and shore-charging capabilities. Wärtsilä also notes that offshore market is an area for growth for hybrid solutions.

By contrast, demand from the autonomous vessel segment is likely to be slower to emerge. The first voyage of Yara's groundbreaking full-electric coastal container carrier *Yara Birkeland* in November 2021 illustrated the challenge. The development of classification rules to govern the operation of an autonomous vessel is continuing, and the expected beginning of operations as an autonomous, all-electric container ship has slipped from 2022 towards 2024.

While demand for autonomous vessels is likely to be driven by economic factors in the short term, market observers expect semi-autonomous or autonomous vessels in the passenger ferry and short-hop segment to be either full-electric or battery-hybrid vessels.

The extension of hybrid-electric solutions into both smaller and larger deepsea vessels remain works in progress. Compact solutions are opening up the workboat and 2 litre vessel segments, as well as small high-speed vessels and crew transfer vessels, to electrification. where no suitable solution had previously been available to ship designers.

Once again, a Norwegian customer was among the early adopters. Hurtigruten Svalbard is trialling a new M15 passenger vessel, to be powered by a twin D4-320 DPI Aquamatic hybrid solution, which will be used by tourists visiting Svalbard in the Arctic Ocean in summer 2022.

Turning to the deepsea market, WinGD has successfully modelled the integration of relatively small capacity energy storage systems aboard a number of vessels. However, the business case for integrating hybrid propulsion trains is likely to be route and trade specific.

Wärtsilä notes that the integration of energy storage systems into larger vessels is likely to be spurred by the introduction of alternative fuels.

"After offshore and RORO/Ropax vessels, we see merchant vessels and cruise vessels as next segments going hybrid. Any new fuel will always come with a hybrid propulsion train," Greene concluded.

A NORDIC STAMP ON CHINESE PRODUCTION

Chinese construction married with advanced European design, engineering and propulsion technology has spawned what has been described as "one of the world's most climate-smart passengerships"

Source: Viking Line

A new Baltic queen, *Viking Glory* is due in Finnish waters by the year's end

The 63,800gt ro-pax ferry *Viking Glory* will bring new scale to the cross-Baltic traffic while promising a level of performance exceeding that of the earlier milestone vessel, the slightly smaller, eight year-old *Viking Grace*, hailed as one of the environmental pioneers of its time.

Following completion of her second and final set of sea trials at the beginning of November, handover by Xiamen Shipbuilding Industry to Mariehamn-based Viking Line is imminent, with a view to the vessel's entry into service on the Turku/Aland Islands/Stockholm route during the early stages of 2022.

The 223m *Viking Glory* takes the dual-fuel-electric powering concept, meticulous attention to every sphere of energy usage, and championing of the passenger experience, as previously encapsulated in the Finnish-built *Viking Grace*, to a new level. After personnel, energy constitutes the second biggest operating cost for Viking Line, rendering further incremental gains in performance vital to long-term profitability and asset worth.

While a Chinese cradle was chosen for the new ship in 2017 because of the financial case and berth availability considerations, *Viking Glory* nevertheless provides a show-case for Nordic know-how. This includes Wartsila's 31-series dual-fuel main machinery, Azipod electric propulsion units, Climeon energy recycling, Deltamarin design, and Koncept interiors.

Beset by early delays in project execution and production, compounded by Covid-induced difficulties, realisation of Viking Line's contract is about one year adrift. At the time of writing, the ferry was expected to arrive in Finnish waters by the end of 2021, to take up duty in the ensuing months as the replacement for the 1988-built Amorella on the Turku/Stockholm schedule, joining the 56,850gt *Viking Grace*. The service involves a call in Aland, ensuring that duty-free onboard sales can be offered by virtue of the islands' autonomous status as a Finnish province.

Deltamarin developed the new vessel concept together with Viking Line and provided assistance to the owner during the tender and contract phases. Tailored to the shallow and sensitive waters embraced by the intended operating profile, special focus was placed on hull lines determination, as well as weight control, further advances in energy efficiency, including waste heat recovery, and improved general arrangement. Chinese-owned, Finnish-head-quartered Deltamarin proceeded with the basic and detail design on behalf of Xiamen, and was also entrusted with project management and supervision.

The newbuild is some 5m longer and and 3m beamier than future running mate *Viking Grace*. *Viking Glory* has been built to 1A Super ice class and will accommodate 2,800 passengers and 200 crew, while the ro-ro freight intake corresponds to 1,500 lane-metres, raising cargo capacity on the Turku/

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Stockholm run by about 500 linear metres relative to the Amorella. The new ship's passenger capacity represents an increase of 400 compared to the Amorella, and is on a par with that of *Viking Grace*.

Viking Line's newbuild scheme had afforded one of the earliest contractual references for the dual-fuel version of the Wartsila 31 engine platform, and at some scale by virtue of an order entailing six engines each of 10-cylinder configuration.

The W31DF has more recently been uprated to 600kW per cylinder at 750rpm, but the available maximum power output when contracts were signed was 550kW/cylinder, such that the plant in *Viking Glory* will have a total potency of 33,000kW. The Azipod XO2100-type propulsors together account for some 22,400kW of the load, with the 'power station' plant also serving the constant, high hotel demand, plus the intermittent, surge requirements of the three Wartsila bow thrusters.

Local delivery: the *Viking Glory* will be the first vessel to be equipped with Wärtsilä's new 31DF engines

The *Viking Grace* had also been an outstanding reference for Wartsila, as the world's first LNG-fuelled passenger-carrying vessel, specified with the Finnish marque's wide-bore 50DF series. Four eight-cylinder models, providing a total power concentration of 30,600kW, are coupled to ABB AMG-type alternators. Energy is fed to a pair of ABB 10,500kW electric propulsion motors, turning stainless steel fixed pitch propellers. The entire plant came from Finnish factories, complementing the ship's domestic production at Turku, then in the hands of STX Europe.

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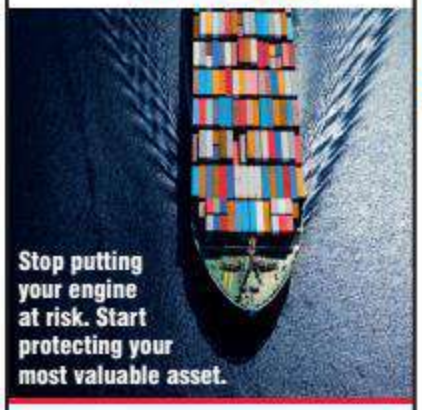

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ENGINE DEVELOPMENT CONTINUES

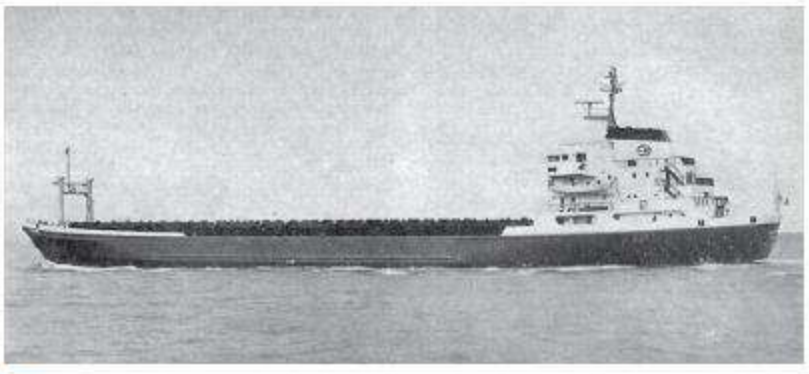
■ **Cunard's first vessel for year-round cruises, the *Cunard Adventurer***

In the December 1971 issue of The *Motor Ship*, our predecessors reported on "the largest diesel engine yet built" – a 10-cylinder 1060mm bore engine of 42,500 bhp output, on the test bed at the Fiat's Grande Motore Trieste works.

In that same issue, Lloyd's Register suggested that the useful upper limit of power of the marine diesel engine would be in the region of 50,000 bhp. The determining factors, apart from sheer size of an even larger-bore engine, would be the thermal loading of available materials, plus lubrication limitations and wear rates. But each of the major engine developers have engines in their portfolios capable of well over double that limit, and with smaller, sub-1000mm bore dimensions. We have to ask: have materials really advanced so much in under 50 years, or was the industry in the 1970s even more conservative than we remember?

With mega-cruise vessels so much a part of today's maritime scenery, it seems odd that as recently as 1971 Cunard was taking delivery of its first-ever year-round, all-cruise ship. The *Cunard Adventurer* was destined for year-round cruises in the Caribbean region, carrying up to 806 passengers.

The main ship description concerned another ship type which is ubiquitous now, but still relatively novel in 1971, a 'fully-cellular' gearless container ship, the Wicklow, built for B&I of Dublin, by Verolme Cork Dockyard, for service between Liverpool and Dublin. With a total capacity of 173 TEU loaded plus 49 empty containers, she would hardly class as a feeder ship today, but then was described as "highly sophisticated". At just a fraction under 100m long, 3442gt, the Wicklow was powered by a MAN 7RV40/54 medium speed engine of 3900 bhp, giving a 15-knot service speed. With fuel consumption at 14.5t/day, she was considered a highly economical vessel to operate.



■ ***Wicklow*, a small but sophisticated fully-cellular container ship**

Several pages were given over to a detailed look at the Doxford Seahorse medium speed engine, which, like the other Doxford designs, was of opposed-piston design. It had been introduced to meet the demands of vessels of about 150,000dwt and 280m length with a maximum propeller diameter of 9.9m. For such a ship, the optimum shaft speed was considered to be around 67rpm, well below the 102rpm of equivalent conventional two-strokes of the time. So a geared drive was considered advantageous in terms of overall efficiency – so even allowing for gearbox power losses, an efficient medium speed unit turning at 300rpm with a suitable reduction gear should provide significant fuel savings. The larger combustion space of the opposed-piston design was considered better suited to the use of high-viscosity heavy fuels, resulting in more cost savings compared with normal four-stroke medium speed units. Although medium speed engines in general were considered noisier than the large two-stroke, the Seahorse design avoided valve gear noise and benefited from a very solid constriction. With power output from 10,000 to 70,000 bhp per shaft, a twin engine installation (thought to add to the overall reliability and safety) would lend itself to a wide variety of large-ship applications.

The Wärtsilä name has become so synonymous with marine engines that it seem surprising that the Finnish shipbuilder had only introduced its first own-design engine, the Wärtsilä 14, a few years previously. The first examples of this small four-stroke unit, mostly applied for auxiliary use, produced just 53 bhp/cylinder. By 1971, thanks to turbocharging as well as higher pressures and piston speeds, the specific output had risen to 183bhp/cylinder at 750rpm in the recently-announced Series 24TS version, extending its use to propulsion as well as auxiliary applications. Improved fuel injection and better materials had contributed to this power hike while maintaining reliability.

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